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Research Article

The Biodiversity Informatics Landscape: Elements, Connections and Opportunities

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Abstract

There are a multitude of biodiversity informatics projects, datasets, databases and initiatives at the global level, and many more at regional, national, and sometimes local levels. In such a complex landscape, it can be unclear how different elements relate to each other. Based on a high-level review of global and European-level elements, we present a map of the biodiversity informatics landscape. This is a first attempt at identifying key datasets/databases and data services, and mapping them in a way that can be used to identify the links, gaps and redundancies in the landscape. While the map is predominantly focused on elements with a global scope, the sub-global focus at the European-level was incorporated in the map in order to demonstrate how a regional network such as the European Biodiversity Observation Network (EU BON) can usefully contribute to connecting some of the nodes within the landscape. We identify 74 elements, and find that the informatics landscape is complex in terms of the characteristics and diversity of these elements, and that there is high variability in their level of connectedness. Overall, the landscape is highly connected, with one element boasting 28 connections. The average "degrees of separation" between elements is low, and the landscape is deemed relatively robust to failures since there is no single point that information flows through. Examples of possible effort duplication are presented, and the inclusion of five policy-level elements in the map helps illustrate how informatics products can contribute to global processes that define and direct political targets. Beyond simply describing the existing landscape, this map will support a better understanding of the landscape's current structure and functioning, enabling responsible institutions to establish or strengthen collaborations, work towards avoiding effort duplication, and facilitate access to the biodiversity data, information and knowledge required to support effective decision-making, in the context of comparatively limited funding for biodiversity knowledge and conservation. To support this, we provide the input matrix and code that created this map as supplementary materials, so that readers can more closely examine the links in the landscape, and edit the map to suit their own purposes.

Keywords

Biodiversity informatics; network; data; indicators

Introduction

As data on the natural world become more complex and more abundant, the challenges of collating, managing, analysing, visualising and sharing them are becoming greater. Biodiversity informatics applies information technology techniques to tackle these challenges, and develops systems that allow data to be stored, accessed and combined in ways that optimally serve its target communities (such as conservation, taxonomy, systematics and ecology communities). At national and international levels, there is a clear

need for information to support decision-making, including monitoring of the impacts of biodiversity-related policies. To address these needs, in their Global Biodiversity Informatics Outlook, Hobern et al. 2013 recommend coordinated action between researchers, policy-makers and other stakeholders to build a culture in which biodiversity information is openly shared, freely available and connected. The global biodiversity informatics landscape has a clear role to play in the foundation of such a culture, in particular by forging connections that enable data to feed into broader processes.

Computerised taxonomic lists were first discussed in the 1950s (Denmark et al. 1958). Since then, biodiversity informatics has evolved to encompass a broad range of dataset and database categories including biogenic habitats, species habitats and distributions, biodiversity metrics, areas of biodiversity importance and protected areas, biogeographic classifications, and environmental descriptors, among others (for example, Weatherdon et al. 2015). Biodiversity informatics projects increasingly integrate datasets from disciplines beyond biodiversity, such as those derived from climate, natural capital, ecosystem services, and socio-economic research, to create informatics products that are far broader in scope than their predecessors.

Within such a diverse landscape, there is high potential for linkages, mutually beneficial relationships, and complementarity. However, there are also risks, including mission overlap, redundancy and duplication of effort. These problems are compounded by issues around data sharing. With considerable shortfalls in data accessibility, discoverability and digestibility (Wetzel et al. 2015), there is a need for greater transparency among providers and curators of biodiversity data. In some cases, data accessibility suffers from a reluctance on the part of data creators to share data at all (Huang et al. 2012). In other cases, data creators are willing to share only metadata, or data with significant restrictions (Groom et al. 2016), and there have been calls for open access to primary data to address this (e.g. Costello et al. 2013). Where data are freely available, a lack of standardisation can make further analysis difficult. At both the global and regional levels, there is a clear perception that data and information are scattered, fragmented, and difficult to access for policy-level and other decision-making purposes (Hobern et al. 2013; Nesshöver et al. 2016). In the face of these challenges, it is important that organisations operating within the biodiversity informatics landscape are able to identify what is commonly referred to (in business plans) as the "Unique Selling Point" (USP) of their product (Weatherdon et al. 2017), and consider how it can assist, and take advantage of, other elements in the landscape. In this way, effort duplication and overlapping objectives can be minimised, and complementarity can be maximised.

This paper maps and explores the elements of the biodiversity informatics landscape, and the links between them. The landscape presented is intended to support organisations in identifying potential connections, strengthening collaborations, and working towards avoiding effort duplication, in the context of comparatively limited funding for biodiversity knowledge and conservation.

Methodology

Potential elements to include in the landscape map were initially identified through web searches using the following criteria:

- Includes online access to biodiversity data and/or related information;
- Is global or European-wide in geographic scope; and
- Is connected to other elements in the landscape, by uptaking and/or providing data and information.

Projects with time-bound and/or ad-hoc funding and decision-support tools were mostly excluded, with the focus instead on established datasets, databases and data services. Additional elements were collated via grey literature materials, such as Hernàndez Ernst et al. 2010 and Weatherdon et al. 2015. This study did not look at local, national, or regional-level initiatives, Europe (as a region) excepted in order to highlight how regional biodiversity observation networks can contribute to connecting some of the nodes within the landscape. To provide context on how informatics elements contribute to policy processes, several policy-level elements were included in the map, despite not being informatics products.

Linkages between elements were initially identified using publicly-available information. For each element in the map, background information, i.e. metadata, was compiled following a standard format. The map and its linkages were subsequently refined based on expert feedback received through informal discussions, including at a number of international meetings:

- 10th GEO European Projects Workshop, 31 May – 2 June 2016, Berlin (Germany);
- GEO BON Open Science Conference & All Hands Meeting, 4 – 8 July 2016, Leipzig (Germany);
- GEO-XIII Plenary, 7 – 10 November 2016, St. Petersburg (Russian Federation);
- 4th EU BON ("Building the European Biodiversity Observation Network" project) Stakeholder Roundtable, 17 November 2016, Berlin (Wetzel et al. 2017).

Based on the feedback received, it was possible to add and edit elements and the links between them. The final "landscape map" was created using MATLAB. The circular map and linkages were generated from an adjacency matrix using the circularGraph MATLAB script. Post-hoc adjustments to the landscape map (such as colour-shading to highlight different element types) were made in Sketch app. We provide the input matrix and code that created this map as supplementary materials (Suppl. materials 1, 2). This is to enable readers to more closely examine the links in the landscape, and edit the map to suit their purposes. Figs 1, 2, 3 are also available in high resolution as supplementary materials (Suppl. material 3).

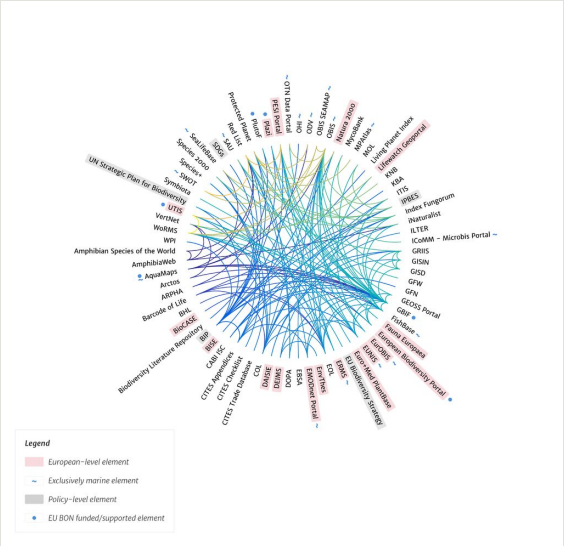

Figure 1. doi

A non-exhaustive map of the global and European biodiversity informatics landscape.

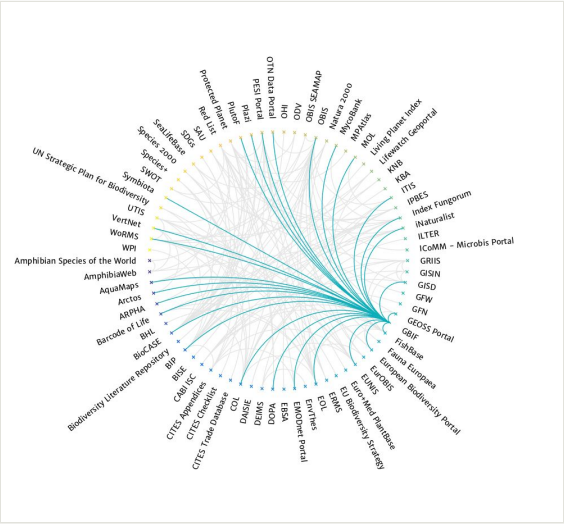

Figure 2. doi

A highly-connected element in the landscape: the Global Biodiversity Information Facility (GBIF).

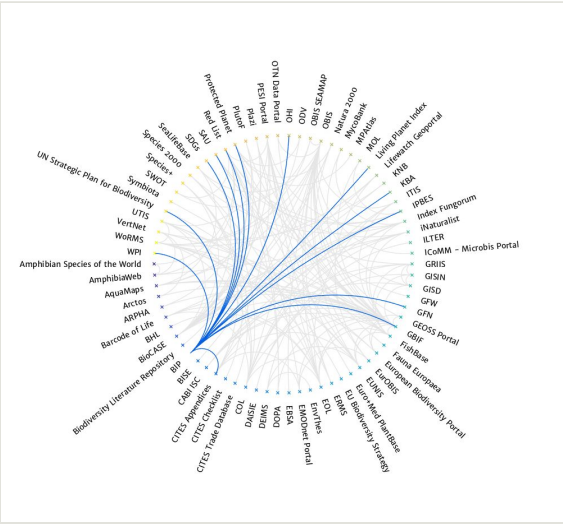

Figure 3. doi

An example of links from the biodiversity informatics landscape to the policy-level: the Biodiversity Indicators Partnership (BIP).

Results

The landscape

The landscape map generated through this study contains 74 elements (Fig. 1). Shortened names or acronyms of elements have been used in a number of cases; their expanded names are given in Annex 1. Standardised metadata on each element are available in Annex 2. A significant proportion of the elements identified are hosted by publicly funded organisations such as museums (e.g. Fauna Europaea, hosted by Museum für Naturkunde, Berlin), with some hosted by national research centres (e.g. Global Register of Introduced and Invasive Species (GRIIS), hosted by the Italian Institute for Environmental Protection and Research (ISPRA)). A large number of other elements have non-/inter-governmental organisations or other business types as institutional homes (e.g. the Ocean Biogeographic Information System (OBIS) is hosted by an intergovernmental organisation; Protected Planet is hosted by a non-profit organisation).

In order to differentiate global and European-level elements, European elements (e.g. European Nature Information System (EUNIS)) are highlighted in red colour. Within the European context, The European Biodiversity Observation Network (EU BON; Hoffmann et al. 2014) is intended to be the European contribution to the global-scale Group on Earth Observation Biodiversity Observation Network (GEO BON). To demonstrate the existing role of EU BON in the landscape, elements that it is closely linked to, or sponsors, are identified in the map by a blue dot. These elements perform a variety of significant roles

within the landscape, ranging from tools and platforms for data collection and management (PlutoF; Plazi), to provision of taxonomic backbones (Unified Taxonomic Information Service, UTIS), open data hosting (Global Biodiversity Information Facility (GBIF)/OBIS) and visualisation of analysed and modelled data (GBIF). Biodiversity data publishing tools and platforms are essential contributors to the landscape map: Pensoft's ARPHA, for instance, is a platform for collaborative biodiversity data publishing that is fully integrated with PlutoF and GBIF via the Biodiversity Data Journal, which provides a variety of templates that accommodate the various forms of data publishing (e.g. Red List compliant Species Conservation Profiles; Cardoso et al. 2016). A number of the elements identified relate exclusively to the marine environment, and have been highlighted in the map using a blue wave symbol.

The elements of the landscape are highly varied in terms of their purpose and scope, and those performing single, specific roles often feed into more complex elements. For instance, site-level biodiversity data collected for a research project (e.g. time-series of species abundance) may be collated and incorporated in a regional or global database, and then used — potentially along with many other such datasets — for a policy-relevant purpose. For example, species abundance data may be used as part of an indicator (the Living Planet Index, in this example) to track progress against a regional or global biodiversity target (Aichi Biodiversity Target 12). Other secondary purposes may include the use of biodiversity informatics databases by conservation organisations to identify areas of biodiversity importance (e.g. use of the IUCN Red List of Threatened Species in the identification of Key Biodiversity Areas (IUCN 2016), or by the corporate sector and investment banks for environmental sensitivity screening during the planning phase of development projects (Martin et al. 2015).

The connectedness of elements within the landscape also varies significantly, ranging from one link to 28. The most highly-connected element in the landscape is GBIF (Fig. 2).

Types of elements

The elements of the landscape can be classed in three broad, sometimes overlapping, categories. Firstly, there are **elements with a single specific focus**, for instance the Catalogue of Life (CoL) is a taxonomic backbone used by the IUCN Red List of Threatened Species and GBIF to allow taxonomic harmonisation, browsing and reporting operations across various resources in a consistent way, and to provide a means to compare/crosswalk names from one source to another.

Higher-level elements rely on one or more other elements. For instance, AquaMaps harvests species occurrence data from GBIF and OBIS, in addition to life-history parameters from FishBase, enabling it to create and provide access to automated distribution maps for thousands of marine species.

Finally, there are a number of **complex elements** in the global landscape that rely on several other elements, while also providing more in-depth explorative and/or analytical functionalities to their users. An example is the European Marine Observation and Data

Network (EMODnet) Portal, which can combine multiple datasets in interactive maps, drawing on EurOBIS (the European node of OBIS), the Euopean Register of Marine Species (ERMS), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) appendices, and the IUCN Red List of threatened Species, among other sources. Likewise, the European Biodiversity Portal intends to act as a data broker for selected elements of the landscape such as GBIF and the Long-Term Ecological Research (LTER) network, as well as various sources of remotely-sensed data, along with providing data analysis and visualisation tools.

Linkages with policy-level elements

Many of the elements in the map feed into processes at the policy-level. In order to reflect important relationships between policy and informatics initiatives, five policy-level elements have been added to the map: the Biodiversity Indicators Partnership (BIP); the United Nations' (UN) Sustainable Development Goals (SDGs); the UN Strategic Plan for Biodiversity 2011-2020; the EU Biodiversity Strategy; and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). Since these are not informatics initiatives, they are differentiated from the map's other elements by a grey background. The inclusion of the policy-level elements provides context on how informatics products contribute to global processes that define and direct political targets with regard to biodiversity and sustainable development.

Additionally, the policy-level elements are themselves connected. One example is the BIP (Fig. 3), which draws on numerous informatics elements to host a suite of indicators, which then are used to assess progress towards the multiple aspects of the UN Strategic Plan for Biodiversity. Many of the elements shown connected to GBIF in Fig. 2 also contribute to indicators under the BIP via GBIF. This highlights a level of complexity not fully apparent from the figures shown here: each element acts as a node in an information chain, and if any of these is compromised then this can have consequences at the highest levels of the chain.

Many of the indicators brought together under the BIP are subsequently taken up by the IPBES process (e.g. the indicator under the BIP on coverage of protected areas, derived from Protected Planet), while other indicators under IPBES stem directly from individual informatics elements (e.g. the 'Species Protection Index' indicator under IPBES, which draws data from Map of Life (MOL)). A further example of policy-level impact is the path (Despot-Belmonte et al. 2017a) taken by the data used to inform the indicator under the BIP, 'Growth in Species Occurrence Records Accessible Through GBIF', which is used to track progress towards Aichi Biodiversity Target 19. Some of the data used in this indicator come to GBIF from OBIS and its numerous nodes such as EurOBIS (in Europe), including MedOBIS for the Mediterranean Sea, and OBIS Black Sea (the latter two are sub-regional and are therefore not shown in the map).

There are opportunities for the indicator curators that have emerged to track progress against the UN Strategic Plan for Biodiversity to assess progress towards the UN Sustainable Development Goals and the EU Biodiversity Strategy. The BIP, in particular, is

already evolving to fill this niche. One key policy-level portal not shown on the map is Environment Live, which has been built to support country-level reporting under Multilateral Environmental Agreements (MEAs) and UN-related assessments such as the Global Environment Outlook (Barthod et al. 2016). Environment Live is at this stage excluded from the map as its connections to the other elements are unclear, though its potential to contribute to biodiversity assessments is very significant (Fig. 3).

Network analysis

Network analysis shows that the biodiversity informatics landscape is well-connected and is not divided into disconnected, separate communities (Fig. 4). Many elements in the network have links to many other elements, with an average geodesic distance of 3.0. This compares well to the distance across other scientific networks. For example, the distance is almost identical to that of the British and Irish botanist network in the 19th Century (2.9), and lower than most scientific citation networks, where it ranges from 4 to 9.7 (Groom et al. 2014; Newman 2001). There are also many crosslinks in the network, meaning that there are many different paths between elements. This results in a relatively high graph density (0.053). This well-linked structure makes the network relatively robust to failure of any one part, however, certain actors, most noticeably GBIF, have such a central role that their failure would impact the network significantly. Without GBIF the average geodesic distance of the network is 3.5 and the graph density is 0.046.

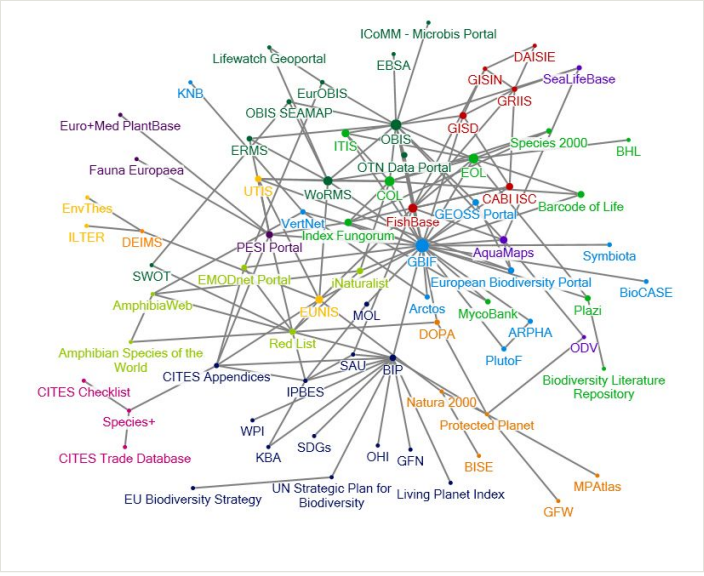

Figure 4. doi

The network of biodiversity informatics organisations. The network visualisation was created using NodeXL (Version 1.0.1.229) (Smith et al. 2009) and was laid out with the Harel–Koren Fast Multiscale algorithm and then adjusted manually to remove overlaps. The colours represent clusters identified using the Girvan–Newman algorithm.

The ten most connected elements are are follows:

1. GBIF (Fig. 2)
2. OBIS
3. COL
4. EOL
5. WoRMS
6. FishBase
7. ITIS
8. EUNIS
9. AquaMaps
10. Index Fungorum (Fig. 4)

Discussion

The biodiversity informatics landscape is diverse in terms of the scope, objectives and methodologies of its underlying elements. The map presented here shows that this diversity also extends to the degree of connectedness of elements within the landscape. Although a network analysis demonstrated that the landscape is well-connected overall, there is undoubtedly scope for improved connections, and enhanced data-sharing between elements. The map should not be considered exhaustive in terms of existing elements or linkages, and readers should be aware that this is a snapshot of the landscape as it is in 2017. Furthermore, although extensive consultation took place during the building of the map, it was beyond the scope of this exercise to consult the responsible institutions behind all the elements.

With many organisations acting independently to maintain informatics products, there are instances of effort-duplication, and possibilities for new linkages can also be viewed as missed opportunities that currently limit the efficiency of the landscape. This is particularly important as funding for such projects is relatively limited, and the cost of data creation and curation is significant (Juffe-Bignoli et al. 2016).

Effort duplication

Although the majority of elements offer something unique to the landscape, their broader missions sometimes overlap. An example is the potential for effort duplication between iNaturalist and PlutoF, both of which are citizen science initiatives, and both of which contribute observation data to GBIF. Like iNaturalist, PlutoF is now dynamically linked to GBIF as a result of the EU BON project, resulting in near-real-time updates. Both iNaturalist and PlutoF are supplied by data from citizen scientists and verified by other members of their communities. iNaturalist and PlutoF share many common features, not least in terms of data standards, and hence interoperability. Enhanced collaborations between the two might therefore result in more significant outcomes.

A further example is that of the elements providing taxonomic information, which are common within the map. This appears to be a section of the landscape where organisations have responded positively to instances of effort duplication. Over time, elements with a specific focus have been subsumed by lists that are broader in scope. An example is the amalgamation of FishNet2, MaNIS, HerpNET and ORNIS into VertNet, a single vertebrate data hub (VertNet 2017). Although these elements did not overlap in terms of their focal taxon, their incorporation into a single platform dealing with all vertebrates represents a move towards efficiency and improved accessibility for users. Similarly, at the European level, effort duplication is minimised by having taxonomic databases with different focuses feeding into a broader, overarching element (Fauna Europaea is focused on terrestrial animals, Euro+Med PlantBase specialises in plants, Index Fungorum deals with fungi, and ERMS is marine focused. All of these are collated into a common taxonomic database, the Pan-European Species Directories Infrastructure, PESI (de Jong et al. 2015).

Other sections of the map stand out as possible areas of overlap. For example, there are four different elements dealing with invasive species at the global level, and sharing similar objectives. The Global Invasive Species Database (GISD) aims to share specialist knowledge on invasive species with a broad audience. The Global Register of Introduced and Invasive Species (GRIIS) provides country-level inventories of introduced and invasive species. The Global Invasive Species Information Network (GISIN) provides a platform for sharing information on invasive species. The Centre for Agriculture and Biosciences International Invasive Species Compendium (CABI ISC) collates a range of science-based information on invasive species to support decision-making. GISD, GRIIS and GISIN do not act in isolation (IUCN's Invasive Species Specialist Group is involved in managing both GISD and GRIIS), and appear to have good data-sharing processes among themselves, but it is nevertheless unclear to what extent there is overlap in their workflows and outputs, and with those of CABI ISC. Discussions with the curators and users of these initiatives would be needed to establish whether effort duplication is an issue for these elements, and whether there are potential areas in which efficiency could be improved.

Similarly, the informatics landscape is supported by several different taxonomic backbones. Many of the other elements in the landscape depend on these backbones to standardise their taxonomic information. One example is the World Register of Marine Species (WoRMS). Two further backbones, Species 2000 and the Integrated Taxonomic Information System (ITIS), together form the Catalogue of Life (CoL). The GBIF Backbone Taxonomy, referred to as the Nub taxonomy, has been assembled from 54 different sources, including WoRMS, ITIS and CoL (GBIF 2017).

The existence of multiple different taxonomic backbones has the potential to result in inconsistencies in the way taxonomic information is stored and presented across the landscape, which in turn has potential implications for the interoperability of the different elements. In one example, Species+ uses the standardised taxonomies adopted by CITES (Conf. 12.11 (Rev. CoP17)). This varies from the CoL backbone used by elements including the IUCN Red List of Threatened Species. For Species+, changes to nomenclature to reflect accepted use in biology must be adopted by the Conference of the

Parties to the Conventions (i.e. national governments), which occurs every three years. This reflects a robust process for accepting changes, but also provides an example of how inconsistencies between taxonomic datasets may arise.

For taxonomic backbone data, linkages could be strengthened, for example by improving the harmonization efforts of taxonomic datasets and backbone data. Examples exist that have already reduced redundancies, such as VertNet (described above). However, tighter linkages between backbones (e.g. from PESI to CoL) could be fostered by future projects and initiatives. A further approach to aligning different taxonomic initiatives and making their data available is UTIS, which gathers information from various taxonomic sources (PESI, CoL, WoRMS, Natura2000 and TreatmentBank).

Opportunities

Based on the network analysis, it appears that fostering interaction between more members of the community, particularly those on the periphery, would benefit the whole community, making it more resilient. More links would also benefit individual actors, making them less reliant on a few partners for their connection to the network.

Beyond additional linkages and improved interoperability, there are broader opportunities that have the potential to impact the entire biodiversity informatics landscape. One such opportunity is the rise of technologies like Google Earth, which could in the future act as a hub for multiple datasets. Sharing and synthesising biodiversity data into a unified global map has been described as a key challenge for informaticians (Guralnick and Hill 2009). With the emergence of Google Earth and similar technology, an integrated world map could eventually be a reality.

Currently, work is ongoing to create a global biodiversity observation network through GEO BON, with multiple thematic, regional, and national biodiversity observation networks (BONs) in development (Scholes et al. 2008; Proença et al. 2016). As part of this process, EU BON and its European Biodiversity Portal have the potential to act as a hub or broker for biodiversity data within the European context. As a regional observation network, EU BON could provide leadership and build relationships within an often fragmented informatics landscape. As the network develops, several of EU BON's own products are becoming integrated in the landscape, or are supporting it (see Fig. 1), providing the foundation for EU BON to respond to gaps and create collaborations where they are needed.

Next steps

The map presented here has been produced at a time when biodiversity observation networks are in development, and when biodiversity informatics initiatives are proliferating. It provides a useful resource for organisations involved in developing new initiatives, or expanding the remits of those that exist. It can be used to identify work that is already being done, in addition to probable gaps that could be filled. It may additionally help the

custodians of existing initiatives to identify potential linkages with other elements, including at the policy-level.

The inclusion of elements specific to Europe has particular relevance to the emerging EU BON, highlighting those niches that are already occupied, and also gaps where EU BON might most meaningfully contribute. Further work could include identifying specific entry points in the landscape for EU BON's products. An additional next step could be to assess the sustainability of the landscape's elements from a business planning perspective, identifying elements at risk of being lost, and the potential implications for other elements they are linked to in the landscape. Such an exercise would help to highlight elements that are critical to the long-term sustainability of EU BON.

Beyond datasets and databases, the human dimension of the biodiversity informatics landscape should not be underestimated, as it is crucial to the landscape's functioning and evolution. Communities of practice collectively hold significant knowledge and expertise (for example, on software, infrastructure, and best practice) on which the biodiversity informatics landscape depends. However, the human dimension brings with it a range of working cultures that sometimes create barriers to collaboration, and hence barriers to connections within the landscape. There is a crucial role for funding bodies, including the many national governments that have agreed to the Global Earth Observation System of Systems (GEOSS) Data Sharing Principles, to play in encouraging funding-recipients to dismantle barriers to data access, and in funding work that results in a better-functioning, and better-connected, biodiversity informatics landscape. Funding models that do not promote long-term, sustainable work and data-sharing should be overhauled.

Contributing to policy-level processes is one way in which the landscape can most meaningfully have an impact. The wealth of information available in the landscape could undoubtedly be better communicated to policy-makers and other decision-makers. Although work is ongoing to address this (Despot-Belmonte et al. 2017), it remains a key challenge that requires consideration by all institutions involved in biodiversity informatics.

Annex 1. Element expanded names

For full names of elements see Table 1.

Table 1.

Full names of elements.

Short Name	Long Name
Amphibian Species of the World	Amphibian Species of the World
AmphibiaWeb	AmphibiaWeb
AquaMaps	AquaMaps
Arctos	Arctos

ARPHA	ARPHA Writing Tool
Barcode of Life	International Barcode of Life
BHL	Biodiversity Heritage Library
BioCASE	Biological Collection Access Service
Biodiversity Literature Repository	Biodiversity Literature Repository
BIP	Biodiversity Indicators Partnership
BISE	Biodiversity Information System for Europe
CABI ISC	Centre for Agriculture and Biosciences International: Invasive Species Compendium
CITES Appendices	Convention on International Trade in Endangered Species of Wild Fauna and Flora Appendices
CITES Checklist	Convention on International Trade in Endangered Species of Wild Fauna and Flora Checklist
CITES Trade Database	Convention on International Trade in Endangered Species of Wild Fauna and Flora Trade Database
COL	Catalogue of Life
DAISIE	Delivering Alien Invasive Species Inventories for Europe
DEIMS	Dynamic Ecological Information Management System
DOPA	Digital Observatory for Protected Areas
EBSA	Ecologically or Biologically Significant Marine Areas
EMODnet Portal	European Marine Observation and Data Network Portal
EnvThes	Environmental Thesaurus
EOL	Encyclopedia Of Life
ERMS	European Register of Marine Species
EU Biodiversity Strategy	EU Biodiversity Strategy to 2020
Euro+Med PlantBase	Euro+Med PlantBase
EUNIS	European Nature Information System
EurOBIS	European node of Ocean Biogeographic Information System
European Biodiversity Portal	European Biodiversity Portal
Fauna Europaea	Fauna Europaea
FishBase	FishBase
GBIF	Global Biodiversity Information Facility
GEOSS Portal	Global Earth Observation System of Systems Portal
GFN	Global Footprint Network
GFW	Global Forest Watch
GISD	Global Invasive Species Database
GISIN	Global Invasive Species Information Network

GRIIS	Global Register of Introduced and Invasive Species
ICoMM - Microbis Portal	International Census of Marine Microbes - Microbis Portal
ILTER	International Long Term Ecological Research
iNaturalist	iNaturalist
Index Fungorum	Index Fungorum
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
ITIS	Integrated Taxonomic Information System
KBA	Key Biodiversity Areas
KNB	Knowledge Network for Biocomplexity
Lifewatch Geoportal	Lifewatch Geoportal
Living Planet Index	Living Planet Index
MOL	Map of Life
MPAtlas	MPAtlas
MycoBank	MycoBank
Natura 2000	Natura 2000 Network Viewer
OBIS	Ocean Biogeographic Information System
OBIS SEAMAP	Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations
ODV	Ocean Data Viewer
OHI	Ocean Health Index
OTN Data Portal	Ocean Tracking Network Data Portal
PESI Portal	Pan-European Species Directories Infrastructure
Plazi	Plazi
PlutoF	PlutoF
Protected Planet	Protected Planet
Red List	International Union for Conservation of Nature Red List of Threatened Species
SAU	Sea Around Us
SDGs	Sustainable Development Goals
SeaLifeBase	SeaLifeBase
Species 2000	Species 2000
Species+	Species+
SWOT	State of the World's Sea Turtles
Symbiota	Symbiota
UN Strategic Plan for Biodiversity	United Nations Strategic Plan for Biodiversity 2011-2020
UTIS	Unified Taxonomic Information Service
VertNet	VertNet

WoRMS	World Register of Marine Species
WPI	Wildlife Picture Index

Annex 2. Element metadata

Amphibian Species of the World

Short name: Amphibian Species of the World

Long name: Amphibian Species of the World

Website: http://research.amnh.org/vz/herpetology/amphibia/

Responsible Institution: American Museum of Natural History

Category: data curator, data distributor

Description: an amphibian taxonomy reference

Main users: researchers

Geographic scope and realm: global

AmphibiaWeb

Short name: AmphibiaWeb

Long name: AmphibiaWeb

Website: http://www.amphibiaweb.org/

Responsible Institution: University of California at Berkeley

Category: data curator, data distributor

Description: AmphibiaWeb provides information on amphibian declines, natural history, conservation, and taxonomy

Main users: researchers, taxonomists

Geographic scope and realm: global

AquaMaps

Short name: AquaMaps

Long name: AquaMaps

Website: http://www.aquamaps.org

Responsible Institution: FishBase; SeaLifeBase

Category: data curator, data distributor

Description: AquaMaps includes standardised distribution maps for over 22,000 species of fish, marine mammals and invertebrates. These maps are computer-generated predictions of natural occurrence of marine species, based on the environmental tolerance of a given species. The maps use colour-coding for showing the likelihood of a species to occur in a given area.

Main users: researchers, fisheries

Geographic scope and realm: global, marine

Arctos

Short name: Arctos

Long name: Arctos

Website: https://arctosdb.org/

Responsible Institution: Texas Advanced Computing Center, University of Texas at Austin

Category: data curator

Description: “a collaboration among multiple scientific collections that serves data on over 3 million natural history museum records”

Main users: collection managers, curators, collection users, researchers, educators

Geographic scope and realm: global

ARPHA

Short name: **ARPHA**

Long name: ARPHA Writing Tool

Website: http://arphahub.com

Responsible Institution: Pensoft

Category: Data and journal publishing platform

Description: ARPHA-BioDiv is a set of standards, guidelines, recommendations, tools, workflows, journals and services, based on the ARPHA Publishing Platform of Pensoft,

designed to ease scholarly publishing of biodiversity and biodiversity-related data that are of primary interest to GEO BON networks

Main users: researchers

Geographic scope and realm: global

Barcode of Life

Short name: Barcode of Life

Long name: International Barcode of Life

Website: http://www.barcodeoflife.org/

Responsible Institution: Consortium for the Barcode of Life (CBOL)

Category: data curator

Description: "The International Barcode of Life project is the largest biodiversity genomics initiative ever undertaken. Hundreds of biodiversity scientists, genomics specialists, technologists and ethicists from 25 nations are working together to construct a richly parameterized DNA barcode reference library that will be the foundation for a DNA-based identification system for all multi-cellular life"

Main users: researchers

Geographic scope and realm: global; marine and terrestrial

BHL

Short name: BHL

Long name: Biodiversity Heritage Library

Website: http://www.biodiversitylibrary.org

Responsible Institution: BHL Consortium

Category: data distributor

Description: the Biodiversity Heritage Library is a consortium of natural history and botanical libraries. The aim of this consortium is to digitise and thus make freely available the biodiversity literature held in their collections. The BHL works with the international taxonomic community and other stakeholders to ensure that biodiversity heritage is made accessible. The BHL has so far digitised millions of pages of taxonomic literature.

Main users: researchers

Geographic scope and realm: global; marine and terrestrial

BioCASE

Short name: BioCASE

Long name: Biological Collection Access Service

Website: http://www.biocase.org/

Responsible Institution: Botanic Garden and Botanical Museum Berlin-Dahlem

Category: data curator, data distributor

Description: “a transnational network of primary biodiversity repositories. It links together specimen data from natural history collections, botanical/zoological gardens and research institutions worldwide with information from huge observation databases.”

Main users: researchers

Geographic scope and realm: global

Biodiversity Literature Repository

Short name: Biodiversity Literature Repository

Long name: Biodiversity Literature Repository

Website: http://biolitrepo.org

Responsible Institution: Plazi and Pensoft

Category: Data repository

Description: A community public repository for biodiversity-related publications, images, and data associated with them based at Zenodo

Main users: researchers, collection managers, environmentalists, students

Geographic scope and realm: global

BIP

Short name: BIP

Long name: Biodiversity Indicators Partnership

Website: http://www.bipindicators.net

Responsible Institution: UNEP-WCMC

Category: policy-level element

Description: the BIP is a partnership of international organisations working on indicator development. It brings together indicators that allow biodiversity trends to be monitored in support of the Strategic Plan for Biodiversity 2011 – 2020, which includes the Aichi Biodiversity Targets. It hosts at least one indicator for 17 of the 20 Targets. More broadly, it supports Multinational Environmental Agreements (MEAs), the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), the Sustainable Development Goals (SDGs), national and regional governments, and other sectors.

Main users: civil servants, decision-makers

Geographic scope and realm: global; marine and terrestrial

BISE

Short name: BISE

Long name: Biodiversity Information System for Europe

Website: http://biodiversity.europa.eu/

Responsible Institution: European Environment Agency

Category: data curator, data distributor

Description: “a single entry point for data and information on biodiversity supporting the implementation of the EU strategy and the Aichi targets in Europe.”

Main users: researchers

Geographic scope and realm: Europe

CABI ISC

Short name: CABI ISC

Long name: Centre for Agriculture and Biosciences International Invasive Species Compendium

Website: http://sites.cabi.org/isc/

Responsible Institution: Centre for Agriculture and Biosciences International

Category: data curator, data distributor

Description: “an encyclopaedic resource that brings together a wide range of different types of science-based information to support decision-making in invasive species management worldwide.”

Main users: researchers, site managers, taxonomists

Geographic scope and realm: global

CITES Appendices

Short name: CITES Appendices

Long name: Convention on International Trade in Endangered Species of Wild Fauna and Flora Appendices

Website: https://www.cites.org/eng/app/index.php

Responsible Institution: United Nations Environment

Category: data creator, data distributor

Description: Appendices I, II and III to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) list species that are protected from overexploitation. Each appendix corresponds to a different level of protection.

Main users: governments (civil servants, decision-makers), researchers

Geographic scope and realm: global; marine and terrestrial

CITES Checklist

Short name: CITES Checklist

Long name: Convention on International Trade in Endangered Species of Wild Fauna and Flora Checklist

Website: http://checklist.cites.org/

Responsible Institution: United Nations Environment

Category: data creator, data distributor

Description: the Checklist of CITES Species allows users to search all CITES-listed species, including scientific names and synonyms. It also provides information on historical changes to the level of protection afforded to species.

Main users: governments (civil servants, decision-makers), researchers

Geographic scope and realm: global; marine and terrestrial

CITES Trade Database

Short name: CITES Trade Database

Long name: Convention on International Trade in Endangered Species of Wild Fauna and Flora Trade Database

Website: http://trade.cites.org

Responsible Institution: United Nations Environment

Category: data creator, data distributor

Description: the CITES Trade Database contains information on imports and exports of CITES-listed species. These are reported by national authorities, usually on an annual basis. Data in the database are freely available, and specific datasets can be accessed from the website using search queries.

Main users: governments (civil servants, decision-makers), researchers

Geographic scope and realm: global; marine and terrestrial

COL

Short name: COL

Long name: Catalogue of Life

Website: http://www.catalogueoflife.org

Responsible Institution: Naturalis Biodiversity Center

Category: data curator, data distributor

Description: the Catalogue of Life is the most comprehensive database of species currently available. It contains information on the names, relationships and distributions of species.

Main users: researchers, policy and decision-makers in governments and international organisations, the general public

Geographic scope and realm: global; marine and terrestrial

DAISIE

Short name: DAISIE

Long name: Delivering Alien Invasive Species Inventories for Europe

Website: http://www.europe-aliens.org/

Responsible Institution: Centre for Ecology & Hydrology, Natural Environment Research Council

Category: data creator, data curator, data distributor

Description: “a ‘one-stop-shop’ for information on biological invasions in Europe, delivered via an international team of leading experts in the field of biological invasions, latest technological developments in database design and display, and an extensive network of European collaborators and stakeholders”

Main users: researchers, site managers, taxonomists

Geographic scope and realm: Europe

DEIMS

Short name: DEIMS

Long name: Dynamic Ecological Information Management System

Website: https://data.lter-europe.net/deims/

Responsible Institution: Centre for Ecology & Hydrology, Natural Environment Research Council

Category: data curator, data distributor

Description: “a place where you can register your research site, data products/activities and datasets.”

Main users: researchers

Geographic scope and realm: global

DOPA

Short name: DOPA

Long name: Digital Observatory for Protected Areas

Website: http://dopa.jrc.ec.europa.eu

Responsible Institution: Joint Research Centre

Category: data distributor

Description: DOPA is a set of web services and interfaces which allows users to monitor multiple aspects of protected areas. It combines spatial data from the WDPA with species richness, ecoregion, land-use and population data.

Main users: park managers, park agencies, other decision-makers and researchers

Geographic scope and realm: global; marine and terrestrial

EBSA

Short name: EBSA

Long name: Ecologically or Biologically Significant Marine Areas

Website: https://www.cbd.int/ebsa/

Responsible Institution: Convention on Biological Diversity Secretariat

Category: data creator, data distributor

Description: data portal for Ecologically or Biologically Significant Marine Areas (EBSAs)

Main users: researchers, marine spatial planners, fisheries

Geographic scope and realm: global

EMODNet Portal

Short name: EMODNet Portal

Long name: European Marine Observation and Data Network Portal

Website: http://www.emodnet.eu/

Responsible Institution: EMODnet Secretariat

Category: data creator, data distributor

Description: “a network of organisations supported by the EU’s integrated maritime policy. These organisations work together to observe the sea, process the data according to international standards and make that information freely available as interoperable data layers and data products”

Main users: decision makers, researchers

Geographic scope and realm: Europe, marine

EnvThes

Short name: EnvThes

Long name: Environmental Thesaurus

Website: http://vocabs.ceh.ac.uk/evn/tbl/envthes.evn

Responsible Institution: Long Term Ecological Research (LTER) Network

Category: data curator

Description: “thesaurus for long term ecological research, monitoring, experiments”

Main users: researchers

Geographic scope and realm: global

EOL

Short name: EOL

Long name: Encyclopedia Of Life

Website: http://eol.org

Responsible Institution: EOL Secretariat

Category: data curator, data distributor

Description: the Encyclopedia Of Life aims to bring knowledge of different life-forms of animals, plants, protists and bacteria from books, journals, databases, websites and specimen collections to one place. The EOL is free and open to access for all.

Main users: general public, educators, students, researchers

Geographic scope and realm: global; marine and terrestrial

ERMS

Short name: ERMS

Long name: European Register of Marine Species

Website: http://www.marbef.org/data/erms.php

Responsible Institution: ERMS Executive Committee

Category: data curator, data distributor

Description: “an authoritative taxonomic list of species occurring in the European marine environment”

Main users: researchers, taxonomists,

Geographic scope and realm: Europe, marine

EU Biodiversity Strategy

Short name: EU Biodiversity Strategy

Long name: EU Biodiversity Strategy to 2020

Website: http://ec.europa.eu/environment/nature/biodiversity/strategy/

Responsible Institution: European Commission

Category: Policy-level element

Description: “The EU Biodiversity Strategy aims to halt the loss of biodiversity and ecosystem services in the EU and help stop global biodiversity loss by 2020. It reflects the commitments taken by the EU in 2010, within the international Convention on Biological Diversity.”

Main users: Policy-makers

Geographic scope and realm: Europe, terrestrial and marine

Euro+Med PlantBase

Short name: Euro+Med PlantBase

Long name: Euro+Med PlantBase

Website: www.emplantbase.org/

Responsible Institution: Dipartimento di Scienzeambientali e Biodiversità ed Orto botanico, Università degli Studi di Palermo

Category: data curator, data distributor

Description: “an on-line database and information system for the vascular plants of Europe and the Mediterranean region, against an up-to-date and critically evaluated consensus taxonomic core of the species concerned.”

Main users: researchers, taxonomists

Geographic scope and realm: Europe, Mediterranean

EUNIS

Short name: EUNIS

Long name: European Nature Information System

Website: https://eunis.eea.europa.eu/

Responsible Institution: European Environment Agency

Category: data curator, data distributor

Description: “brings together European data from several databases and organisations into three interlinked modules on sites, species and habitat types”

Main users: researchers

Geographic scope and realm: Europe

EurOBIS

Short name: EurOBIS

Long name: European Ocean Biogeographic Information System

Website: http://www.eurobis.eu/

Responsible Institution: Flanders Marine Institute (VLIZ)

Category: data curator, data distributor

Description: EurOBIS aims “to centralize the largely scattered biogeographic data on marine species collected by European institutions and to make these data freely available and easily accessible.”

Main users: researchers, taxonomists

Geographic scope and realm: Europe, marine

European Biodiversity Portal

Short name: European Biodiversity Portal

Long name: European Biodiversity Portal

Website: http://biodiversity.eubon.eu/

Responsible Institution: EU BON

Category: data curator, data distributor

Description: The European Biodiversity Portal was developed by the European Biodiversity Observation Network (EU BON, eubon.eu). It is an online platform, which facilitates the delivery of relevant biodiversity information and analysis to a range of end users (including researchers, policy-level users and other biodiversity stakeholders), thus supporting the biodiversity science and policy interface.

Main users: researchers, decision-makers, policy level users, the public

Geographic scope and realm: Europe, marine and terrestrial

Fauna Europaea

Short name: Fauna Europaea

Long name: Fauna Europaea

Website: http://www.fauna-eu.org/

Responsible Institution: Museum für Naturkunde, Berlin

Category: data curator, data distributor

Description: “Europe's main zoological taxonomic index. Scientific names and distributions of all living, currently known, multicellular, European land and freshwater animal species are available in one authoritative database.”

Main users: researchers, taxonomists

Geographic scope and realm: Europe

FishBase

Short name: FishBase

Long name: FishBase

Website: http://www.fishbase.org

Responsible Institution: FishBase Consortium

Category: data distributor

Description: FishBase provides online access to a variety of information and fish species data. This includes taxonomy, distribution, morphology, behaviour, habitats, ecology, biometrics, population dynamics, as well as data on reproduction, metabolism and genetics.

Main users: researchers, fisheries, zoologists

Geographic scope and realm: global, fish species

GBIF

Short name: GBIF

Long name: Global Biodiversity Information Facility

Website: http://www.gbif.org

Responsible Institution: GBIF Secretariat

Category: data curator, data distributor

Description: global biodiversity database that provides access to point data on species occurrences. GBIF brings together over 15,500 datasets from over 1,000 publishing institutions. Fifty-four countries currently contribute to GBIF, alongside forty-three other participants and affiliates. The data stored by the facility are largely on species' distributions and changes over time.

Main users: researchers

Geographic scope and realm: global; marine and terrestrial

GEOSS Portal

Short name: GEOSS Portal

Long name: Group of Earth Observations Portal

Website: http://www.geoportal.org/

Responsible Institution: Group on Earth Observations

Category: data curator, data distributor

Description: "a Global Earth Observation System of Systems (GEOSS) that will link Earth observation resources world-wide across multiple Societal Benefit Areas - Biodiversity and Ecosystem Sustainability, Disaster Resilience, Energy and Mineral Resources Management, Food Security and Sustainable Agriculture, Infrastructure & Transportation Management, Public Health Surveillance, Sustainable Urban Development, Water Resources Management - and make those resources available for better informed decision-making."

Main users: researchers

Geographic scope and realm: global

GFN

Short name: GFN

Long name: Global Footprint Network

Website: http://www.footprintnetwork.org/en/index.php/GFN

Responsible Institution: Global Footprint Network

Category: data curator, data distributor, data creator

Description: The Ecological Footprint is the Global Footprint Network's main tool, which is a data-driven metric demonstrating how close the world is to living sustainably.

Main users: decision-makers, the public

Geographic scope and realm: global

GFW

Short name: GFW

Long name: Global Forest Watch

Website: http://www.globalforestwatch.org

Responsible Institution: World Resources Institute

Category: data creator, data distributor, data curator

Description: GFW is a mapping application that uses satellite imagery, crowdsourcing, and external datasets to provide near-real-time information on forest loss.

Main users: governments, the private sector, NGOs, journalists, universities, and the general public

Geographic scope and realm: global; terrestrial

GISD

Short name: GISD

Long name: Global Invasive Species Database

Website: http://www.iucngisd.org/gisd/

Responsible Institution: IUCN

Category: data curator, data distributor

Description: “a free, online searchable source of information about alien and invasive species that negatively impact biodiversity.”

Main users: researchers, taxonomists, site managers

Geographic scope and realm: global

GISIN

Short name: GISIN

Long name: Global Invasive Species Information Network

Website: http://www.gisin.org/

Responsible Institution: Natural Resource Ecology Laboratory, Colorado State University

Category: data curator, data distributor

Description: “a platform for sharing invasive species information at a global level”

Main users: researchers, taxonomists, site managers

Geographic scope and realm: global

GRIIS

Short name: GRIIS

Long name: Global Register of Introduced and Invasive Species

Website: http://www.griis.org/

Responsible Institution: Institute for Environmental Protection and Research

Category: data curator, data distributor

Description: “the Global Register of Introduced and Invasive Species (GRIIS) presents validated and verified inventories of introduced and invasive species at the country level”

Main users: researchers, taxonomists, site managers

Geographic scope and realm: global

ICoMM - Microbis Portal

Short name: ICoMM - Microbis Portal

Long name: International Census of Marine Microbes - Microbes Portal

Website: https://vamps.mbl.edu/portals/icomm/icomm.php/microbis

Responsible Institution: Josephine Bay Paul Center

Category: data creator, data distributor

Description: the ICoMM Microbis Portal is a database which serves legacy (including geospatial and environmental data), lipidomic and pyrosequencing data, as well as associated contextual data. The Microbis Portal links to lipid structures and a mass spectrometry library containing lipid data derived from microbes from both modern and ancient environments.

Main users: researchers

Geographic scope and realm: global

ILTER

Short name: ILTER

Long name: International Long Term Ecological Research

Website: https://www.ilternet.edu/

Responsible Institution: ILTER Coordinating Committee

Category: data curator

Description: “the International Long-Term Ecological Research (ILTER) consists of networks of scientists engaged in long-term, site-based ecological and socio-ecological research.”

Main users: researchers

Geographic scope and realm: global

iNaturalist

Short name: iNaturalist

Long name: iNaturalist

Website: http://www.inaturalist.org

Responsible Institution: California Academy of Sciences

Category: data creator, data distributor

Description: iNaturalist allows users to identify species they observe and record their locations. Users can develop their own projects using the platform, and collaborate with other users to gather specific types of data. Data can be exported from the website, and research-grade observations are available to scientists through GBIF. iNaturalist presents citizen science observations online alongside datasets from other biodiversity informatics projects including Catalogue of Life, uBio and the IUCN Red List of Threatened Species.

Main users: public, researchers

Geographic scope and realm: global, terrestrial and marine

Index Fungorum

Short name: Index Fungorum

Long name: Index Fungorum

Website: http://www.indexfungorum.org/

Responsible Institution: Royal Botanic Gardens, Kew

Category: data curator

Description: "the Index Fungorum, the global fungal nomenclator coordinated and supported by the Index Fungorum Partnership, contains names of fungi (including yeasts, lichens, chromistan fungal analogues, protozoan fungal analogues and fossil forms) at all ranks."

Main users: researchers, taxonomists

Geographic scope and realm: global

IPBES

Short name: IPBES

Long name: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

Website: http://www.ipbes.net/

Responsible Institution: IPBES Secretariat

Category: policy-level element

Description: "the intergovernmental body which assesses the state of biodiversity and of the ecosystem services it provides to society, in response to requests from decision makers."

Main users: Policy-makers

Geographic scope and realm: Global; marine and terrestrial

ITIS

Short name: ITIS

Long name: Integrated Taxonomic Information System

Website: http://www.itis.gov

Responsible Institution: Interagency Taxonomy Steering Committee, USA

Category: data distributor

Description: ITIS provides easily accessible database of taxonomic data and a directory of taxonomic expertise. The database is reviewed periodically to ensure high quality with accurate classifications, revisions and additions of newly described species. As ITIS develops, it aims to include the authority (author and date), taxonomic rank, associated synonyms and vernacular names where available, a unique taxonomic serial number, data source information and data quality indicators. Changes to taxonomic information in the database and expert reviews will be tracked.

Main users: researchers

Geographic scope and realm: global (initial emphasis on North America), terrestrial and marine

KBAs

Short name: KBAs

Long name: Key Biodiversity Areas

Website: www.keybiodiversityareas.org/

Responsible Institution: BirdLife International and Conservation International

Category: data distributor, data curator

Description: Key Biodiversity Areas are places of global significance for biodiversity conservation, identified based on their importance for maintaining species populations.

Main users: Governments, intergovernmental organizations, NGOs, the private sector, and other stakeholders

Geographic scope and realm: global; marine and terrestrial

KNB

Short name: KNB

Long name: The Knowledge Network for Biocomplexity

Website: https://knb.ecoinformatics.org/

Responsible Institution: University of South Carolina Beaufort

Category: data curator, data distributor

Description: “an efficient way to share, discover, access and interpret complex ecological data. Due to rich contextual information provided with KNB data, scientists are able to integrate and analyse data with less effort.”

Main users: researchers

Geographic scope and realm: global

LifeWatch Geoportal

Short name: LifeWatch Geoportal

Long name: LifeWatch Geoportal

Website: http://maps.elie.ucl.ac.be/lifewatch/geoviewer.html

Responsible Institution: Earth and Life Institute

Category: data curator, data distributor

Description: “LifeWatch offers a place where researchers can share expertise and information; it is also a structure providing access to numerous databases as well as tools for analysis and modeling.”

Main users: Researchers; environmental managers

Geographic scope and realm: Europe; marine and terrestrial

Living Planet Index

Short name: Living Planet Index

Long name: Living Planet Index

Website: http://www.livingplanetindex.org

Responsible Institution: Zoological Society of London and World Wide Fund for Nature

Category: data creator, data distributor

Description: the Living Planet Index is a measure of global biodiversity. The index is focused on vertebrates, and is based on population trends.

Main users: policy-makers, researchers

Geographic scope and realm: global; marine and terrestrial

MOL

Short name: MOL

Long name: Map of Life

Website: https://mol.org/

Responsible Institution: Map of Life Steering Committee

Category: data curator, data distributor

Description: “built on a scalable web platform geared for large biodiversity and environmental data, Map of Life endeavors to provide ‘best-possible’ species range information and species lists for any geographic area.”

Main users: researchers

Geographic scope and realm: global

MPAtlas

Short name: MPAtlas

Long name: MPAtlas

Website: http://www.mpatlas.org/

Responsible Institution: Marine Conservation Institute

Category: data curator, data distributor

Description: “a tool to provide real-time information on current and proposed MPAs and their effectiveness in protecting marine life”

Main users: researchers

Geographic scope and realm: global

MycoBank

Short name: MycoBank

Long name: MycoBank

Website: http://www.mycobank.org/

Responsible Institution: Westerdijk Fungal Biodiversity Institute

Category: data curator

Description: "an on-line database aimed as a service to the mycological and scientific society by documenting mycological nomenclatural novelties (new names and combinations) and associated data, for example descriptions and illustrations."

Main users: researchers

Geographic scope and realm: global

Natura 2000

Short name: Natura 2000

Long name: Natura 2000 Network Viewer

Website: http://natura2000.eea.europa.eu/

Responsible Institution: European Environment Agency

Category: data distributor

Description: data portal for Natura 2000 sites. “Natura 2000 is an ecological network of protected areas, set up to ensure the survival of Europe's most valuable species and habitats. Natura 2000 is based on the 1992 Habitats Directive, but also incorporates sites designated under the 1979 Birds Directive.”

Main users: researchers

Geographic scope and realm: Europe

OBIS

Short name: OBIS

Long name: Ocean Biogeographic Information System

Website: http://www.iobis.org

Responsible Institution: IOC-UNESCO International Oceanographic Data and Information Exchange (IODE) programme

Category: data curator, data distributor

Description: OBIS provides access to information on the distribution of marine species. It is a part of UNESCO's Intergovernmental Oceanographic Commission. The aim of OBIS is to create a comprehensive picture of marine life from existing smaller datasets.

Main users: researchers, fishery scientists and managers, policy makers, educators, amateur naturalists, environmental NGOs, consultants, nature conservation organisations, and students.

Geographic scope and realm: global; marine

OBIS SEAMAP

Short name: OBIS SEAMAP

Long name: Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations

Website: http://seamap.env.duke.edu

Responsible Institution: Nicholas School of the Environment, Duke University

Category: data distributor, data curator

Description: OBIS-SEAMAP is an interactive online database for megavertebrates (marine mammals, seabirds and sea turtles) and sharks . The database includes both spatial and temporal data. The data is collected from ship and aerial surveys, satellite telemetry and acoustic monitoring, as well as PhotoID around the world.

Main users: researchers

Geographic scope and realm: global, marine

ODV

Short name: ODV

Long name: Ocean Data Viewer

Website: http://data.unep-wcmc.org/

Responsible Institution: UNEP-WCMC

Category: data curator, data distributor

Description: “the Ocean Data Viewer offers users the opportunity to view and download a range of spatial datasets that are useful for informing decisions regarding the conservation of marine and coastal biodiversity.”

Main users: researchers

Geographic scope and realm: global, marine

OHI

Short name: OHI

Long name: Ocean Health Index

Website: http://www.oceanhealthindex.org ; http://ohi-science.org

Responsible Institution: Ocean Health Index

Category: data creator, data distributor

Description: the OHI is the first comprehensive global measurement of ocean health that includes people and human impact as part of the ocean ecosystem. The Index takes advantage of data and information across disciplines, thus providing a broad picture of the health of oceans. More specifically, the Index evaluates how well the ocean provides 10 key benefits to people – and how well it is protected to do so in the future.

Main users: decision- and policy-makers, researchers

Geographic scope and realm: global, marine

OTN Data Portal

Short name: OTN Data Portal

Long name: Ocean Tracking Network Data Portal

Website: http://members.oceantrack.org/

Responsible Institution: Dalhousie University

Category: data curator, data distributor

Description: “the OTN Data Centre is responsible for the collection, aggregation, cross-referencing, and dissemination (both public and private) of acoustic detection data.”

Main users: researchers

Geographic scope and realm: global

PESI Portal

Short name: PESI Portal

Long name: Pan-European Species directories Infrastructure Portal

Website: http://www.eu-nomen.eu/portal/

Responsible Institution: Flanders Marine Institute (VLIZ)

Category: data curator, data distributor

Description: “EU-nomen enables the correct use of species names and their classification, to more accurately manage information on animals and plants. This is the first all-taxa inventory for European species.”

Main users: taxonomists, researchers

Geographic scope and realm: global

Plazi

Short name: Plazi

Long name: Plazi

Website: http://plazi.org/

Responsible Institution: Plazi

Category: data curator, data distributor

Description: A service to mine text and data from scientific literature for information on species, including taxonomic treatments, images, observation records and traits. Plazi makes this information discoverable and citable using digital object identifiers. TreatmentBank (http://treatmentbank.org) is the repository for treatments and data therein; the Biodiversity Literature Repository (http://biolitrepo.org) for extracted scientific illustrations. Both are accessible to humans and APIs.

Main users: taxonomists, researchers

Geographic scope and realm: global

PlutoF

Short name: PlutoF

Long name: PlutoF

Website: https://plutof.ut.ee/

Responsible Institution: Universias Tartuensis; NATARC; Research Group for Biological Informatics

Category: data curator, data distributor

Description: “PlutoF platform has been designed for storing and managing biodiversity data over the web. PlutoF provides database and computing services for the taxonomical, ecological, phylogenetical, etc. research. The purpose of the platform is to provide synergy through common modules for the classifications, taxon names, analytical tools, etc.”

Main users: researchers

Geographic scope and realm: global

Protected Planet

Short name: Protected Planet

Long name: Protected Planet

Website: http://www.protectedplanet.net

Responsible Institution: IUCN and UNEP-WCMC

Category: data curator, data distributor

Description: Protected Planet is the online interface for the World Database on Protected Areas (WDPA). It is a product of UNEP and IUCN, managed at UNEP-WCMC. The WDPA is mandated by the Convention on Biological Diversity, and draws together national datasets on protected areas. The majority of the data are sourced from national governments, and these are supplemented by data from NGOs and other protected area managers.

Main users: researchers, NGOs, businesses, policy and decision-makers in governments and international organisations

Geographic scope and realm: global; marine and terrestrial

Red List

Short name: Red List

Long name: International Union for Conservation of Nature Red List of Threatened Species

Website: http://www.iucnredlist.org

Responsible Institution: IUCN

Category: data creator, data distributor, data curator

Description: the IUCN Red List of Threatened Species provides taxonomic, conservation status, and distribution information on species that have been assessed according to the IUCN Red List Categories and Criteria.

Main users: researchers, policy-makers, the public

Geographic scope and realm: global; marine and terrestrial

SAU

Short name: SAU

Long name: Sea Around Us

Website: http://www.seaaroundus.org

Responsible Institution: The University of British Columbia

Category: data curator, data distributor, data creator

Description: Sea Around Us is a research initiative based at the University of British Columbia. The initiative assesses the impact of fisheries on marine ecosystems around the world. It also offers mitigating solutions to the stakeholders involved in fisheries. The data is presented at spatial scales relevant to policy-making, and where possible, this data is visualised. All data is available freely and downloadable.

Main users: researchers, fisheries

Geographic scope and realm: global, fisheries

SDGs

Short name: SDGs

Long name: Sustainable Development Goals

Website: http://www.un.org/sustainabledevelopment/sustainable-development-goals/

Responsible Institution: United Nations

Category: policy-level element

Description: “the SDGs build on the success of the Millennium Development Goals (MDGs) and aim to go further to end all forms of poverty. The new Goals are unique in that they call

for action by all countries, poor, rich and middle-income to promote prosperity while protecting the planet."

Main users: researchers, NGOs, businesses, policy and decision-makers in governments and international organisations

Geographic scope and realm: global

SeaLifeBase

Short name: SeaLifeBase

Long name: SeaLifeBase

Website: http://www.sealifebase.org

Responsible Institution: a joint project of *Sea Around Us* (University of British Columbia, Vancouver, Canada) and The FishBase Information and Research Group, Inc (FIN, Los Baños, Philippines), and is endorsed and monitored by the FishBase Consortium

Category: data curator, data distributor

Description: "the long-term goal of this project is to create and maintain a FishBase-like information system for all non-fish marine organisms, ca. 400,000 spp. Of these, marine organisms (about 240,000 spp) are the target of the current project phase."

Main users: researchers, fisheries

Geographic scope and realm: global; marine

Species 2000

Short name: Species 2000

Long name: Species 2000

Website: http://sp2000.org

Responsible Institution: Species 2000 Secretariat, hosted at Naturalis Biodiversity Center

Category: data creator

Description: Species 2000 is an autonomous federation of taxonomic database custodians.

Main users: taxonomists

Geographic scope and realm: global; marine and terrestrial

Species+

Short name: Species+

Long name: Species+

Website: http://www.speciesplus.net

Responsible Institution: UNEP-WCMC

Category: data curator, data distributor Type: non-governmental organisation product

Description: Species+ assists parties to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and parties to the Convention on the Conservation of Migratory Species of Wild Animals (CMS), in implementing the conventions, along with other Multilateral Environmental Agreements (MEAs). Species+ provides users with information on species' distributions, alternate names, and legal protection under CITES and/or CMS.

Main users: civil servants

Geographic scope and realm: global; marine and terrestrial

SWOT

Short name: SWOT

Long name: The State of the World's Sea Turtles

Website: http://seamap.env.duke.edu/swot

Responsible Institution: OBIS-SEAMAP team at the Marine Geospatial Ecology Lab, Duke University.

Category: data curator, data distributor

Description: "this online database and mapping application is built with sea turtle nesting and telemetry data contributed to SWOT since 2004 and also incorporates earlier efforts that produced the WIDECAST nesting database. Since 2012, the data collection and database management are conducted by the OBIS-SEAMAP team at the Marine Geospatial Ecology Lab, Duke University."

Main users: researchers

Geographic scope and realm: global

Symbiota

Short name: Symbiota

Long name: Symbiota

Website: http://symbiota.org/

Responsible Institution: Arizona State University, Northern Arizona University, University of Illinois Urbana-Champaign, University of Wisconsin, Harvard University

Category: data curator, data distributor

Description: “the Symbiota Software Project is working toward building a library of webtools to aid biologists in establishing specimen-based virtual floras and faunas.”

Main users: researchers, taxonomists

Geographic scope and realm: global

UN Strategic Plan for Biodiversity

Short name: UN Strategic Plan for Biodiversity

Long name: United Nations Strategic Plan for Biodiversity 2011 - 2020

Website: https://www.cbd.int/sp/

Responsible Institution: Convention on Biological Diversity Secretariat

Category: policy-level element

Description: “this plan provides an overarching framework on biodiversity, not only for the biodiversity-related conventions, but for the entire United Nations system and all other partners engaged in biodiversity management and policy development.”

Main users: researchers, NGOs, businesses, policy and decision-makers in governments and international organisations

Geographic scope and realm: global

UTIS

Short name: UTIS

Long name: Unified Taxonomic Information Service

Website: http://cybertaxonomy.eu/eu-bon/utis/1.0/

Responsible Institution: Botanic Garden and Botanical Museum Berlin-Dahlem

Category: data curator, data distributor

Description: “the Unified Taxonomic Information Service (UTIS) is the taxonomic backbone for the EU BON project”

Main users: taxonomists, researchers

Geographic scope and realm: Europe

VertNet

Short name: VertNet

Long name: VertNet

Website: http://vertnet.org/

Responsible Institution: National Science Foundation, USA

Category: data curator, data distributor

Description: “a tool designed to help people discover, capture, and publish biodiversity data.”

Main users: researchers

Geographic scope and realm: global

WoRMS

Short name: WoRMS

Long name: World Register of Marine Species

Website: http://www.marinespecies.org

Responsible Institution: Flanders Marine Institute (VLIZ)

Category: data curator

Description: WoRMS provides an authoritative and comprehensive list of names of marine organisms, including information on synonymy.

Main users: researchers

Geographic scope and realm: global

WPI

Short name: WPI

Long name: Wildlife Picture Index

Website: http://wpi.teamnetwork.org/wpi/dashboard

Responsible Institution: hp, Conservation International, team network

Category: data creator, data distributor

Description: the Wildlife Picture Index was developed by the Wildlife Conservation Society and the Zoological Society of London as an indicator derived from primary camera trap data. The WPI monitors ground-dwelling tropical medium and large mammals and birds – species that are important economically, aesthetically and ecologically. The Index can be aggregated upwards from the local site to global level, and also disaggregated to capture trends at regional levels, functional groups of interest and national levels, pending adequate national data.

Main users: policy-makers, researchers

Geographic scope and realm: global, terrestrial

Acknowledgements

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Supplementary materials

Suppl. material 1: Biodiversity Informatics Landscape Matrix

Authors: Michel Doudin
Data type: Elements and links
Brief description: The matrix on which Figures 1 - 3 are based. Lists biodiversity informatics elements and their links.
Filename: Biodiversity_informatics_landscape_matrix.xlsx - Download file (13.21 kb)

Suppl. material 2: MATLAB code

Authors: Paul Kassebaum; Michel Doudin
Data type: Code
Brief description: Code used to generate Figures 1 - 3. Based on a script by Paul Kassebaum (https://uk.mathworks.com/matlabcentral/profile/authors/3559574-paul-kassebaum)
Filename: Matlab code.zip - Download file (11.26 kb)

Suppl. material 3: Figures 1 -3: high resolution

Authors: Michel Doudin
Data type: Images
Brief description: High resolution versions of Figures 1 - 3.
Filename: Figures_1-3_high_res.zip - Download file (2.22 MB)