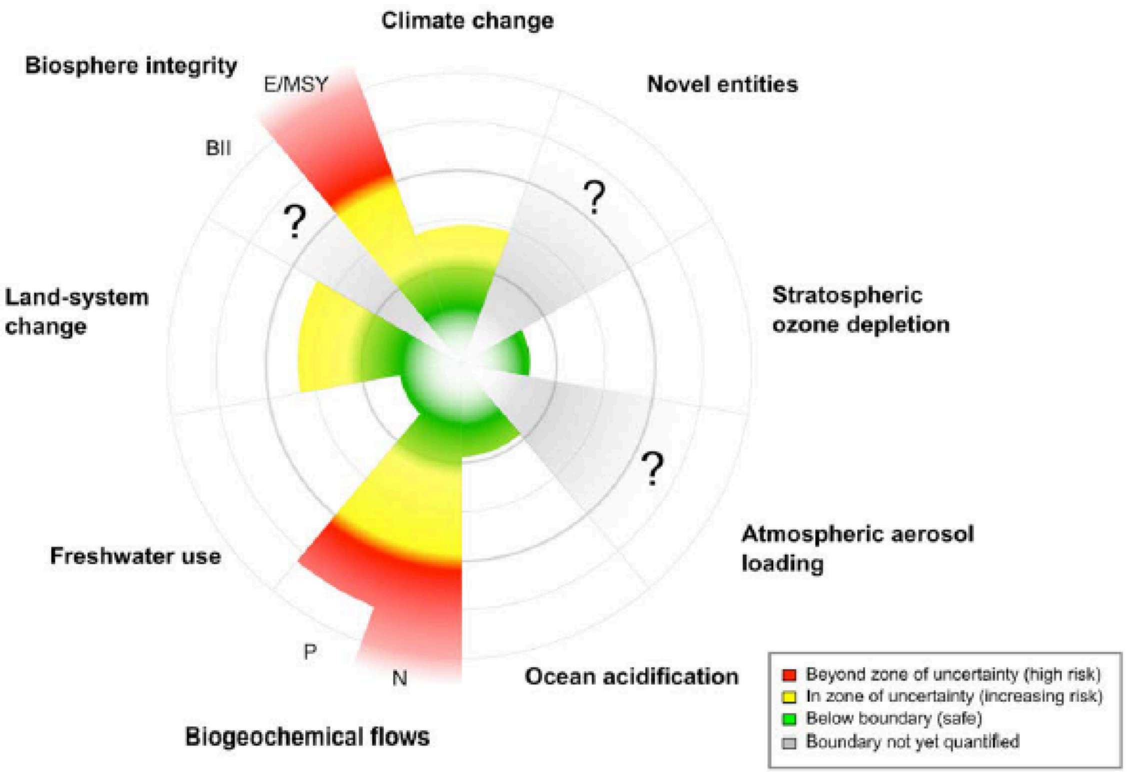
SENCKENBERG

Using Biodiversity Specimen-Based Data to Study Global Change
Missouri Botanical Garden, St. Louis,
2-3 December, 2015



Steffen et al. 2015, Science

SENCKENBERG
world of biodiversity

SENCKENBERG‘S

RESEARCH AND DIGITIZATION STRATEGY

VOLKER MOSBRUGGER, FRANKFURT

Member of the Leibniz Association

Senckenberg Gesellschaft für Naturforschung

- Private society, established 1817

- Mission: Analyzing Biodiversity in Earth System Dynamics – to Serve Science and Society

- Federal Structure: 7 Institutes + 4 Research Stations, BUT: one single work program

- 3 Museums (Dresden, Frankfurt, Görlitz), 4-600.000 visitors

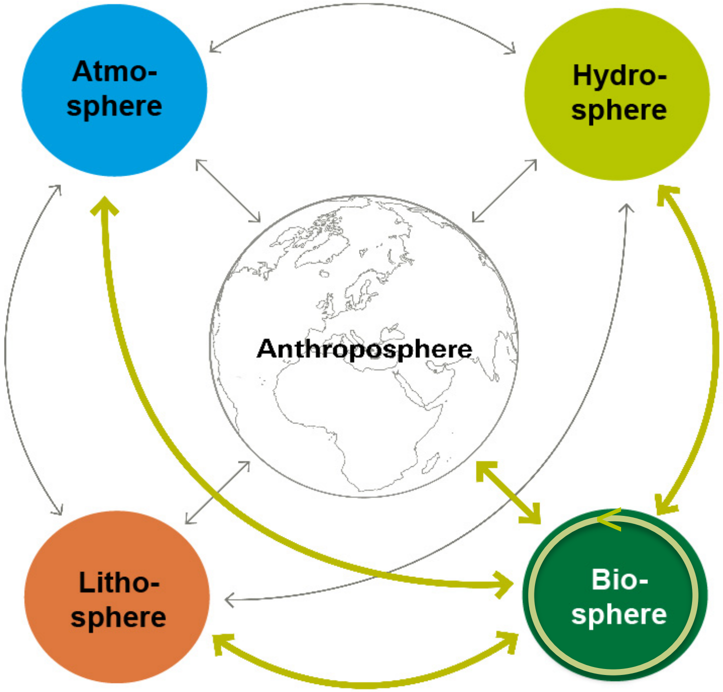
- Collections: 39 million series

- 800 staff, > 500 guest scientists/a, budget: 50 M€/a

Senckenberg Mission:

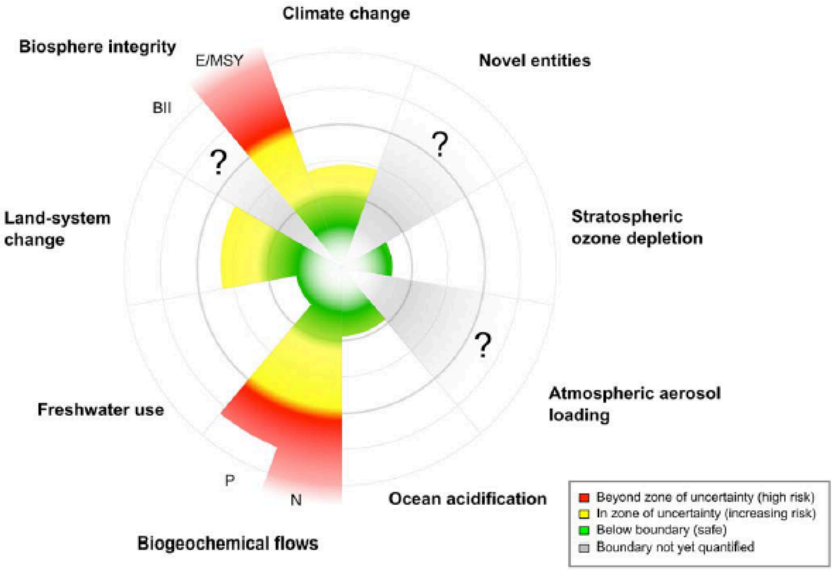
Geobiodiversity: Analyzing Biodiversity in Earth System Dynamics – to Serve Science & Society

- Systemic view + interactions
- Past – Present – Future
- Integration of geo- & biosciences
- „Geobiodiversity Models"
- Integration of societal knowledge demands into research, application and communication

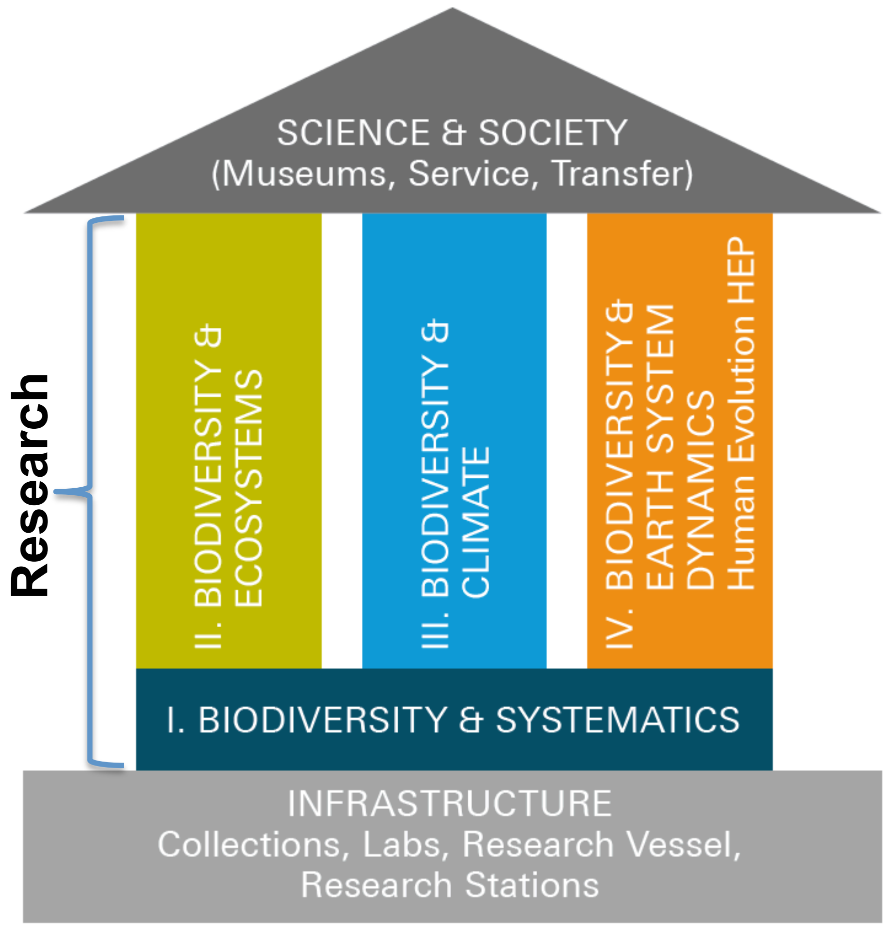


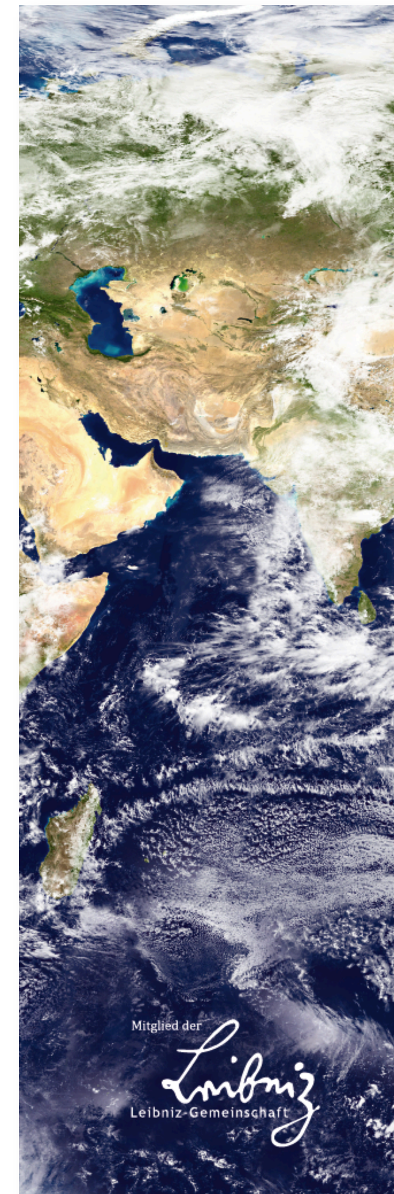
The Anthropocene Challenge:

We are leaving the „safe operating space for humanity"



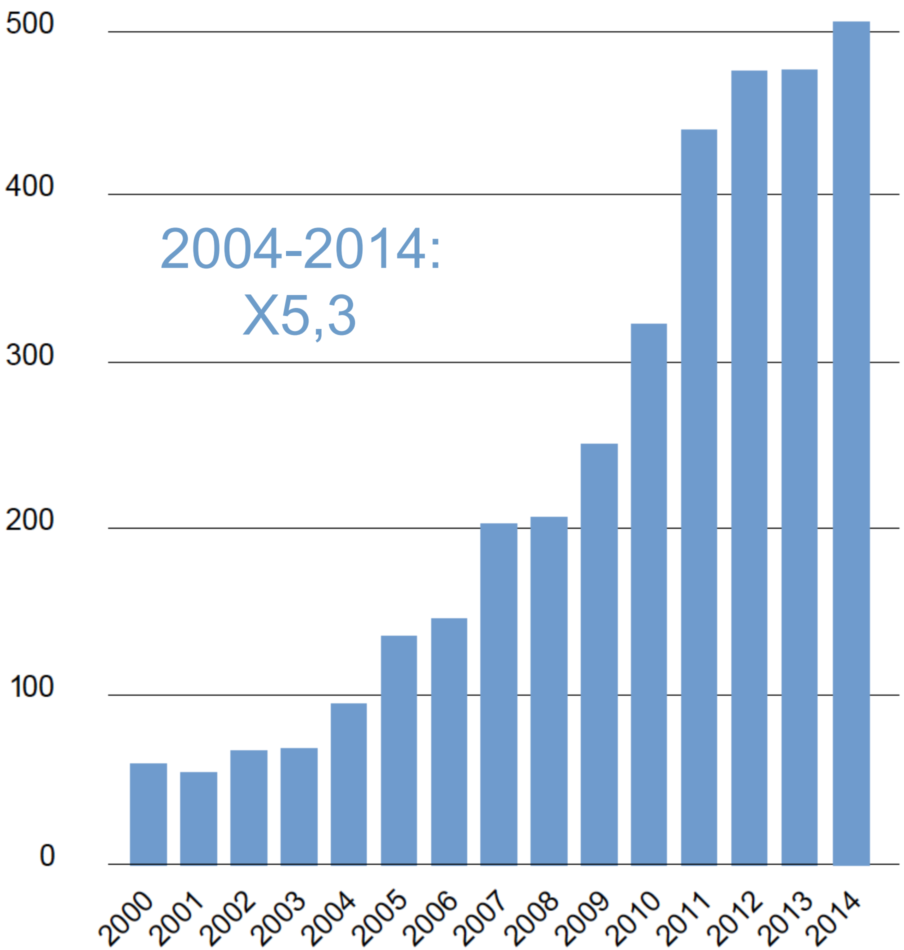
Analyzing Biodiversity in Earth System Dynamics
- to Serve Science and Society -





One institution, 7 institutes, one work program

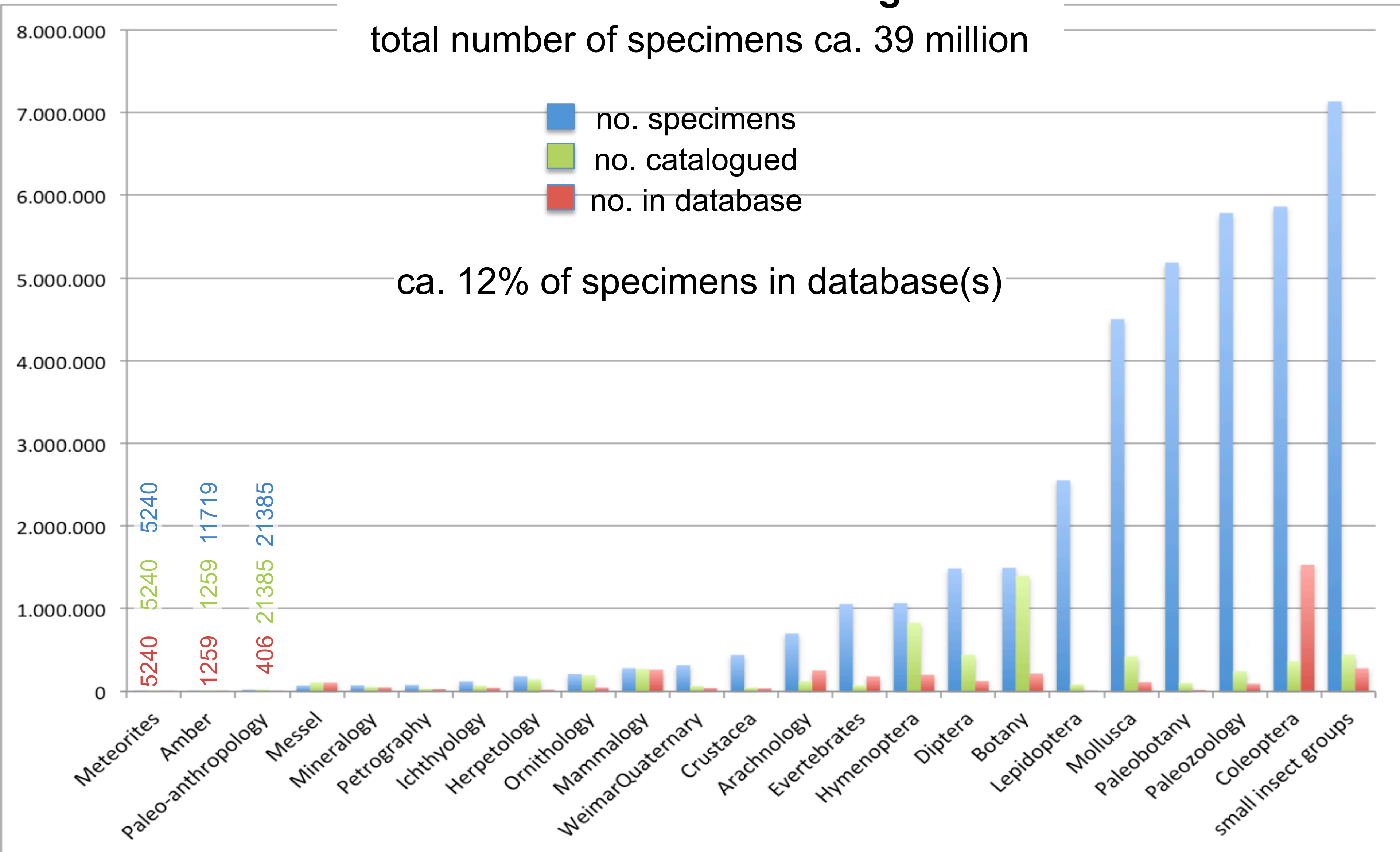
Senckenberg Research
ISI-Publications 2014



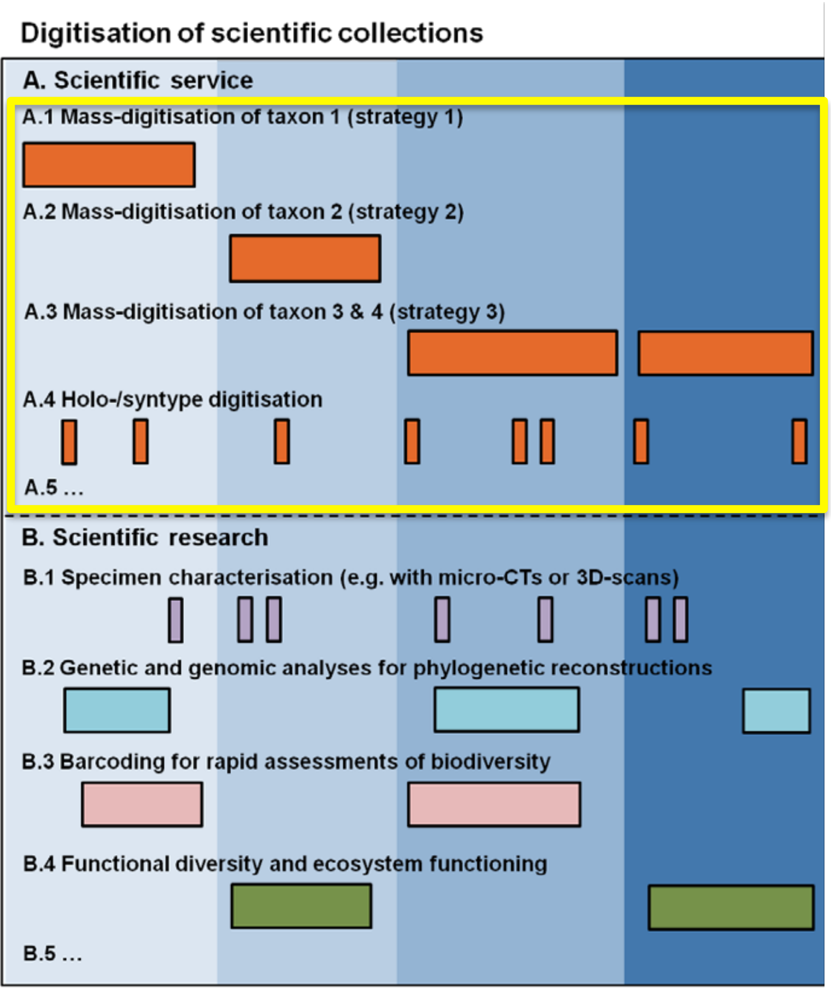
Staff (2004-2014): x3

Current state of collection digitization

total number of specimens ca. 39 million



Digitization of Collections



K. Böhning-Gaese, M. Schleuning, U. Fritz, M. Nuss, K.-D. Klass, T. Hickler, G. Zizka (Frankfurt and Dresden; 22.01.2015)

Digitization of Senckenberg collections is organized according to a modular concept:

- **scientific service module**
  - recording basal information, mainly metadata, for some collections also high-resolution images through mass-digitization procedures (e.g. botany collections); internally funded
- **scientific research module**
  - recording collection specimens or amend already present information with diverse types of data incl. object-digitization, measurements, DNA sequences, distribution data, etc. in the context of research projects; mainly externally funded

Digitization of Collections

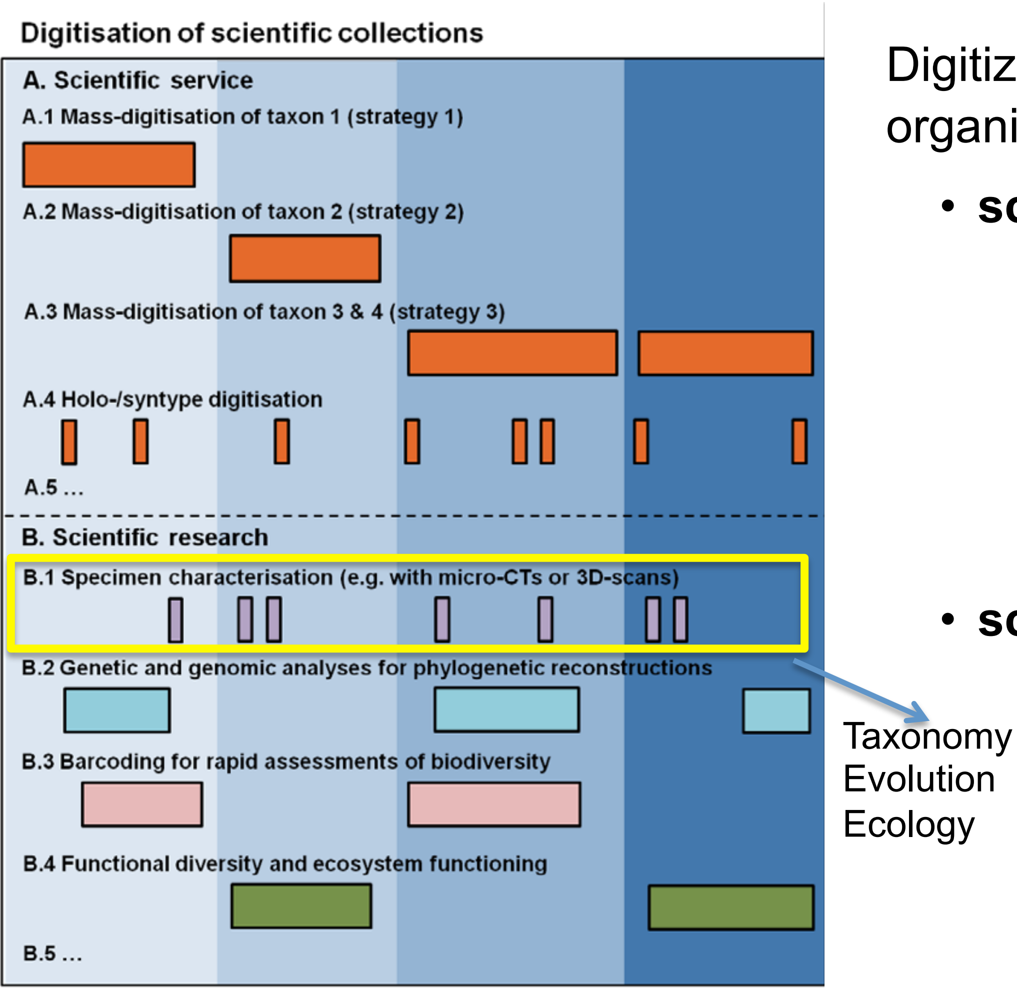
- Scientific Service Module -

Beginning January 2016 three internally funded projects will newly digitize more than 1.1 million specimens within two years

KataQuick	digitization of collection catalogues **of Arachnida, Myriapoda, Herpetology and Ornithology** (-> *service module*)
CARAB	digitization of **Carabid** (Coleoptera) collections incl. high-resolution 3D-photography of type specimens and reorganization of collections (-> *mainly service module*)
IntKonDiArt	digitization of selected **Lepidoptera** and **Heteroptera** collections incl. historical and current distribution records, supported by citizen scientists (-> *service and research module*)

Transition to a newly developed collection database (AQUiLA) early in 2016 will allow for easier access through the web and for more flexible data management.

Digitization of Collections



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Biodiversity of soil organisms
- Mites -

Hans-Jürgen Schulz
Axel Christian
Eberhard Wurst

Oben links: Lasioseius mirabilis- neue Raubmilbenart aus den Halden der Lausitz

Oben rechts: Lasioseius cochlearus – bisher unbekannte Milbe aus Moospolstern von Bäumen Ecuadors

Mitte rechts: Stenognathellus cassagnaui – ausser in den vereinigten Emiraten auch aus Griechenland und im Jemen nachgewiesen.

Unten links: Bourletiella coeruleovernalis – Kugelspringerart bisher nur aus Frankreich bekannt

Unten rechts: Lasioseius patellae – in den Bergen Ecuadors in 2600müNN zwischen Gras und trockenen Blättern entdeckt

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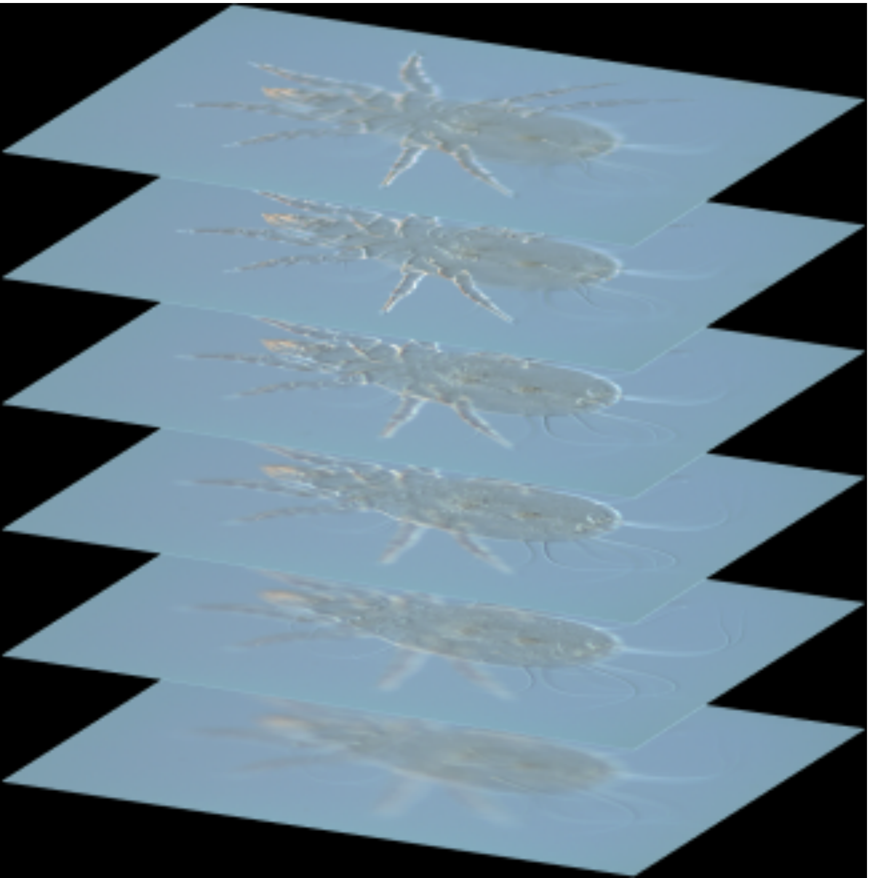
DEVELOPMENT OF STANDARDS FOR THE PHOTOGRAPHIC DOCUMENTATION OF PERMANENT MICROSCOPE SLIDE MOUNTS IN PRECARIOUS MOUNTING MEDIA



We aim to develop a “virtual internet microscope” + „Virtual Microscope Slide Collection“

The internet as research infrastructure

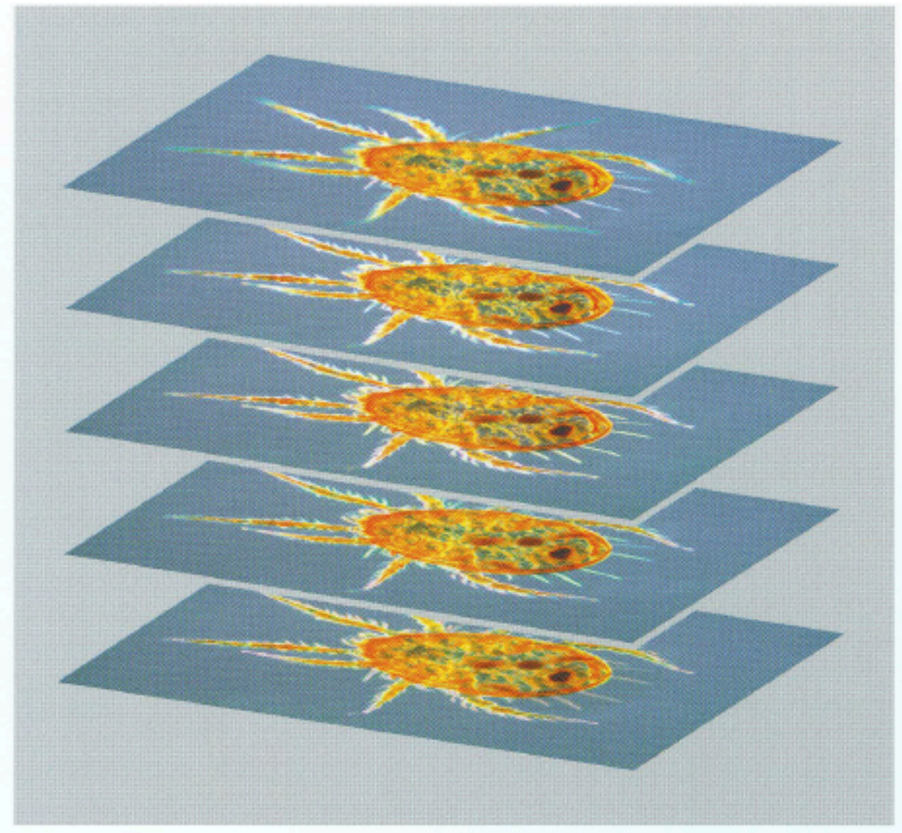
New insights through comparison

Rapid finding of digitized materials on the internet

The contribution of the Senckenberg Museum of Natural History Görlitz: small soil animals (mites, springtails, nematodes, etc.)

Virmisco - The Virtual Microscope Slide Collection

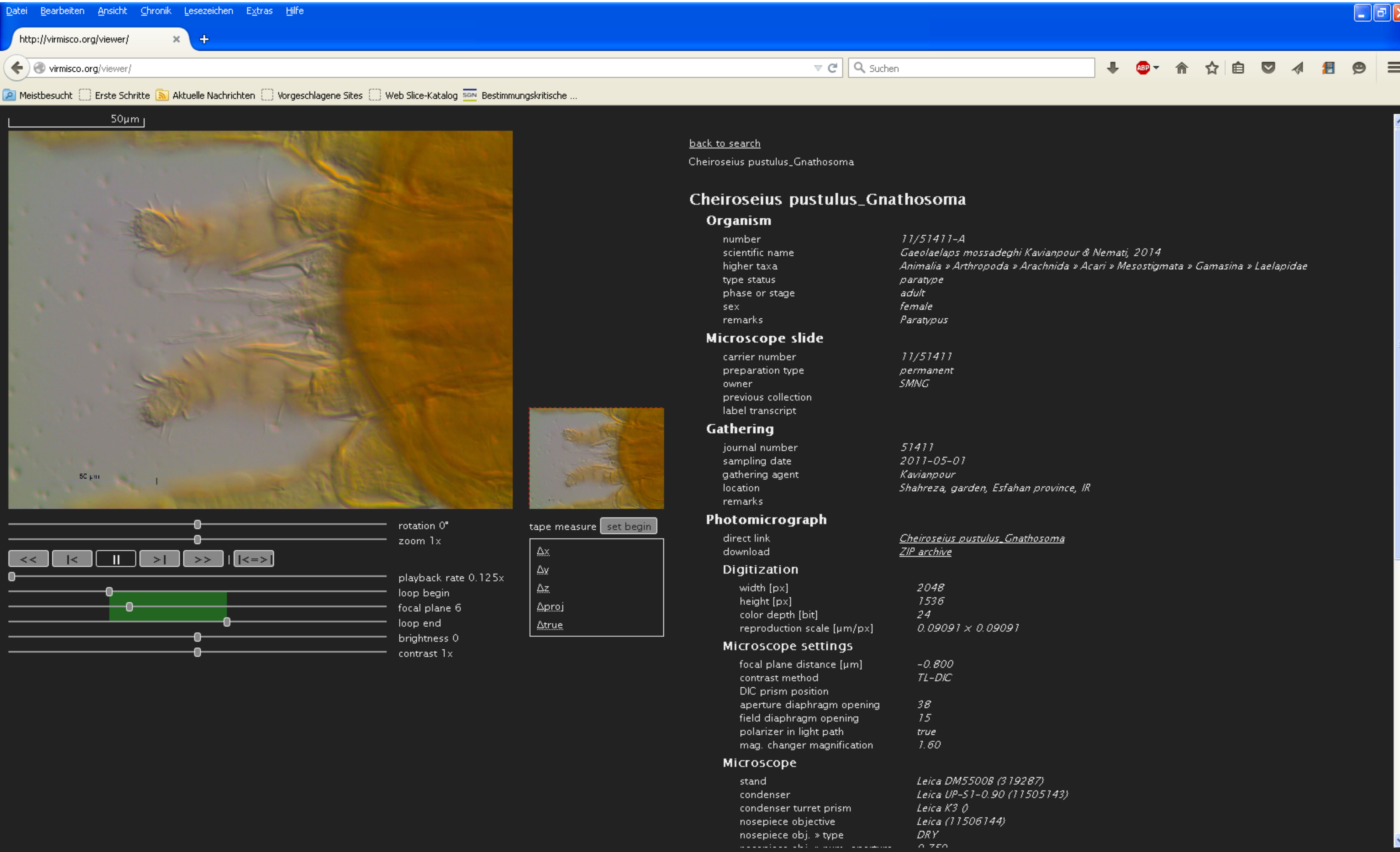
Part from the optional sectioning series of a mite



Scientists are trying more and more to document holotypes using photographs. However, these figures need to be as reliable as a view of the originally selected holotype specimen animal.

Therefore, at the Senckenberg Museum of Natural History Görlitz standards for methods for the photographic documentation of the holotype of soil arthropods are developed. The aim is to present the photographed products on the online database as if they would be seen by the scientist directly through his microscope (see figure).

Screenshot of Virmisco (The Virtual Microscope Slide Collection) Viewer Loop Mode



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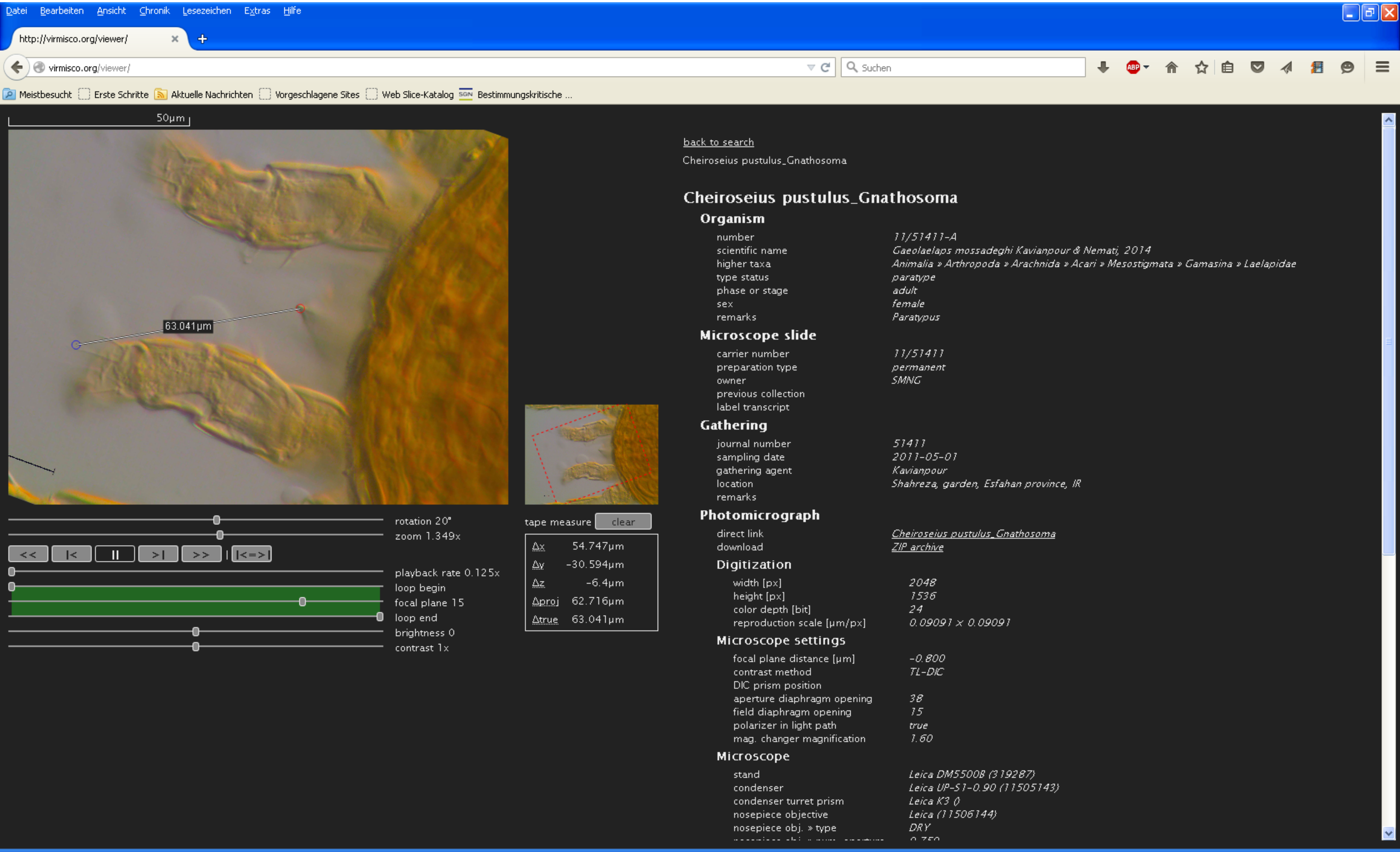
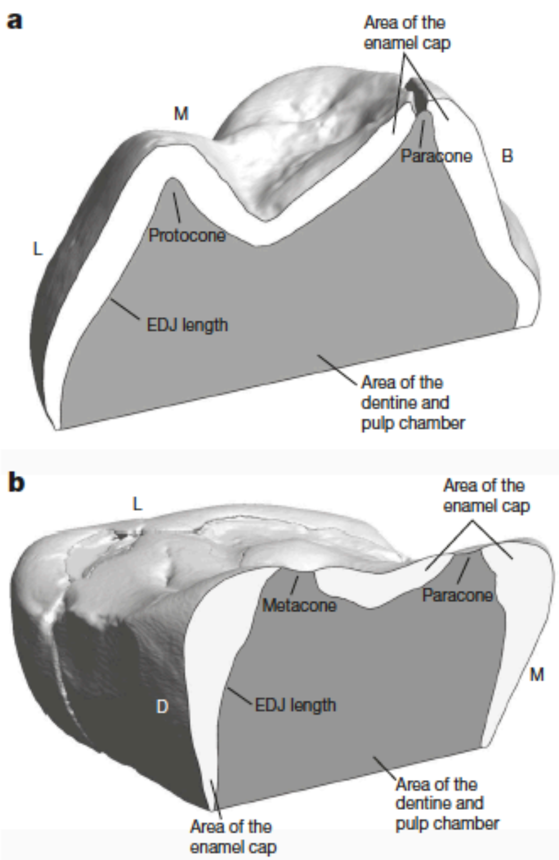
Screenshot of Virmisco Viewer Measurement Mode



Early dispersal of modern humans in Europe and implications for Neanderthal behavior

- Stefano Benazzi, Katerina Douka, Cinzia Fornai, Catherine C. Bauer, Ottmar Kullmer, Jirí Svoboda, Ildiko Pap, Francesco Mallegni8, Priscilla Bayle, Michael Coquerelle, Silvana Condemi, Annamaria Ronchitelli, Katerina Harvati & Gerhard W. Weber. - NATURE, November 2011, doi:10.1038/nature10617

Occlusal view of the deciduous molars from the Uluzzian layers of Grotta del Cavallo (southern Italy)



Cross-sections of Cavallo-B and Cavallo-C for two-dimensional enamel thickness analysis

- The appearance of anatomically modern humans in Europe and the nature of the transition from the Middle to Upper Palaeolithic are matters of intense debate
- Most researchers accept that before the arrival of anatomically modern humans, Neanderthals had adopted several 'transitional' technocomplexes
- Two of these (Uluzzian, Châtelperronian) are key to current interpretations regarding the timing of arrival of anatomically modern humans in the region and their potential interaction with Neanderthal populations
- We reanalyse the deciduous molars from the Grotta del Cavallo (southern Italy), associated with the Uluzzian and originally classified as Neanderthal
- **Using two independent morphometric methods based on microtomographic data, we show that the Cavallo specimens can be attributed to anatomically modern humans**
- **the teeth must date to 45,000–43,000 calendar years before present**
- The Cavallo human remains are therefore the oldest known European anatomically modern humans, confirming a rapid dispersal of modern humans across the continent before the Aurignacian and the disappearance of Neanderthals

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A virtual reconstruction and comparative analysis of the KNM-ER 42700 cranium (1.55 my, Ileret/Kenya)

Anthropologischer Anzeiger January 2015 DOI: 10.1127/anthranz/2015/0387

Catherine C. Bauer & Katerina Harvati

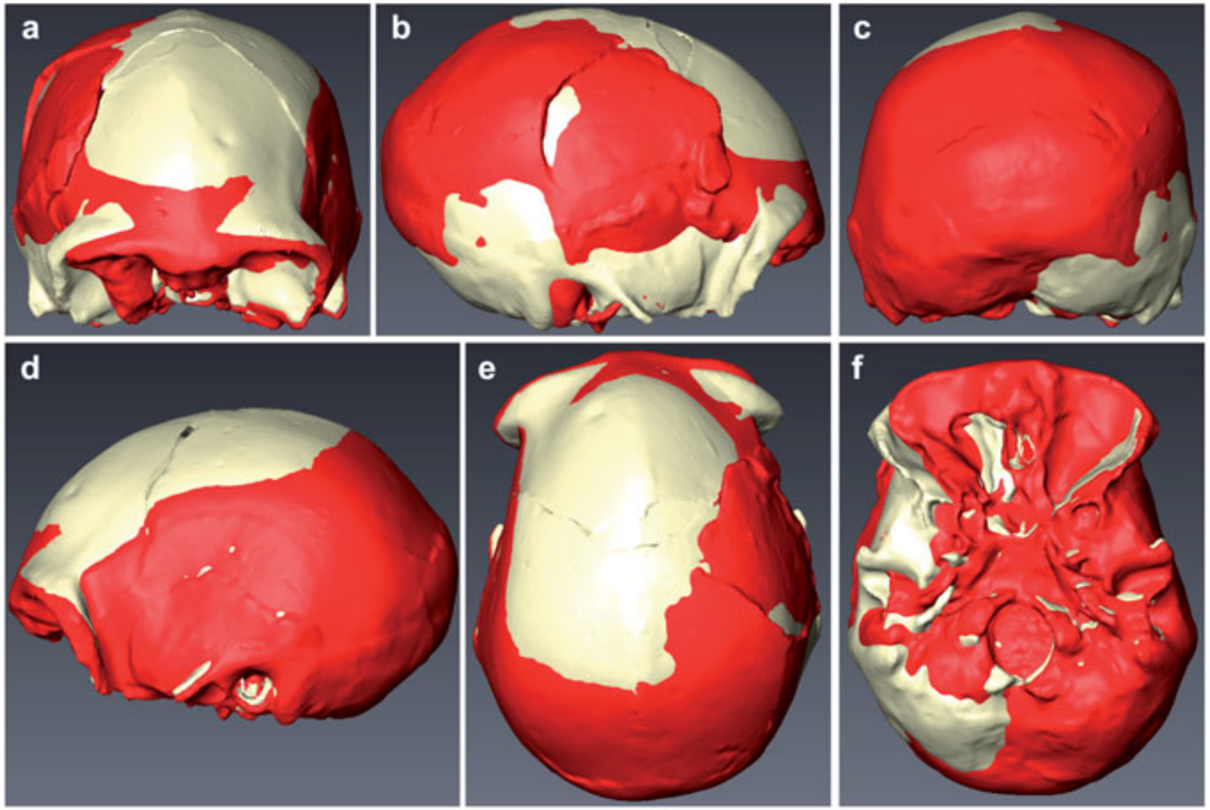


Fig. 4. The virtual reconstruction (beige) superimposed on the original surface scan (red) of KNM-ER 42700 in (a) frontal, (b) right lateral, (c) occipital, (d) left lateral, (e) superior and (f) basal view. Note the replacement of the right supraorbital region in (a) as well as the correction of the slightly sheared skull base in (f).

The virtual reconstruction was carried out on the scan using Avizo®(Version 6.3, ©Visualization Sciences Group), following the procedures outlined by Gunz et al. (2009). In order to conduct a comparative analysis of both the reconstructed and unreconstructed specimen, we collected 23 three-dimensional cranial landmarks (Table 2) on 38 adult crania.

Taxon	Comparative samples
H. habilis	KNM-ER 1813
H. erectus (s.l.)	KNM-ER 3883; KNM-ER 3733; OH 9; KNM-WT 15000; Sangiran 17; Zhoukoudian 1; D2280; Sambungmachan 3
H. heidelbergensis (s.l.)	Kabwe; Sima 5; Dali
H. neanderthalensis	Amud 1; Guattari; Shanidar 1; La Chapelle-aux-Saints; La Ferrassie 1; Gibraltar
Mid-Late Pleistocene-early H. sapiens	Irhoud 2; Singa; Qafzeh 9; Skhul 5
Upper Paleolithic H. sapiens	Predmost 3, 4; Mladec 1, 5; Oase 2; Cro Magnon 1; Cioclovina; Abri Pataud; Dolni Vestonice 3, 13, 15, 16; Grimaldi; Ohalo II; Pavlov 1; Upper Cave 101

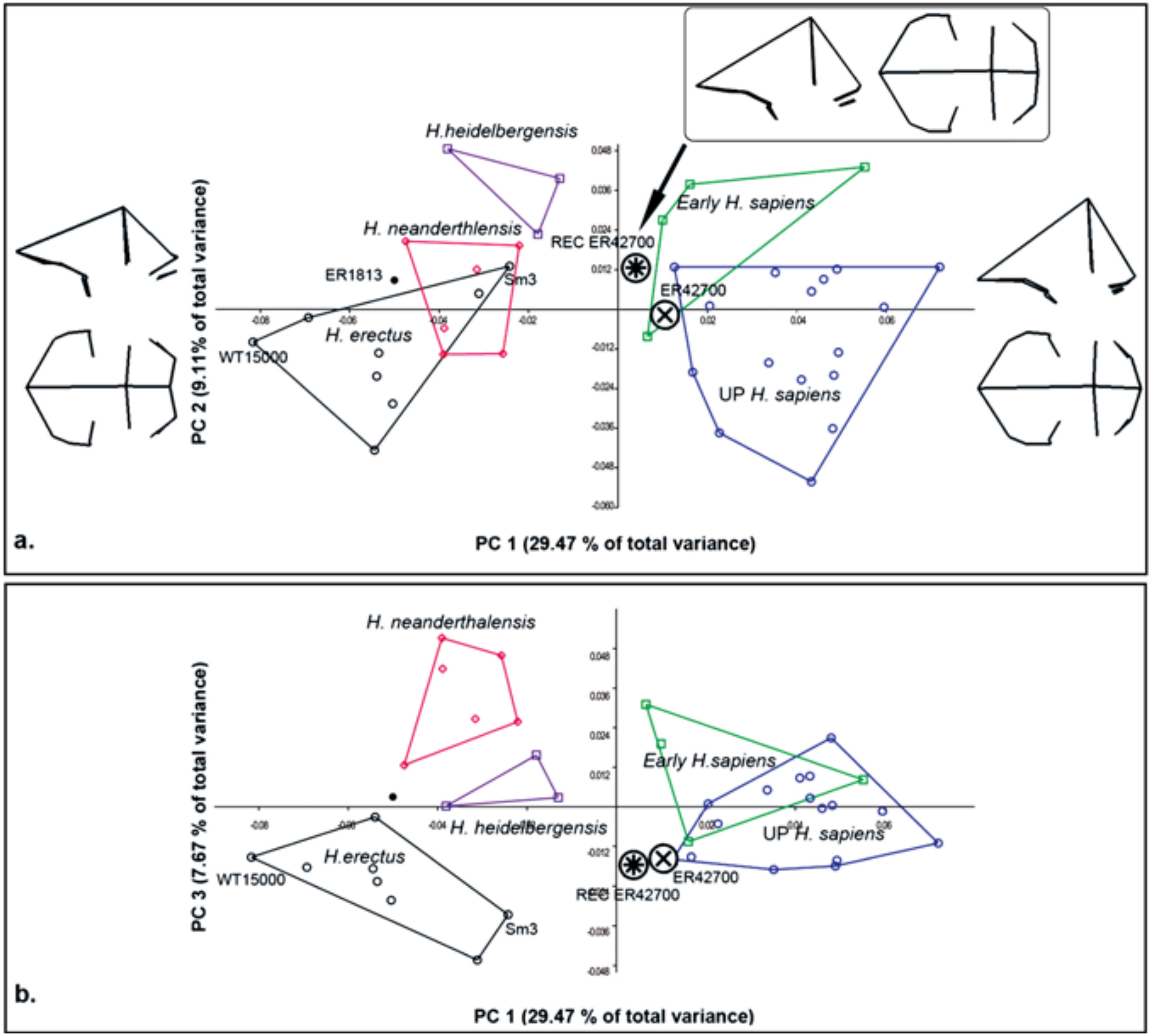
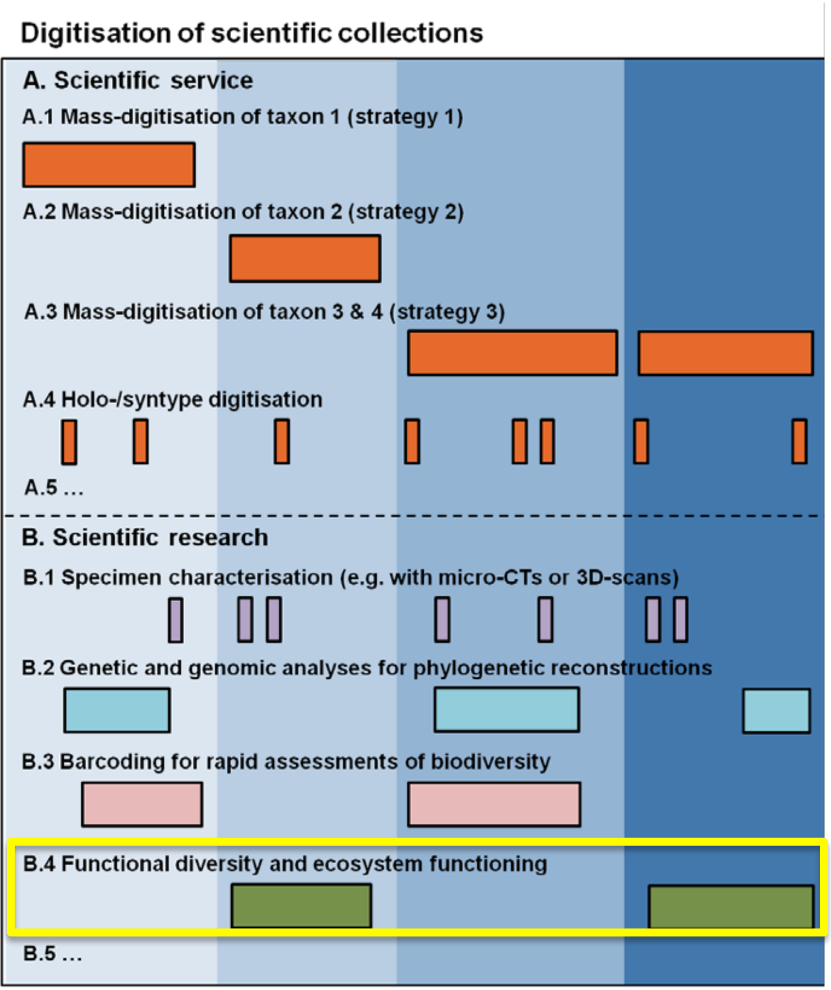


Fig. 5. Principal Components Analysis. Top: PC 1 plotted against PC 2. Shape differences along the PC 1 axis are shown. Bottom: PC 1 plotted against PC 3. Black circles: Homo erectus (s.l.); Green circle: H. habilis; Red diamonds: H. neanderthalensis; Purple squares: H. heidelbergensis (s.l.); Blue circles: Upper Paleolithic Homo sapiens; Green squares: early H. sapiens.

Digitization of Collections



K. Böhning-Gaese, M. Schleuning, U. Fritz, M. Nuss, K.-D. Klass, T. Hickler, G. Zizka (Frankfurt and Dresden; 22.01.2015)

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Linking biodiversity and traits

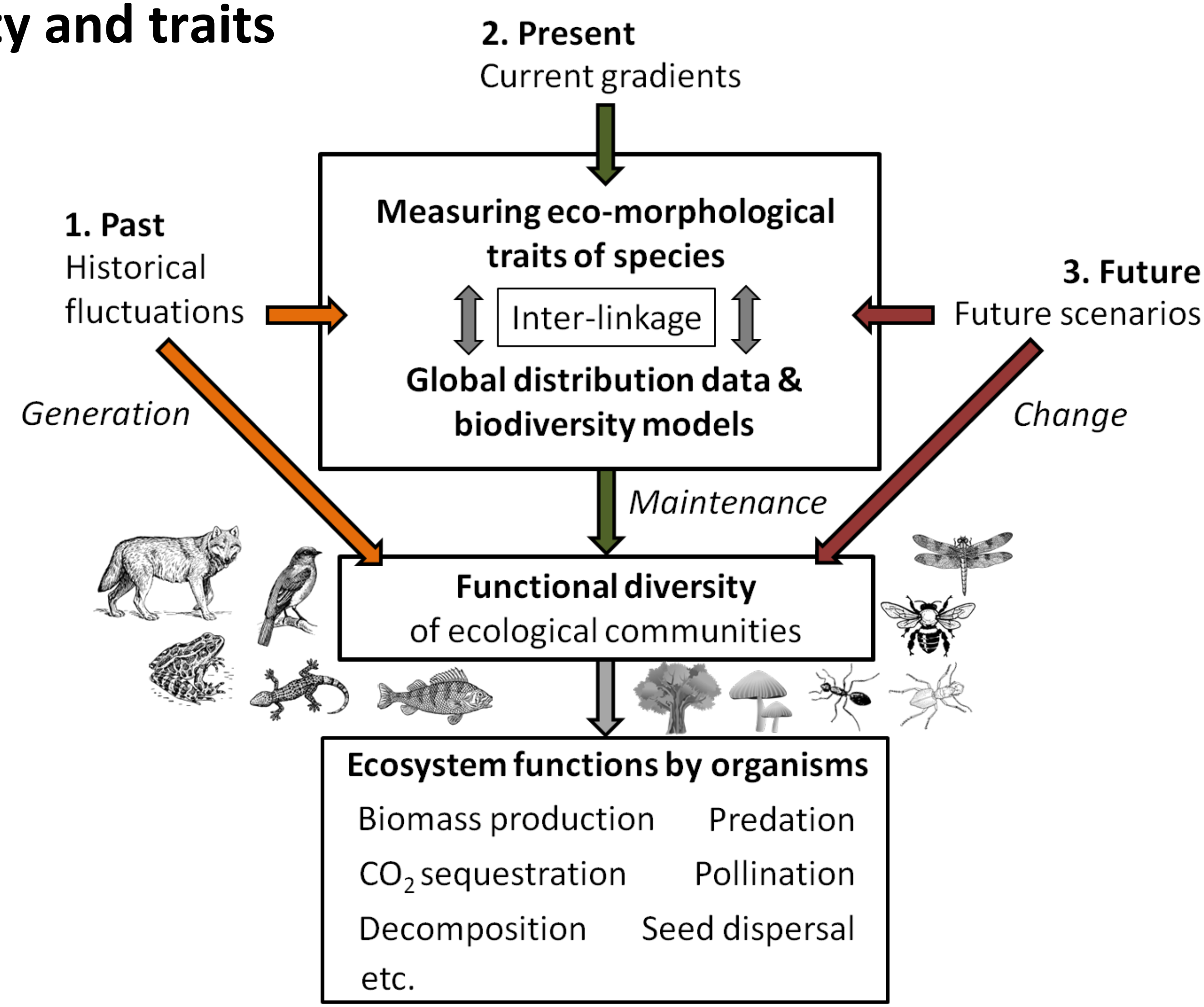
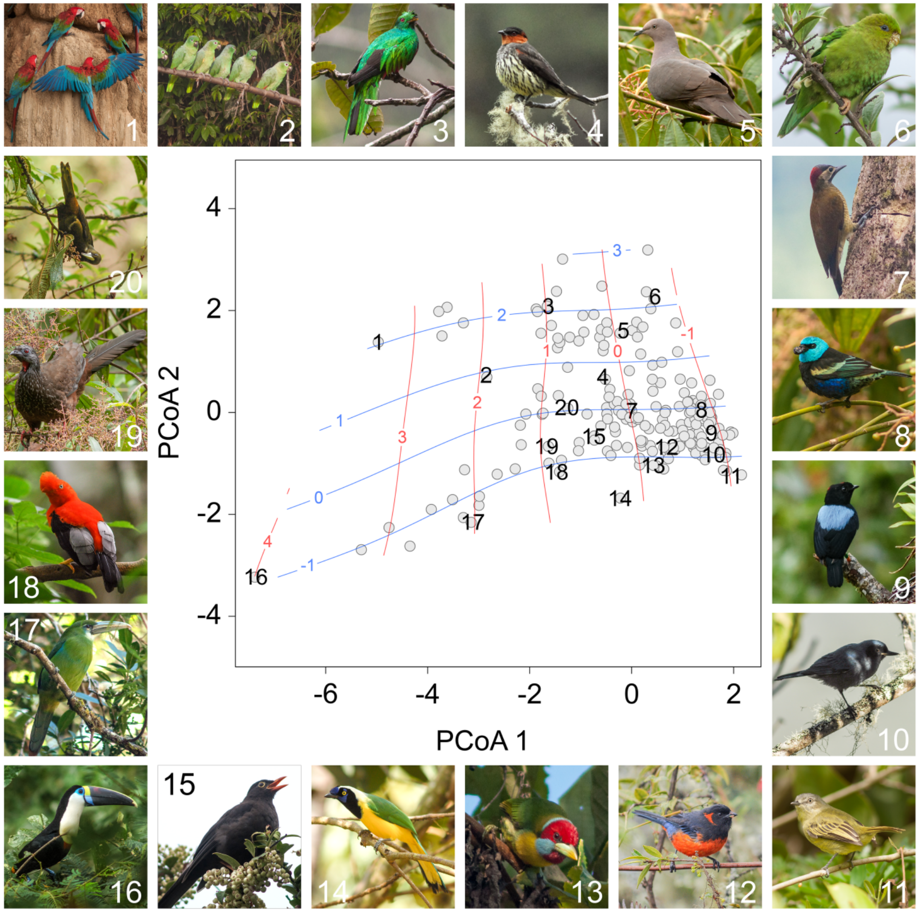


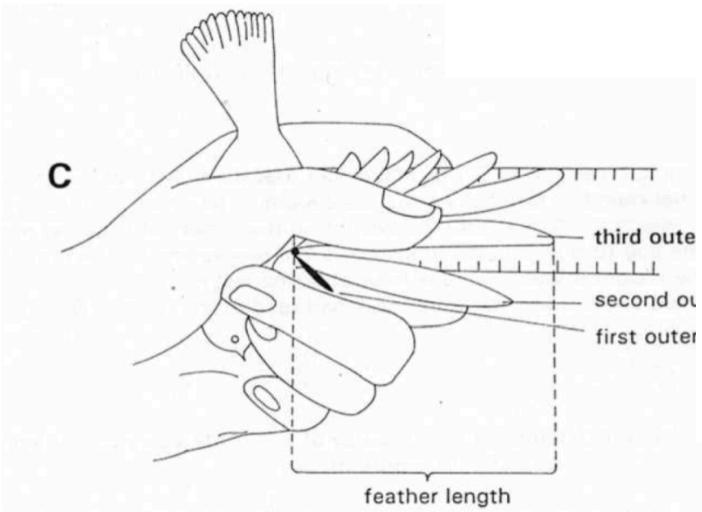
Figure: Schleuning et al. 2015

From biodiversity to functional trait space

For example,
ecomorphological traits of birds

- Beak traits
- Wing and tail traits
- Tarsus, toe and claw traits





Eck, S. et al. 2011. Measuring birds. Vögel vermessen. *Deutsche Ornithologen-Gesellschaft.*

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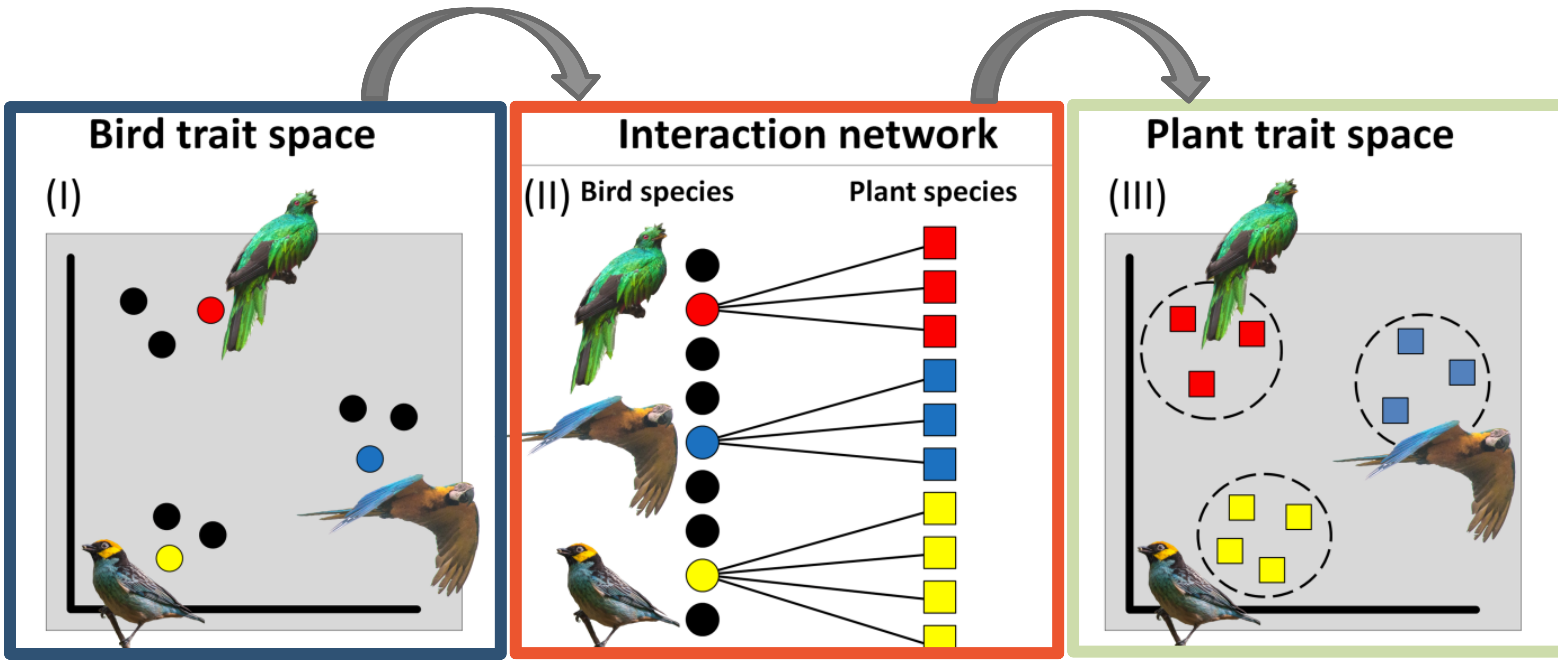
Traits and functional roles of species

Morphology determines distinct functional roles of species



Correspondence:
beak size versus fruit size, body mass – crop mass,
wing pointedness – tree height

Dehling et al. *under review*

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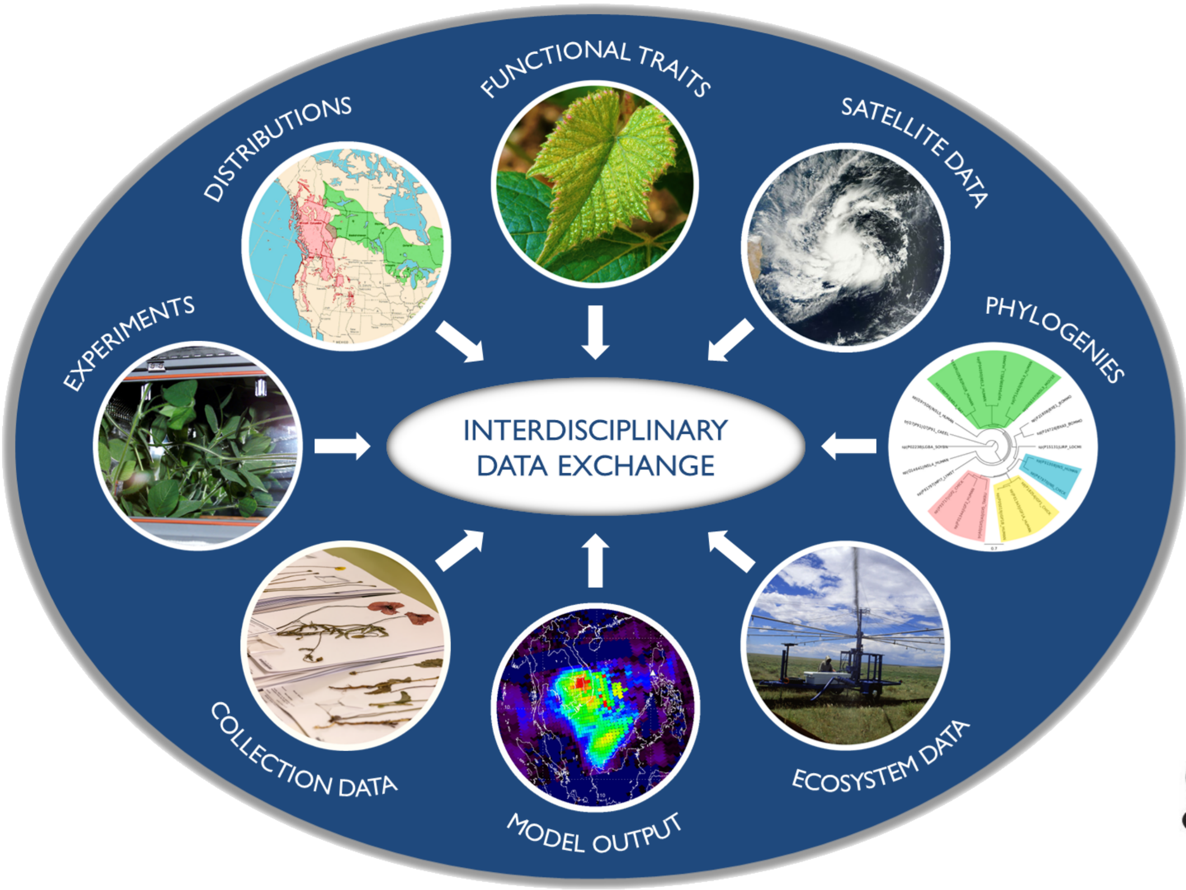
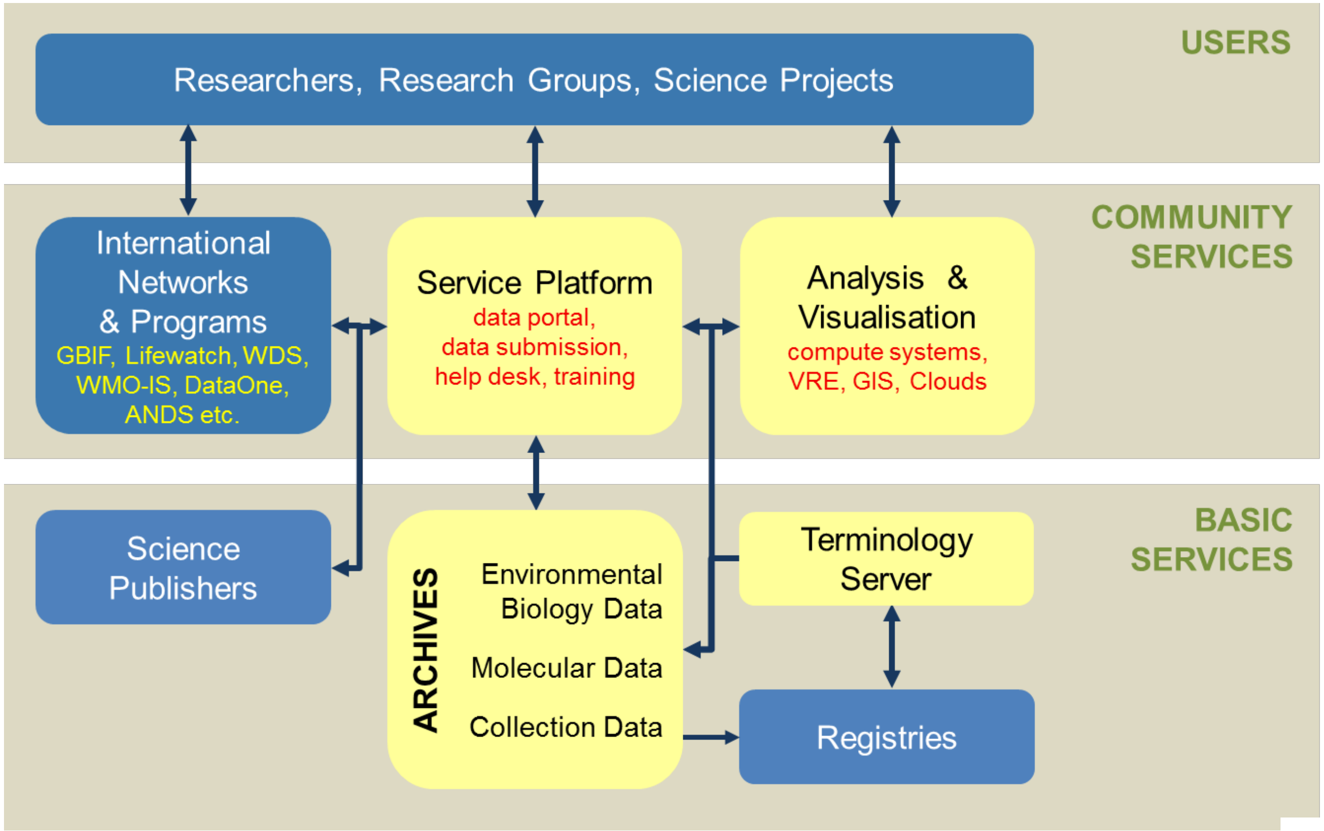
German Federation for the Curation of Biological Data (GFBio)

- national distributed infrastructure, in progress since 2013
- about 12 partners, 1.5 million Euros funding per year, lead Pangea (Bremen)



gfbio

www.gfbio.org



Senckenberg contributions

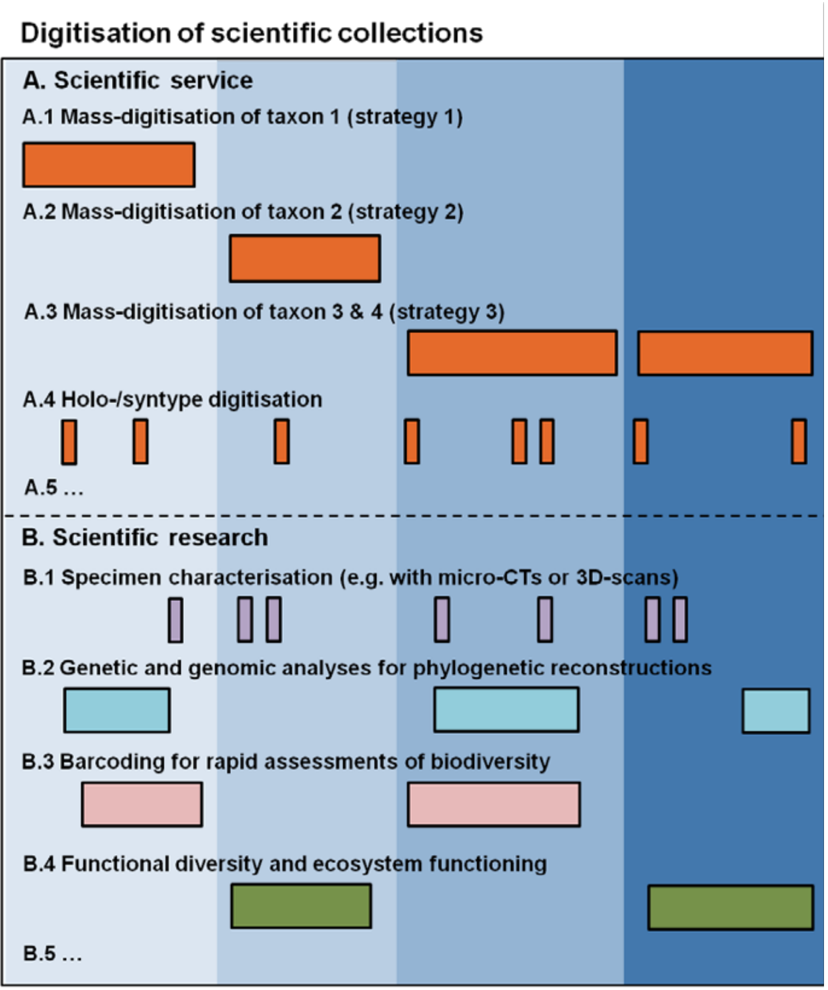
WP 5: Linking collection databases

WP 2: Virtual research environment for data aggregation, visualisation and analysis

WP 7: International interoperability and networking (e.g. IPBES, Belmont Forum)

Multimedia data (including images) functionality was cut! Not done!

What do we need for the future?



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→ **Digitization standards for scientific service modules**

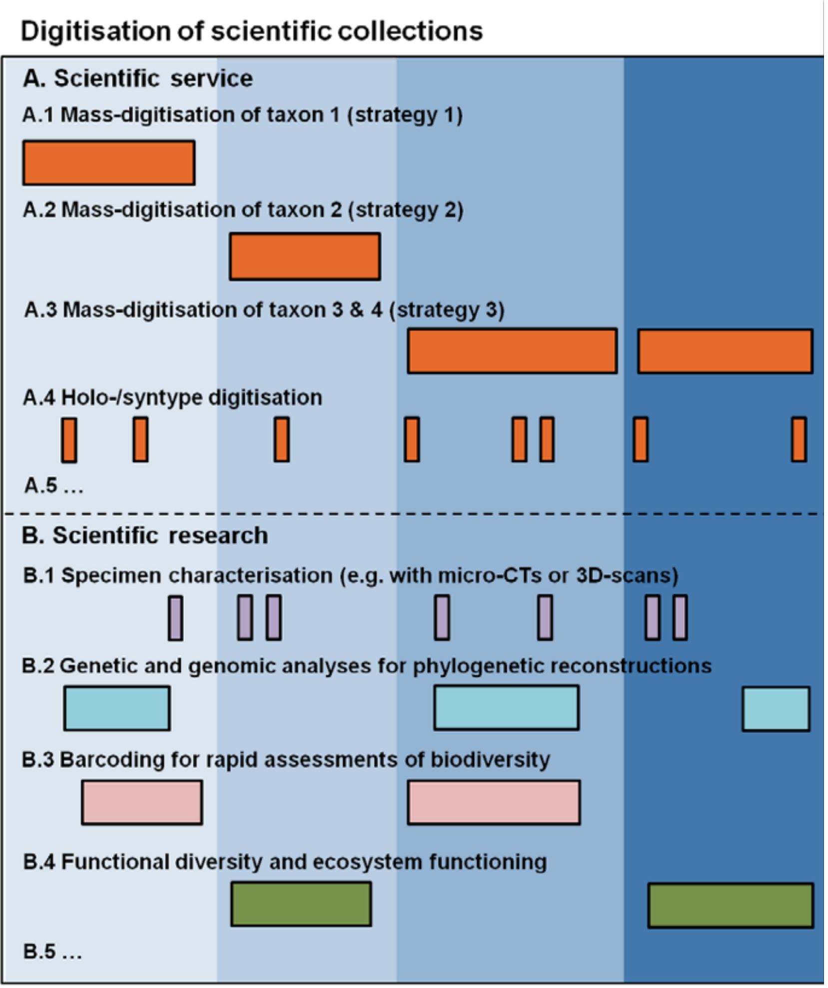
→ **Digitization standards for specific research modules**

Examples of candidate Essential Biodiversity Variables

EBV class	EBV examples	Measurement and scalability	Temporal sensitivity	Feasibility	Relevance for CBD targets and indicators (*1*,*9*)
Genetic composition	Allelic diversity	Genotypes of selected species (e.g., endangered, domesticated) at representative locations.	Generation time	Data available for many species and for several locations, but little global systematic sampling.	Targets: 12, 13. Indicators: Trends in genetic diversity of selected species and of domesticated animals and cultivated plants; RLI.
Species populations	Abundances and distributions	Counts or presence surveys for groups of species easy to monitor or important for ES, over an extensive network of sites, complemented with incidental data.	1 to >10 years	Standardized counts under way for some taxa but geographically restricted. Presence data collected for more taxa. Ongoing data integration efforts (Global Biodiversity Information Facility, Map of Life).	Targets: 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15. Indicators: LPI; WBI; RLI; population and extinction risk trends of target species, forest specialists in forests under restoration, and species that provide ES; trends in invasive alien species; trends in climatic impacts on populations.
Species traits	Phenology	Timing of leaf coloration by RS, with in situ validation.	1 year	Several ongoing initiatives (Phenological Eyes Network, PhenoCam, etc.)	Targets: 10, 15. Indicators: Trends in extent and rate of shifts of boundaries of vulnerable ecosystems.
Community composition	Taxonomic diversity	Consistent multitaxa surveys and metagenomics at select locations.	5 to >10 years	Ongoing at intensive monitoring sites (opportunities for expansion). Metagenomics and hyperspectral RS emerging.	Targets: 8, 10, 14. Indicators: Trends in condition and vulnerability of ecosystems; trends in climatic impacts on community composition.
Ecosystem structure	Habitat structure	RS of cover (or biomass) by height (or depth) globally or regionally.	1 to 5 years	Global terrestrial maps available with RS (e.g., Light Detection and Ranging). Marine and freshwater habitats mapped by combining RS and in situ data.	Targets: 5, 11, 14, 15. Indicators: Extent of forest and forest types; mangrove extent; seagrass extent; extent of habitats that provide carbon storage.
Ecosystem function	Nutrient retention	Nutrient output/input ratios measured at select locations. Combine with RS to model regionally.	1 year	Intensive monitoring sites exist for N saturation in acid-deposition areas and P retention in affected rivers.	Targets: 5, 8, 14. Indicators: Trends in delivery of multiple ES; trends in condition and vulnerability of ecosystems.

Pereira et al. 2013, Science

What do we need for the future?



K. Böhning-Gaese, M. Schleuning, U. Fritz, M. Nuss, K.-D. Klass, T. Hickler, G. Zizka (Frankfurt and Dresden; 22.01.2015)

→ **Digitization standards for scientific service modules**

iDigBio
Integrated Digitized Biocollections

→ **Digitization standards for specific research modules**

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Establishment of Future Earth and IPBES

- **Future Earth**: Network: Global biodiversity monitoring, prediction and reporting

- **IPBES**: Fast-track assessment of scenarios and modelling of *biodiversity and ecosystem services*
- **Furture Earth**: Transdisciplinary research: *co-design, co-productions of science* together with non-scientific knowledge holders

Framework for linking scenarios, biodiversity and ecosystem services

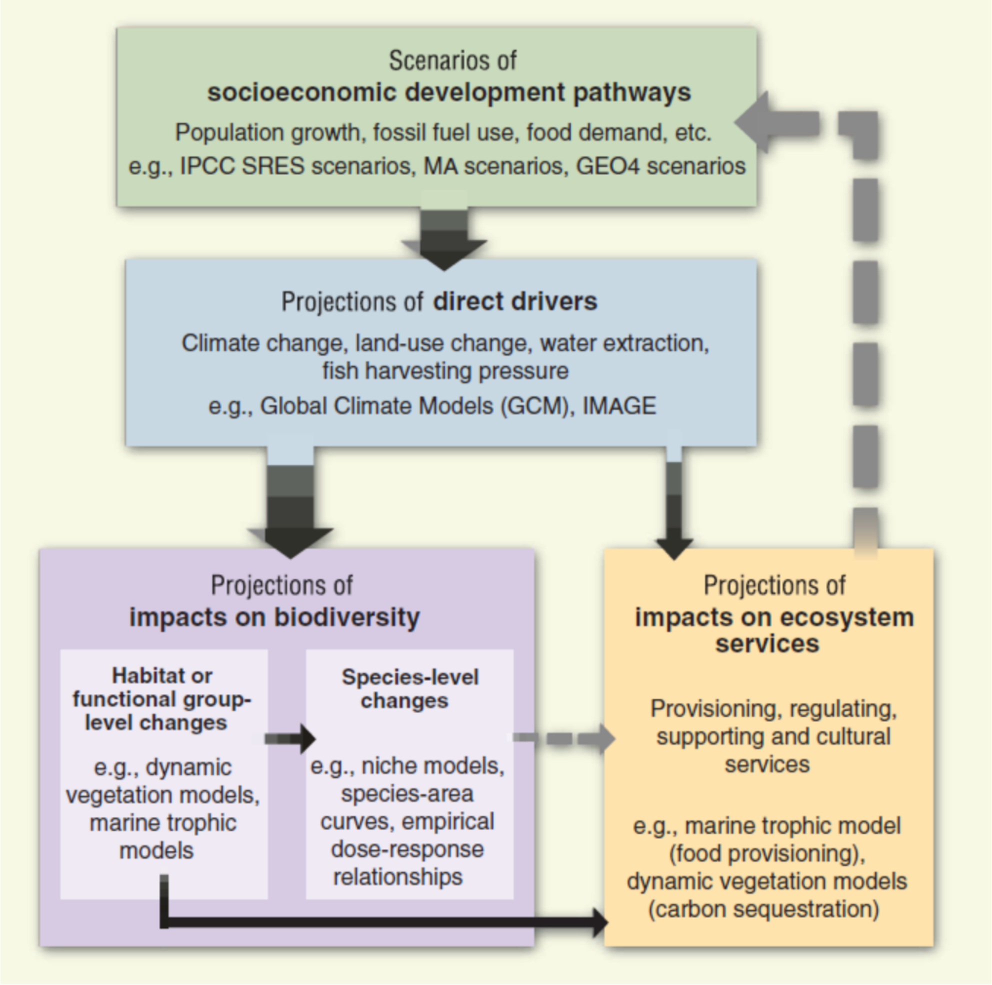


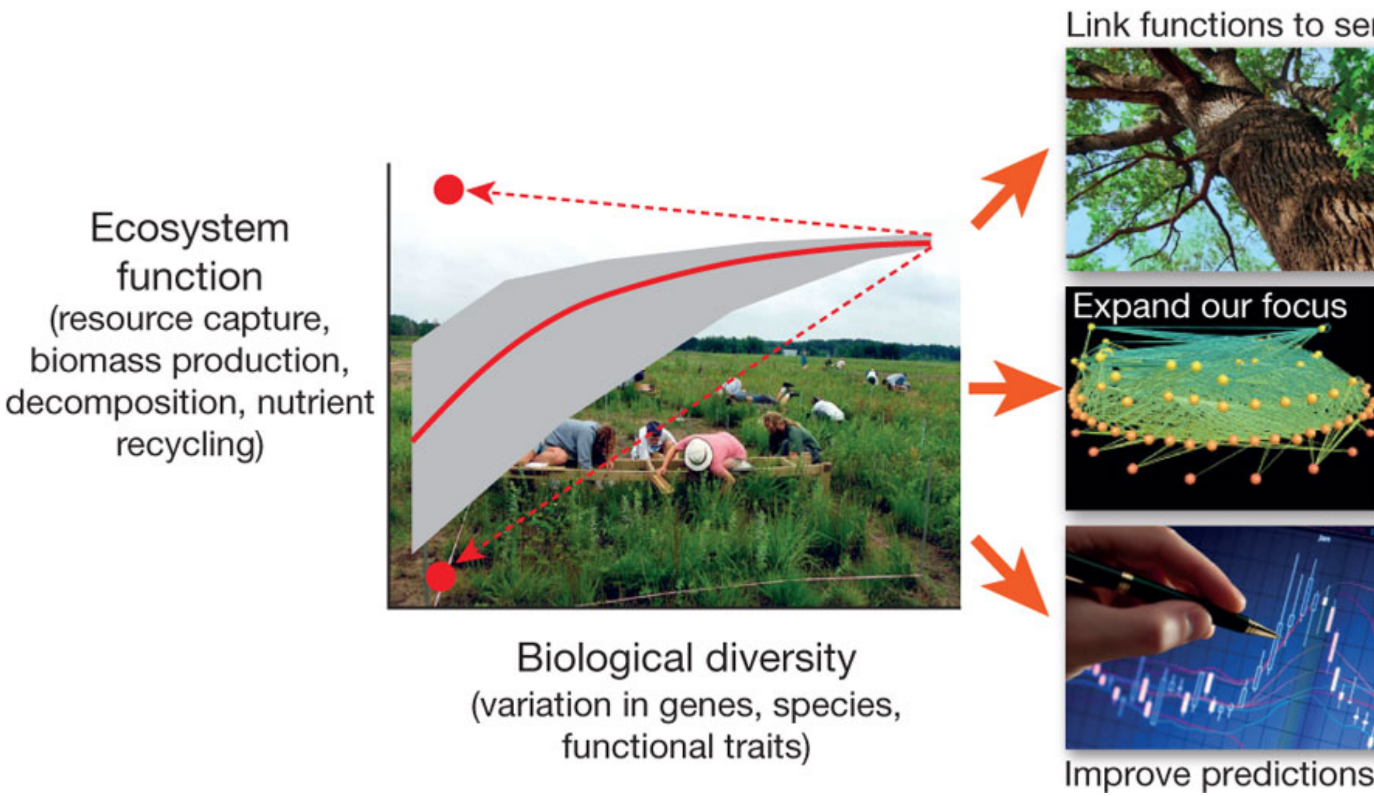
Fig. 1: Overview of methods and models commonly used for constructing biodiversity scenarios

Pereira et al. 2010 *Science*

Comparison of model types

Type of model	Examples	Represention biodiversity	Representation ecosystem functions	Representation ecosystem services = demand
Statistical biodiversity models	Species distribution models, species richness models, PREDICTS	**Strong** for specific components	Weak	Very weak
Functional biodiversity models	Dynamic (global) vegetation models, Mandingley	Weak	**Strong** for specific components	Weak
Ecosystem service models	INVEST ARIES	Very weak	**Strong** for specific components	**Strong** for specific components

Consensus on relationship biodiversity – ecosystem functioning



From functions to ecosystem services

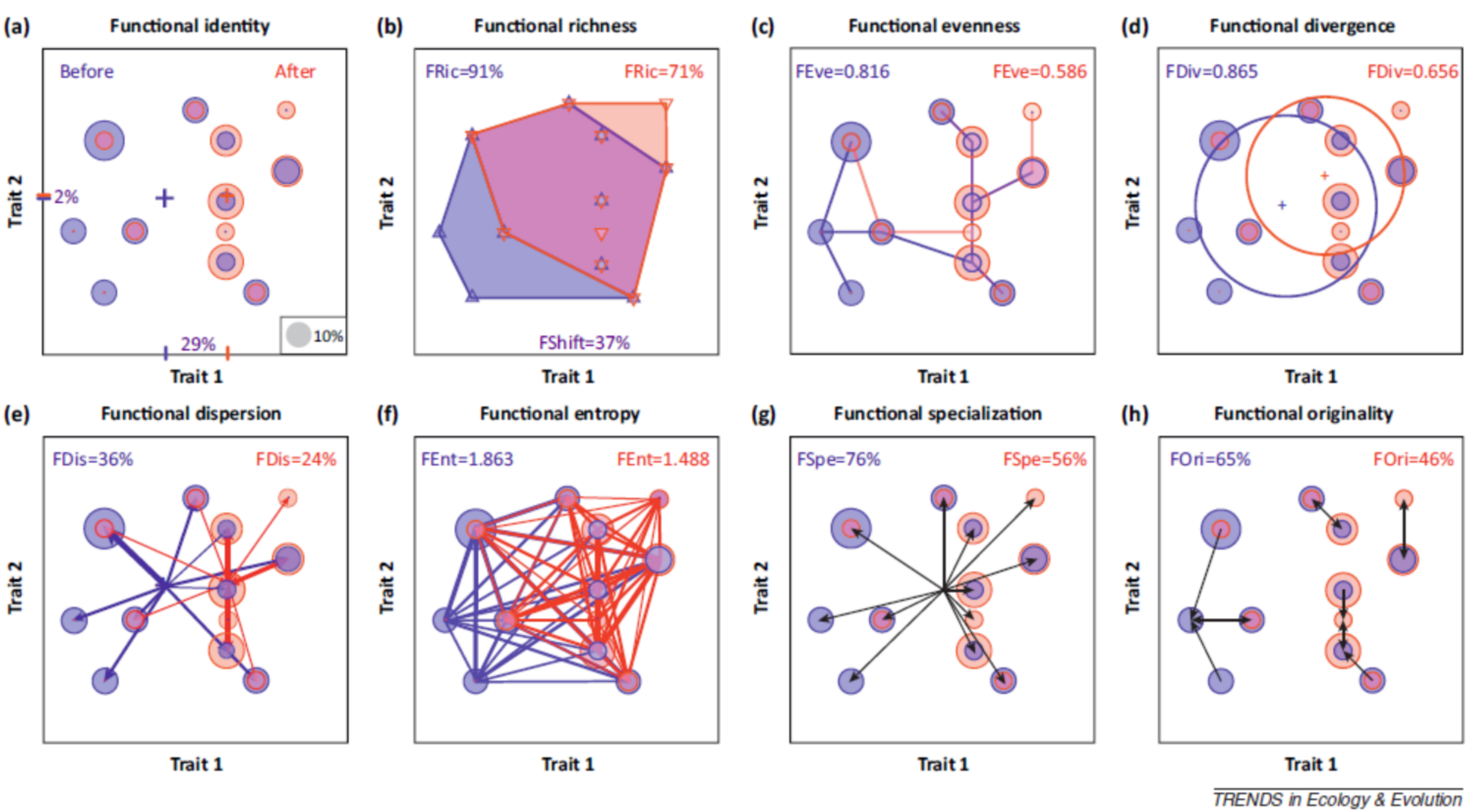
From experiments to natural ecosystems

From experiments to whole landscapes

Conceptual diagram summarizes what we know about the shape of the biodiversity-ecosystem functioning (BEF) relationship based on summaries of several hundred experiments.

Cardinale et al. 2012 *Nature*

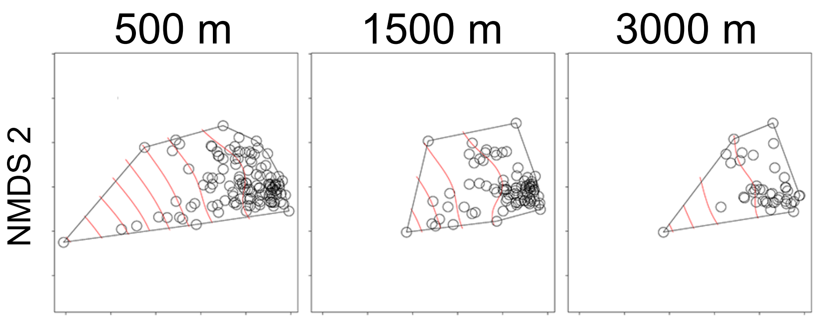
Impact of disturbance on functional trait space

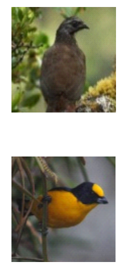


Mouillot et al. 2013 *TREE*

Impact of climate on functional trait space

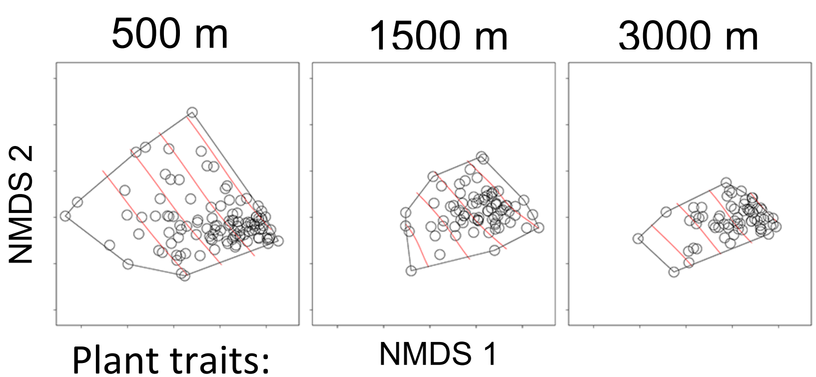
Birds



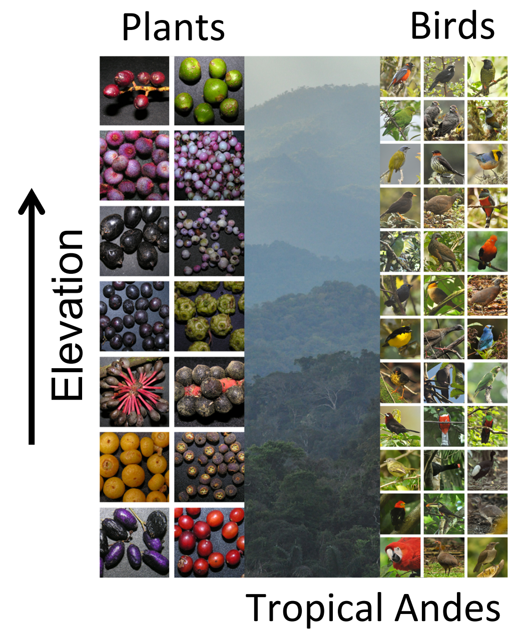


Bird traits:
beak length, beak width, body mass, wing pointedness

Plants



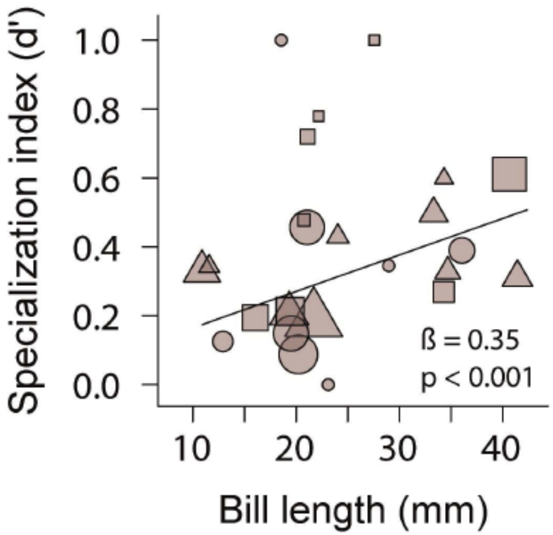
Plant traits:
fruit length, fruit diameter, crop mass, plant height

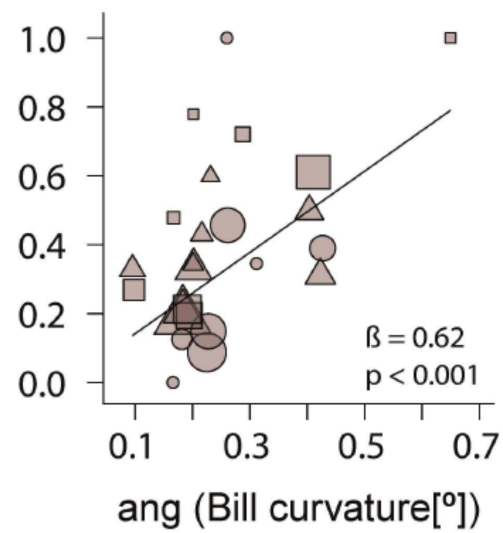


Higher or lower functional redundancy at low elevations/ in the tropics?

Dehling et al. 2014 *Global Ecol Biogeogr*

Impact of traits on specialisation in interaction networks

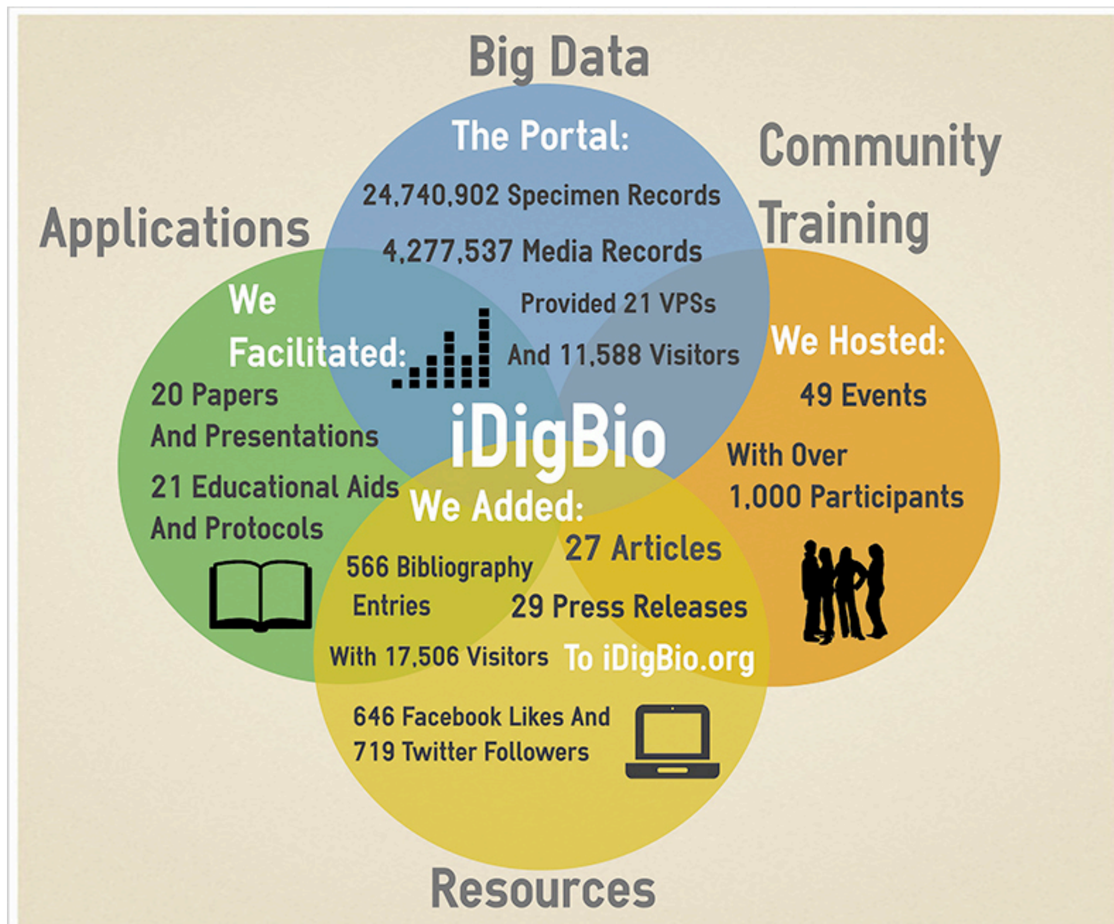




Specialization increases with morphological specialization

Maglianesi et al. 2014 *Ecology*

Integrated Digitized Biocollections



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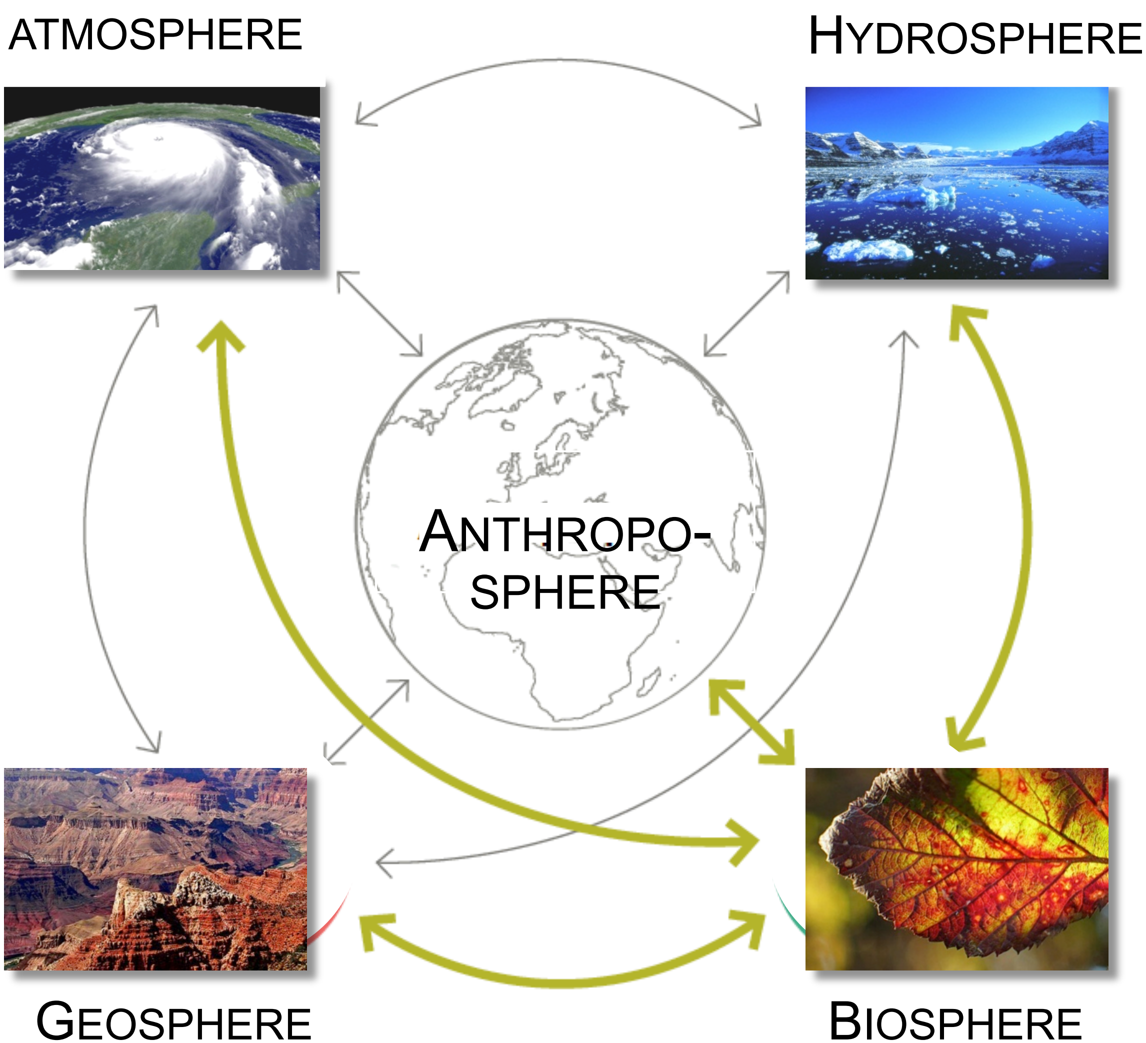
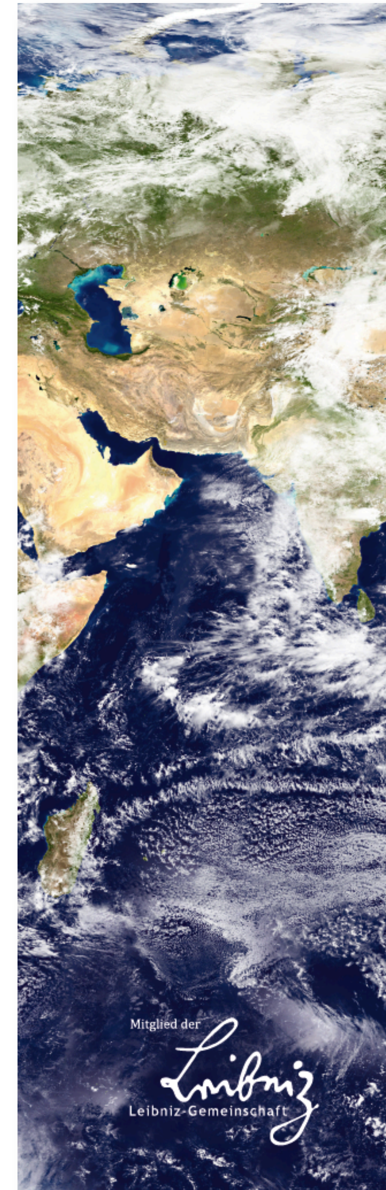
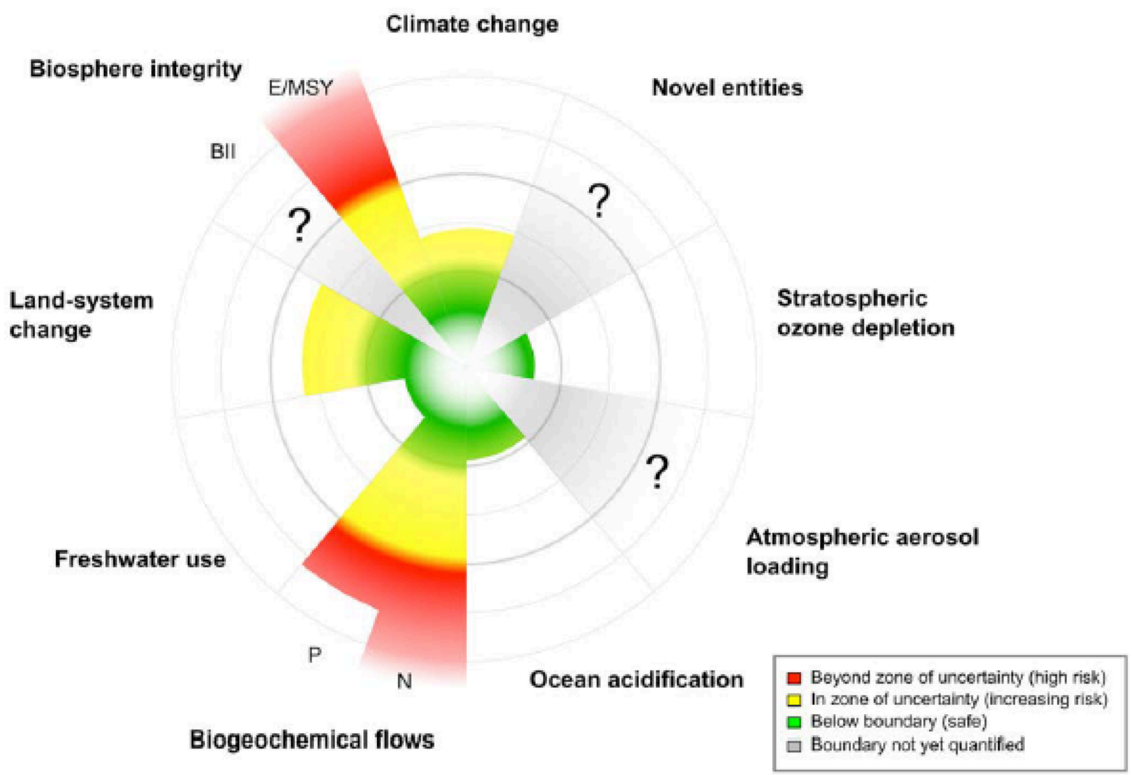
Analyzing Biodiversity in Earth System Dynamics
- to Serve Science and Society -





Using Biodiversity Specimen-Based Data to Study Global Change

Anthropocene Challenge: We are leaving the „safe operating space for humanity"!



Steffen et al. 2015, Science