

# THE NEXT BIODIVERSITY DATA SCIENCE

Arturo H. Ariño

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UNIVERSITY OF NAVARRA

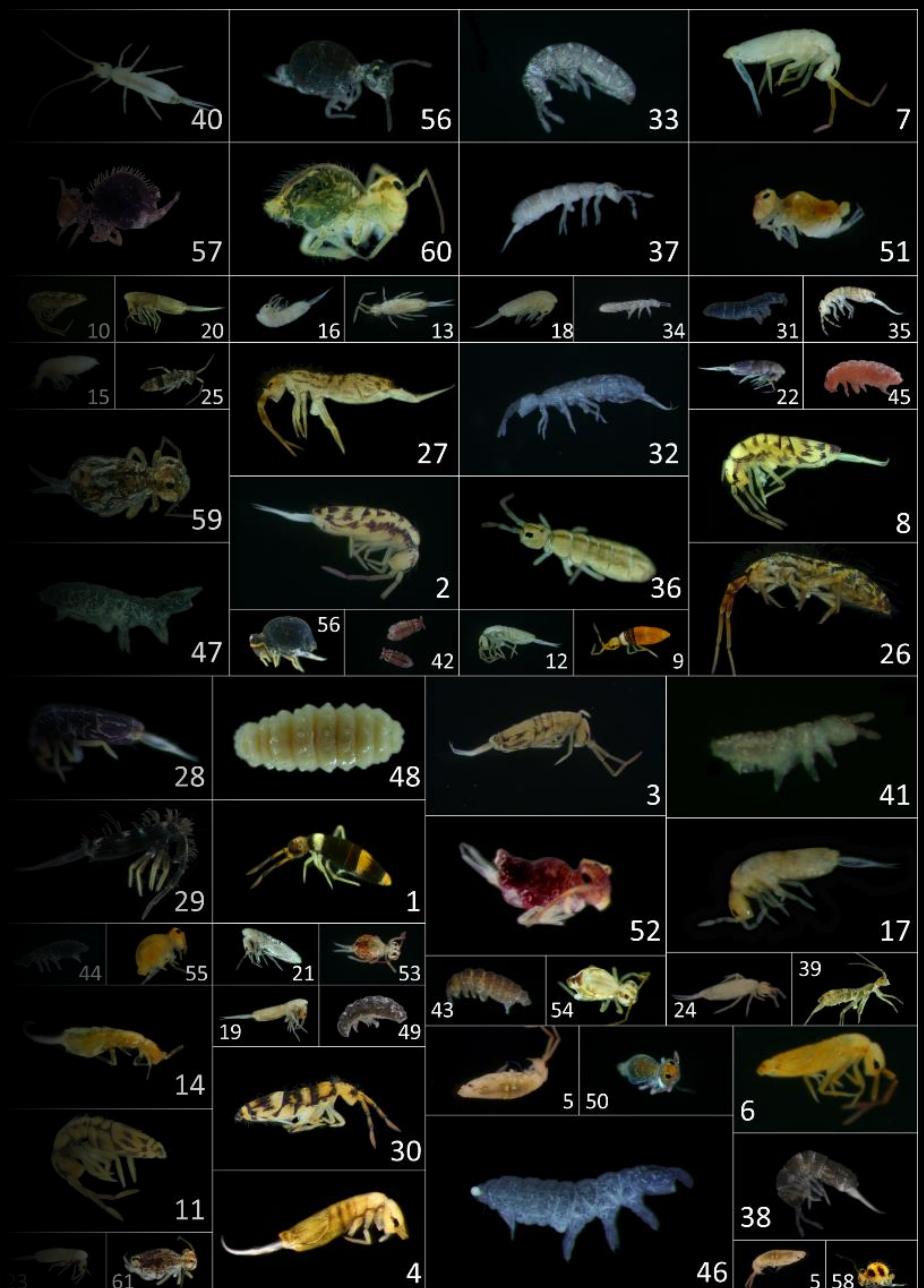


Universidad de Navarra

# BIODIVERSITY: DATA SCIENCE?

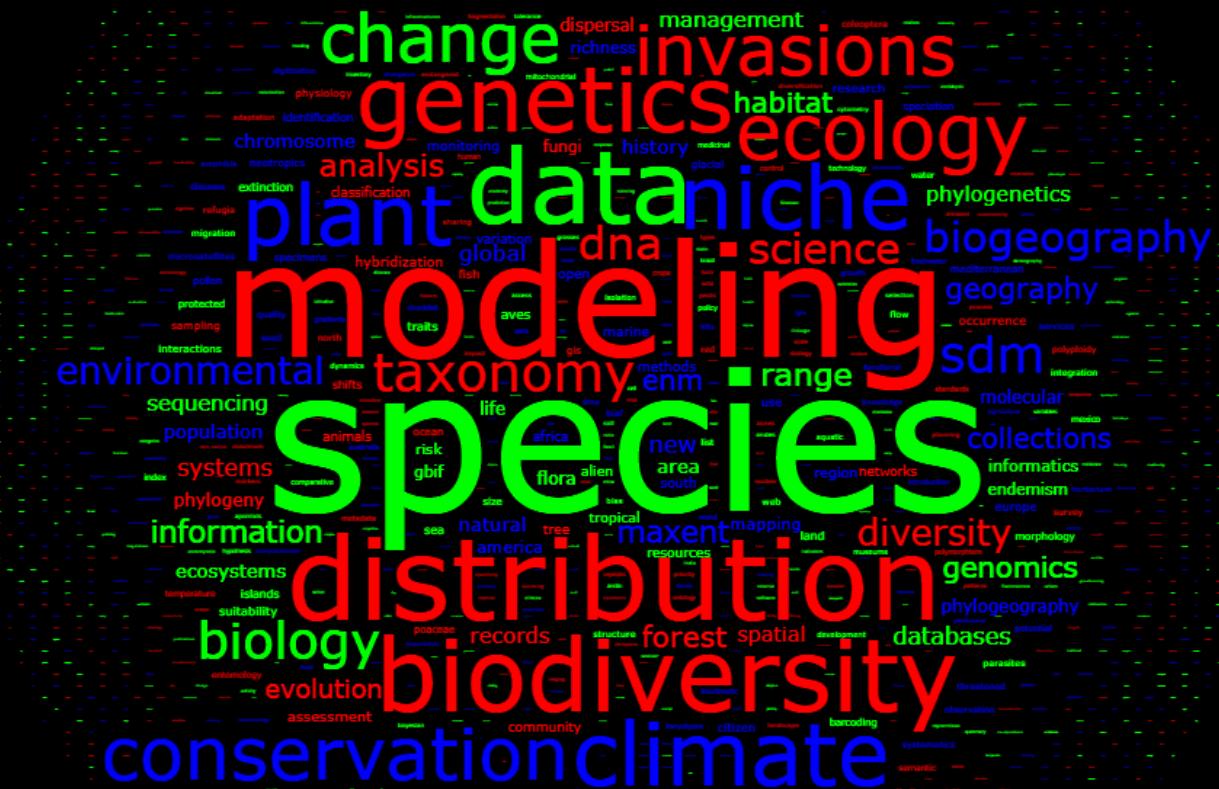
# BIODIVERSITY

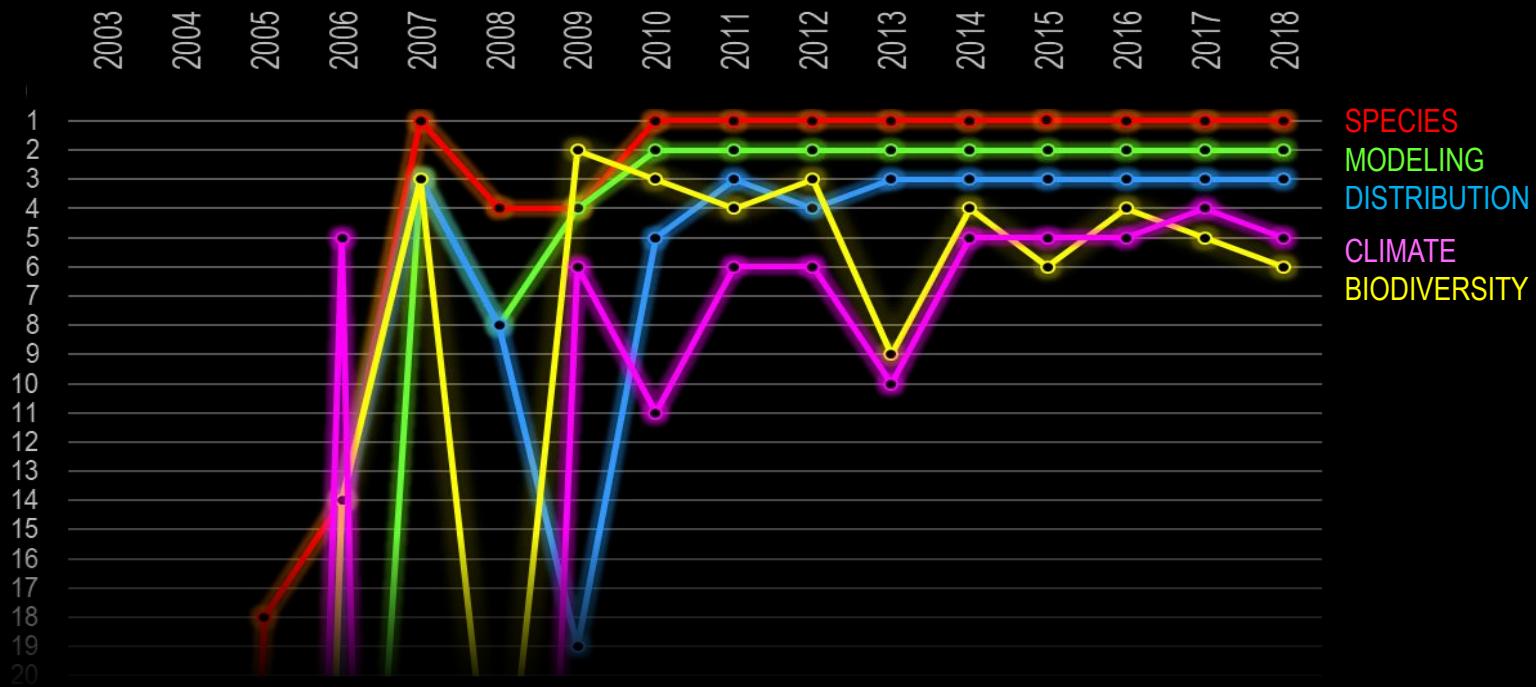
- Variety of life on Earth
- Transversal, mainly Bio
- Data-based
- Knowledge-intensive
- Domain-specific
- Customer for DS
- Producer of DS



# WHY BDS

- Fundamental nature, ecological knowledge
  - Species distributions, models, predictions
  - Global changes and shifts
  - Overall (planet) to local natural w/health
- 
- Sustainable resource availability
  - Invasive species (e.g. coronavirus!)
  - Man-made environmental impact





# THE BIODIVERSITY DATA SCIENCE “UNIT”

WHAT, WHERE, WHEN

Primary Biodiversity Data Record  
PBR

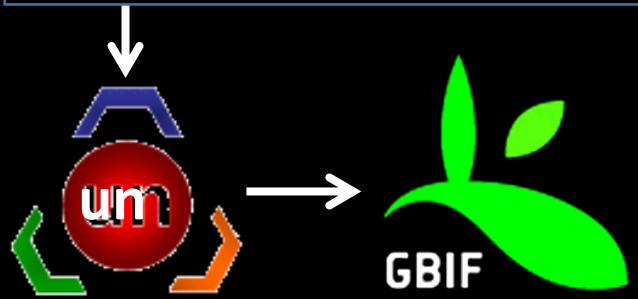


*Megaptera novaeangliae*  
Adult female, live

Off North Truro, MA, USA  
42.101 N, 70.169 W

2010.09.29 21:47 GMT

Arturo H. Ariño  
Aboard *Dolphin VI*  
Canon Eos 450D, 200 mm lens



**LOCUS** SCU49845 5028 bp DNA **PLN** 21-JUN-1999  
**DEFINITION** *Saccharomyces cerevisiae* TCP1-beta gene, partial cds, and Axl2p (AXL2) and Rev7p (REV7) genes, complete cds.  
**ACCESSION** U49845  
**VERSION** U49845.1 **GI:**1293613  
**KEYWORDS**  
**SOURCE**  
**ORGANISM** *Saccharomyces cerevisiae* (baker's yeast)  
*Saccharomyces cerevisiae*  
Eukaryota; Fungi; Ascomycota; Saccharomycotina; Saccharomycetes;  
Saccharomycetales; Saccharomycetaceae; *Saccharomyces*.  
**REFERENCE** 1 (bases 1 to 5028)

**ORIGIN**

```

1 gatcctccat atacaacggt atctccacct caggtaga tctcaacaac ggaaccattg
61 ccgcacatgag acagtttagt atcgctgaga gttacaagct aaaacgagca gtagtcagct
121 ctgcacatcta agccgctgaa gttctactaa ggggtggataa catcatccgt gcaagaccaa
181 gaaccgccaa tagacaacat atgtAACATA tttAGGATAT acctcgaaaa taataaaaccc
241 ccacactgtc attattataa ttagAAACAG aacgcAAAAA ttatccacta tataattcaa
301 agacgcggaaa aaaaaagaac aacgcgtcat agaactttt gcaattcgcg tcacaaataa
361 attttggcaa cttatgtttc ctcttcgagc agtactcgag ccctgtctca agaatgtaat
421 aatacccatc gttaggtatgg ttaaaagatag catctccaca acctcaaagc tccttgccga
481 gagtcggccct cctttgtcga gtaatttca cttttcatat gagaacttat tttcttattc
541 tttactctca catcctgttag tgattgacac tgcaacagcc accatcacta gaagaacaga
601 acaattactt aatagaaaaa ttatatcttc ctcgaaacga tttcctgctt ccaacatcta
661 cgtatatcaa gaagcattca cttaccatga cacagcttca gatttcatta ttgctgacag
721 ctactatatac actactccat cttagtagtgg ccacgcctta tgaggcatat cctatcgaa
781 aacaataaccc cccagtggca agagtcaatg aatcgtttac atttcaaatt tccaaatgata
841 cctataaaatc gtctgttagac aagacagctc aaataacata caattgcttc gacttaccga
901 gctggcttgc gtttgactct agttcttagaa cggtctcagg tgaaccttct tctgacttac
961 tatctgatgc gaacaccacg ttgttatttca atgtaaatact cgagggtacg gactctcccg
1021 acaqcacqtc tttqaacaat acataccaat ttqttgttac aaaccgtcca tccatctcqcc

```

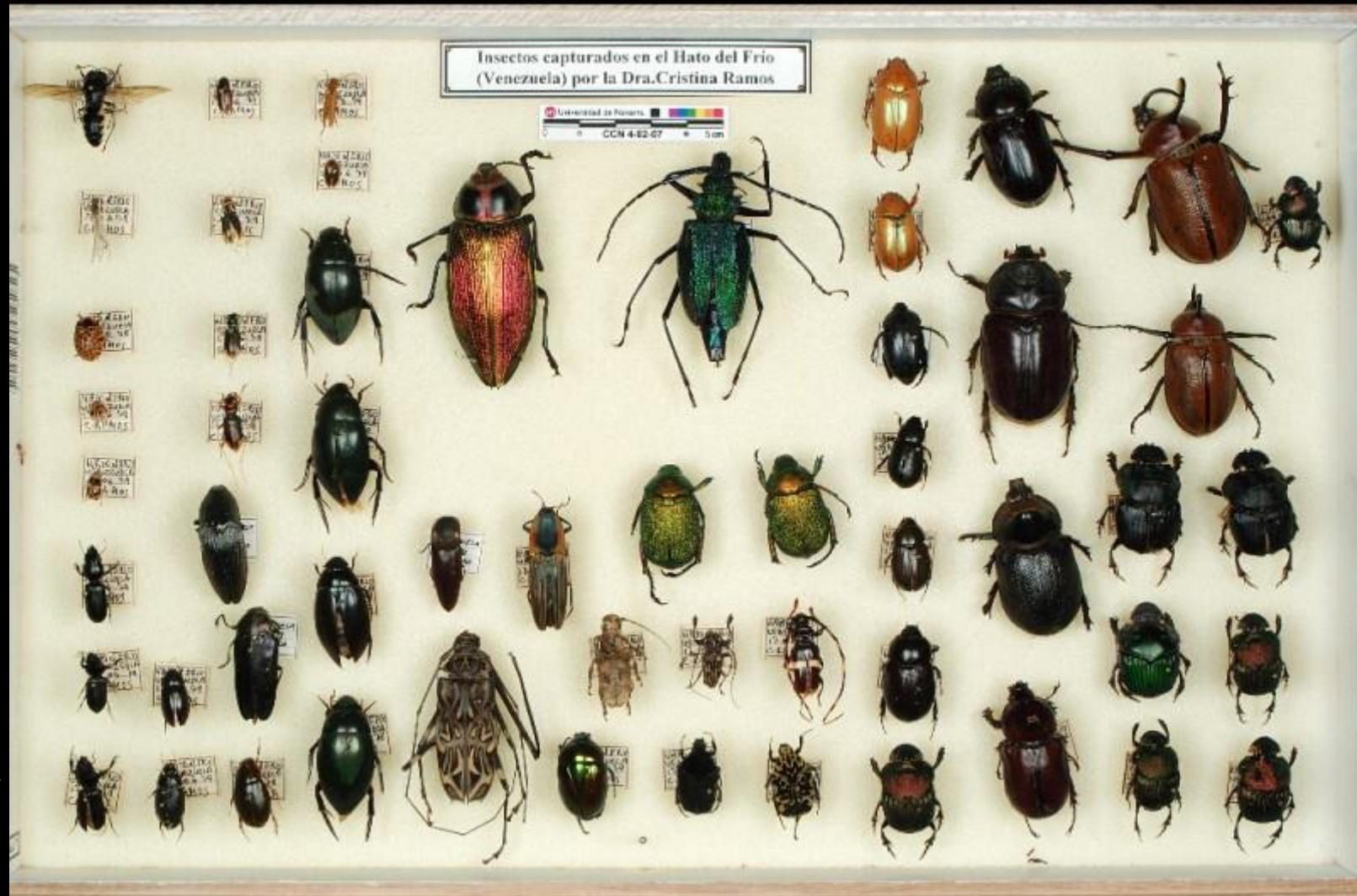
## *Saccharomyces cerevisiae* TCP1-beta

Cask in wreck of ARGO  
2 km E of Akta Képhalos

Stratum 2000 BC

Legit : Homer S.  
Det.: LoScanSQ-X  
Collection: Museum of Beer History (MBH)

# PRIMARY BIODIVERSITY DATA



David Galicia, © Universidad de Navarra

# Ex LABORIS, SAPIENTIA



Photo: Amadeo Urdiain



The Collections of the Science Museum University of Navarra

Invertebrate Collections of the Science Museum University of Navarra

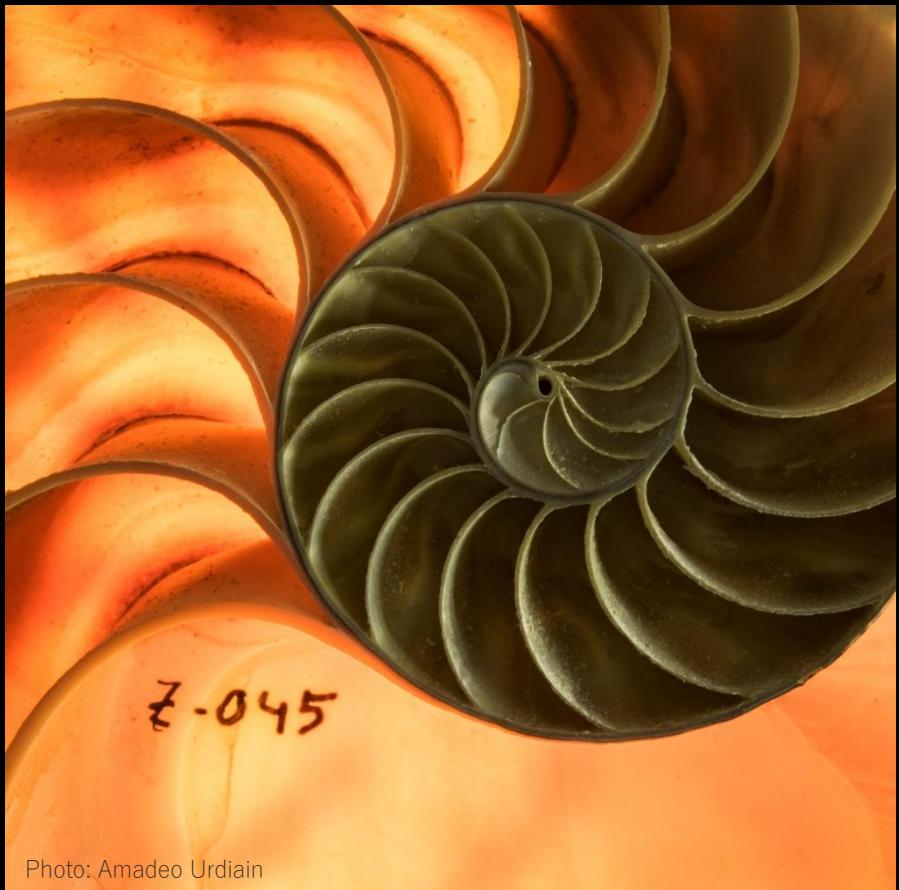


Photo: Amadeo Urdiain

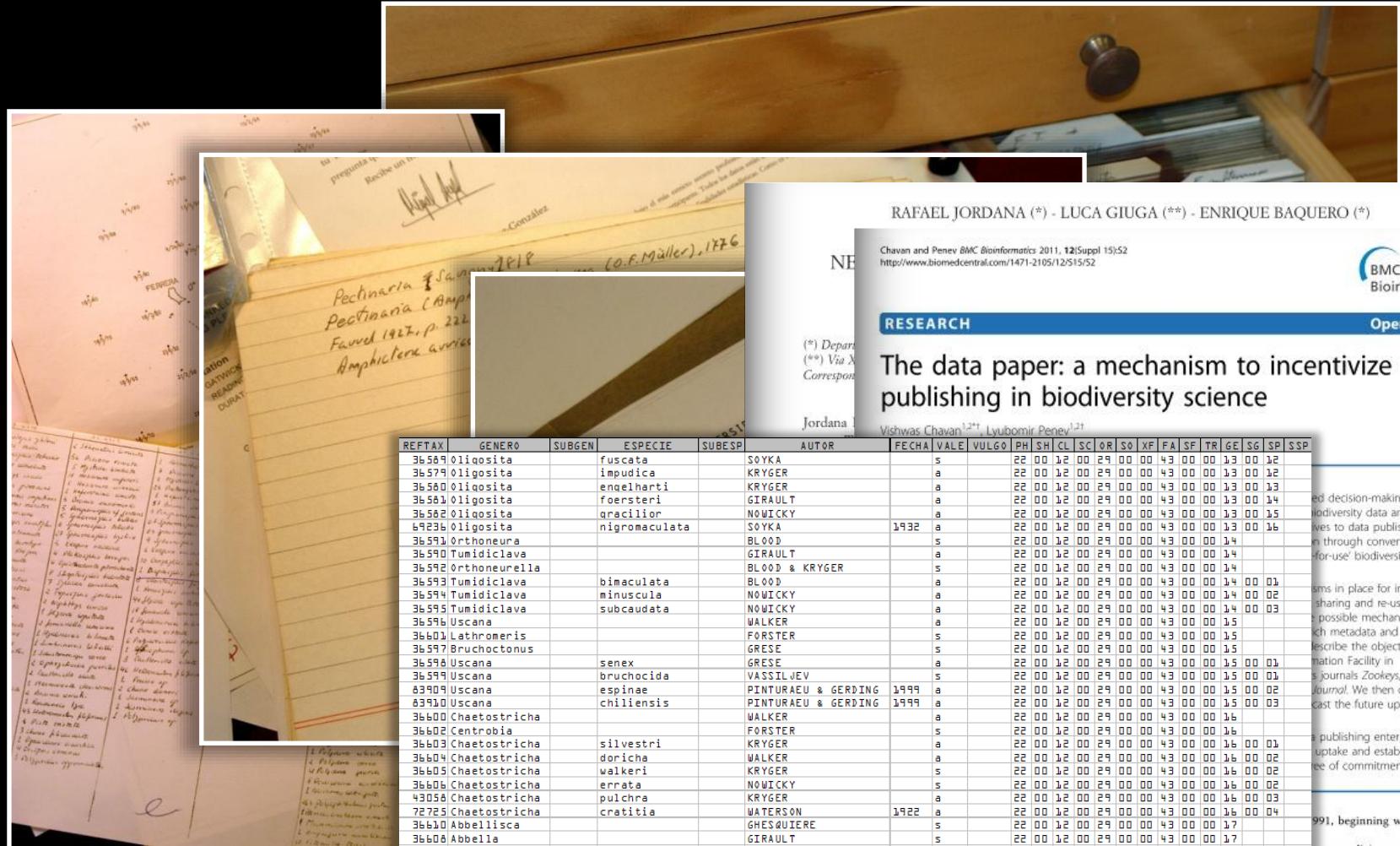


Photo: Amadeo Urdiain



Photo: Amadeo Urdiain

# PBR SOURCING

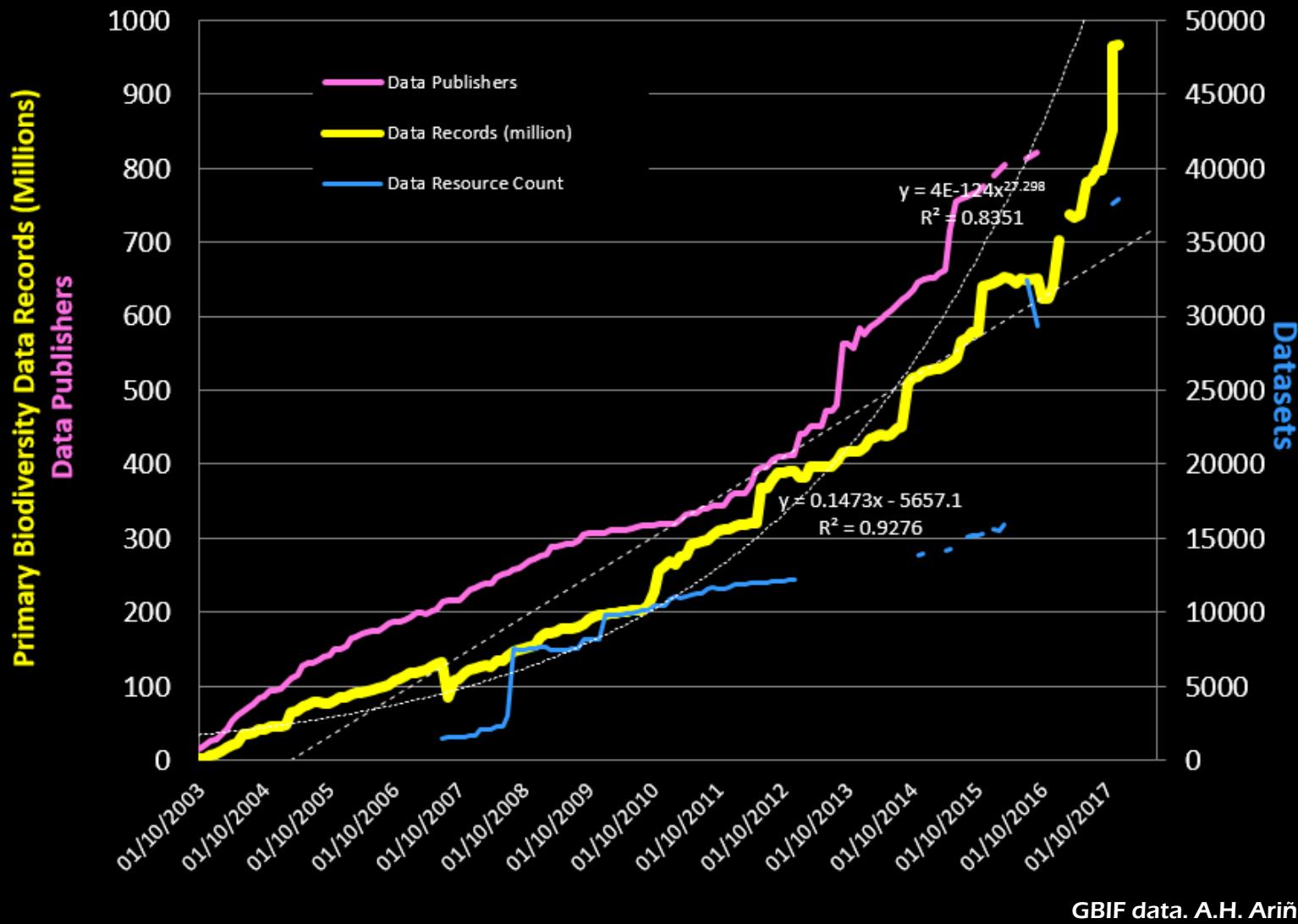


THE NEXT BIODIVERSITY DATA SCIENCE. A.H. ARIÑO 2020 FOR THE GEDE WORKSHOP

encouraged, if our goal is to fill the extensive biodiversity knowledge gap that exists today. This emphasis on free and open access to biodiversity data is in tune with the call for open-access to primary scientific data, which

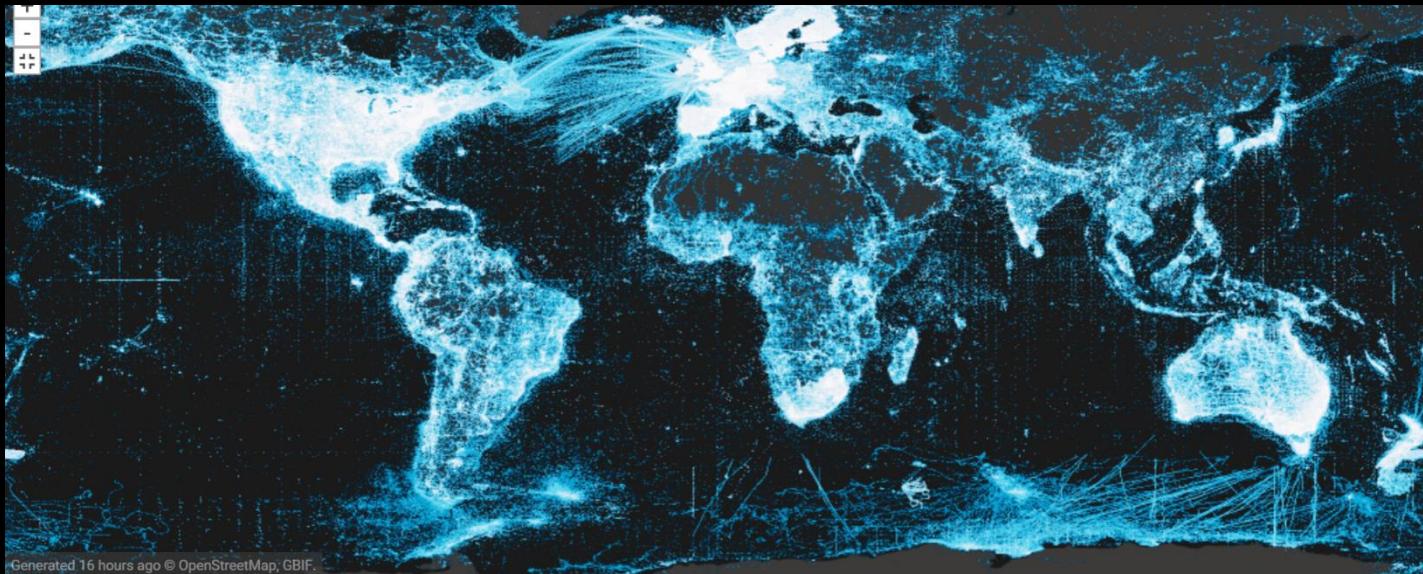
for Economic Co-operation and Development (OECD) also recognized the importance of open access to primary scientific data [23]. Recently established initiatives such as Conservation Commons [24]

# PBR AVAILABILITY



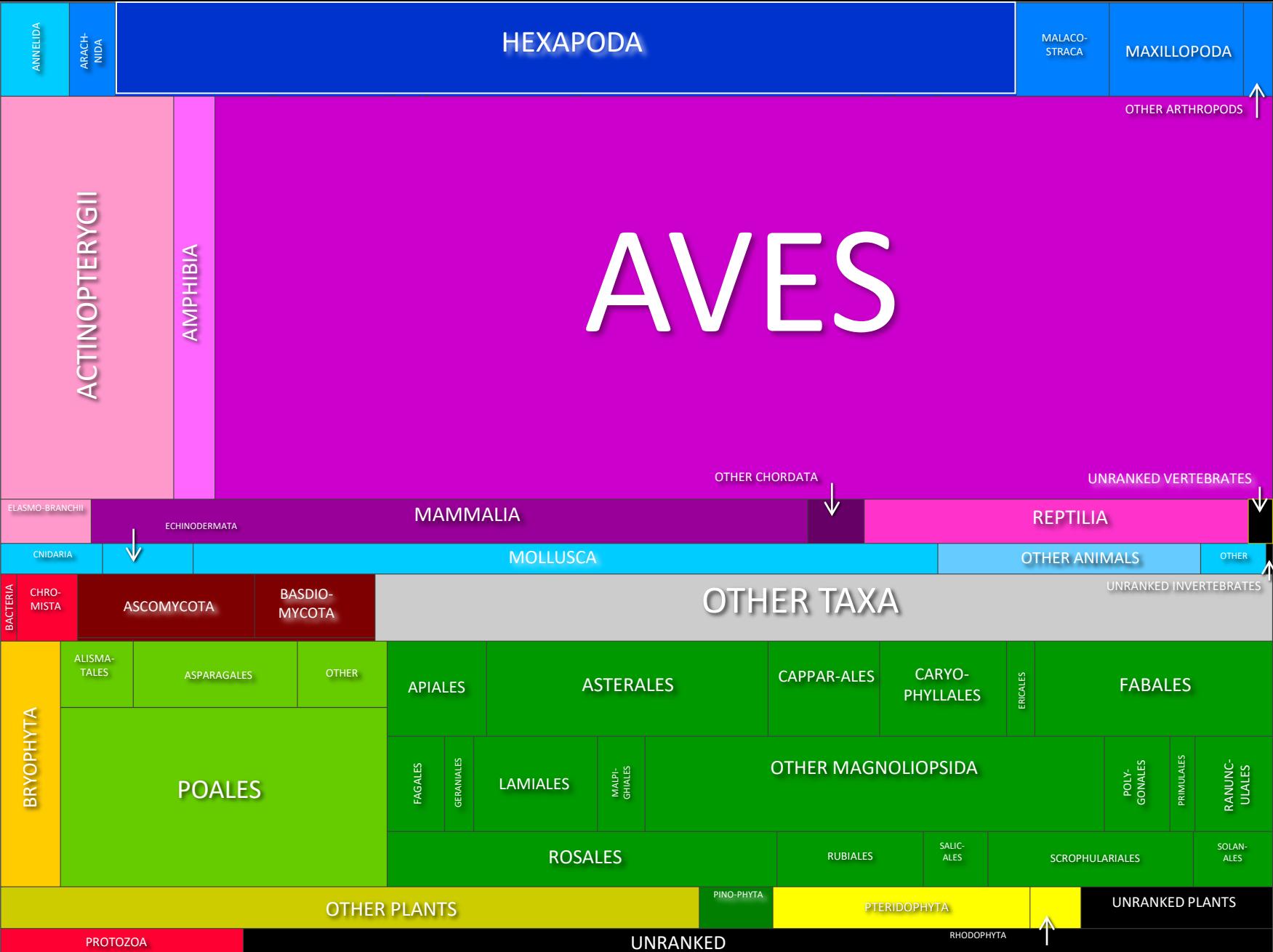
# PBR THROUGH THE AGES

1 349 369 926



< 1800 . 1820 . 1840 . 1860 . 1900 . 1920 . 1940 . 1960 . 1980 . 2000 . 2020 >

PBR: Primary Biodiversity Data Record. What, where, and when an organism was found.



# BDS VERSUS OTHER DS

## Biodiversity Data Science

- Records: Gigascale+
- Very rich records
- Handling unit is the individual record
- Loose record interconnection

## Environmental Data Science (example)

- Records: Terascale+
- Relatively simple records
- Handling unit is the dataset
- Strong record linkage within dataset

# EXAMPLE: THE LIFE+RESPIRA PROJECT



# ROAMING A CITY

30 months

200 volunteers

20,000 trips

47,000 bike km

15,000 car km

16,000 hours moving

3,500 runs with fitbits

77,000 hours gathering data

5 million samples

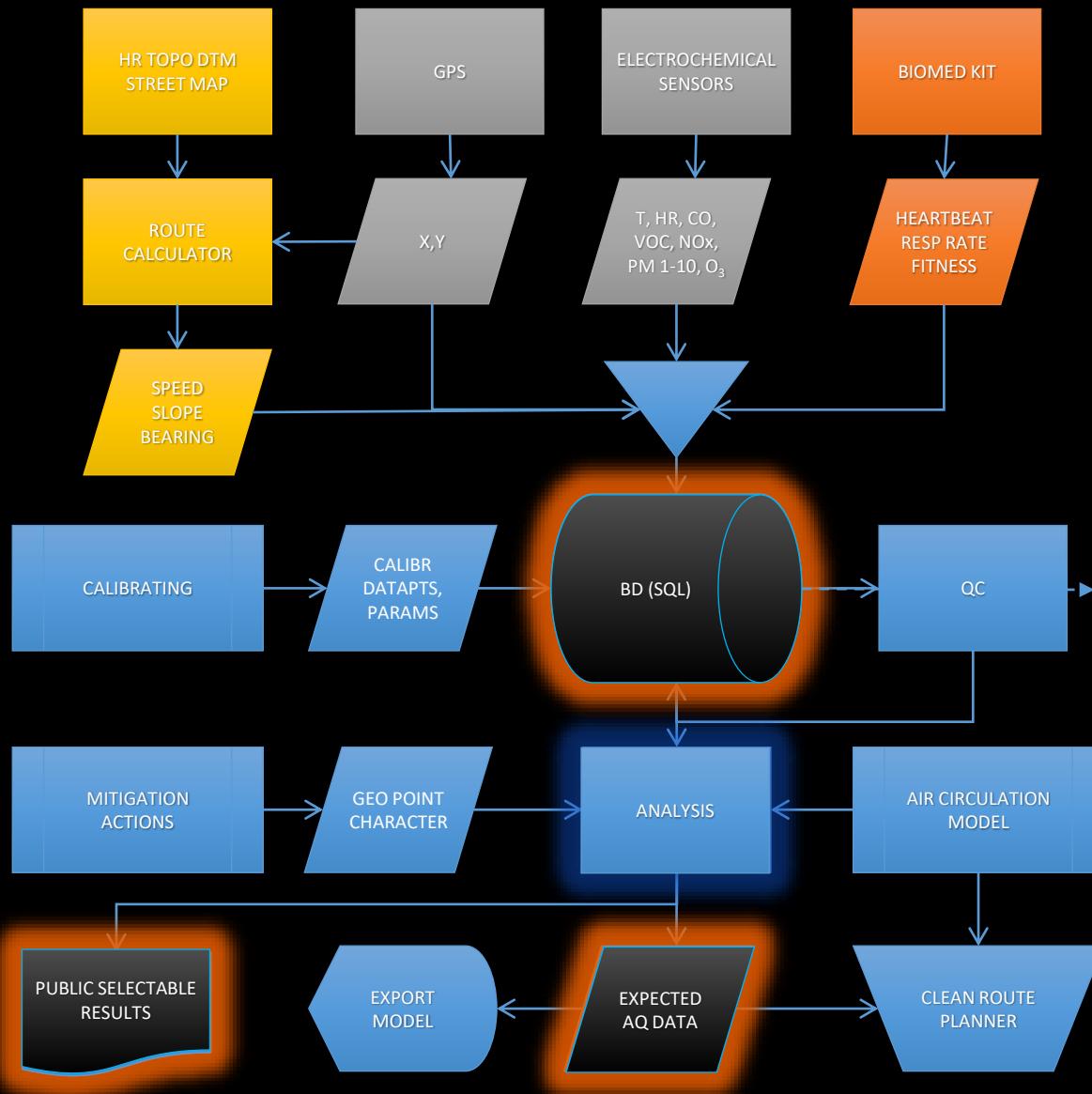
4 million geolocations

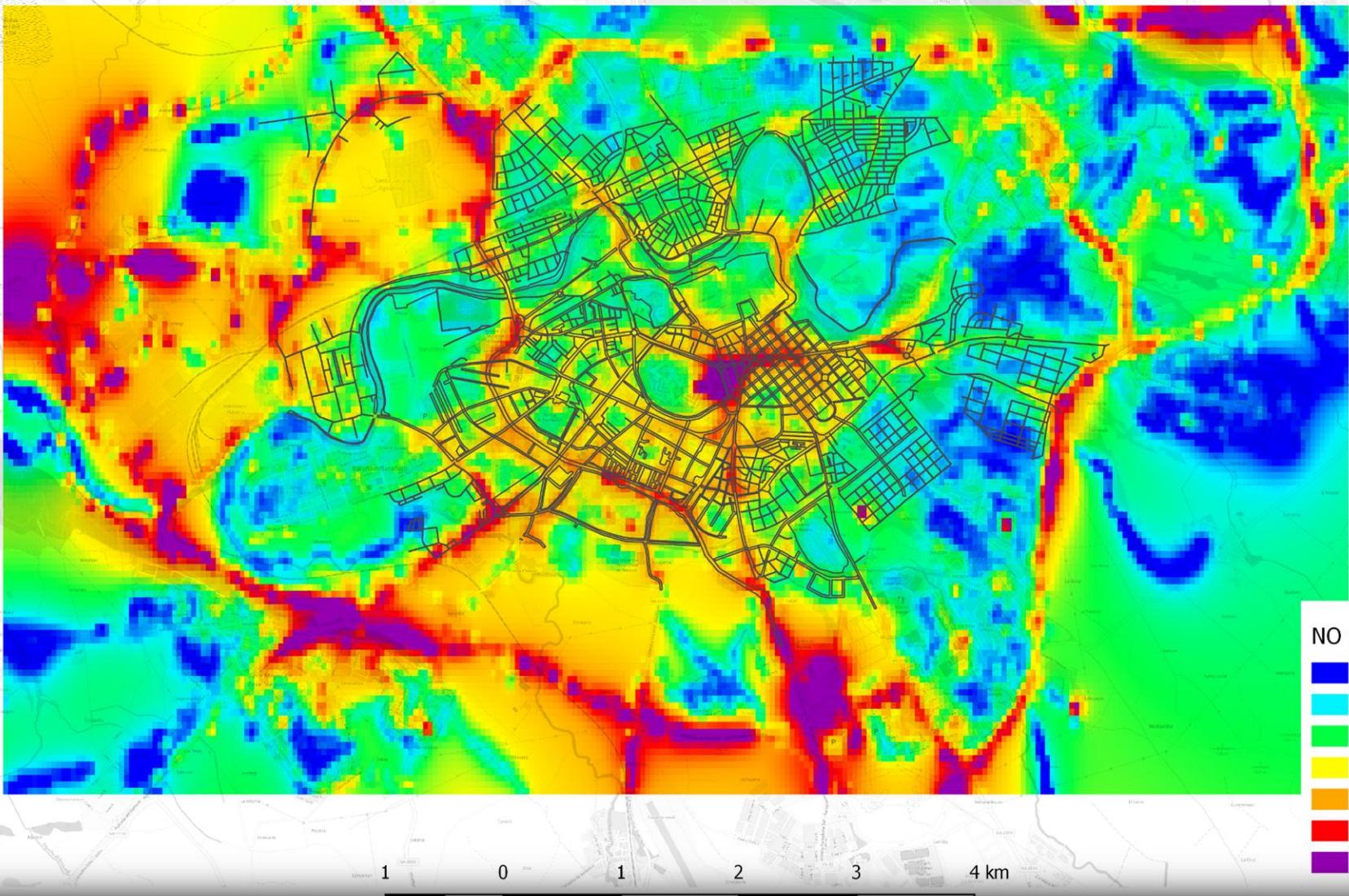
13 million measurements

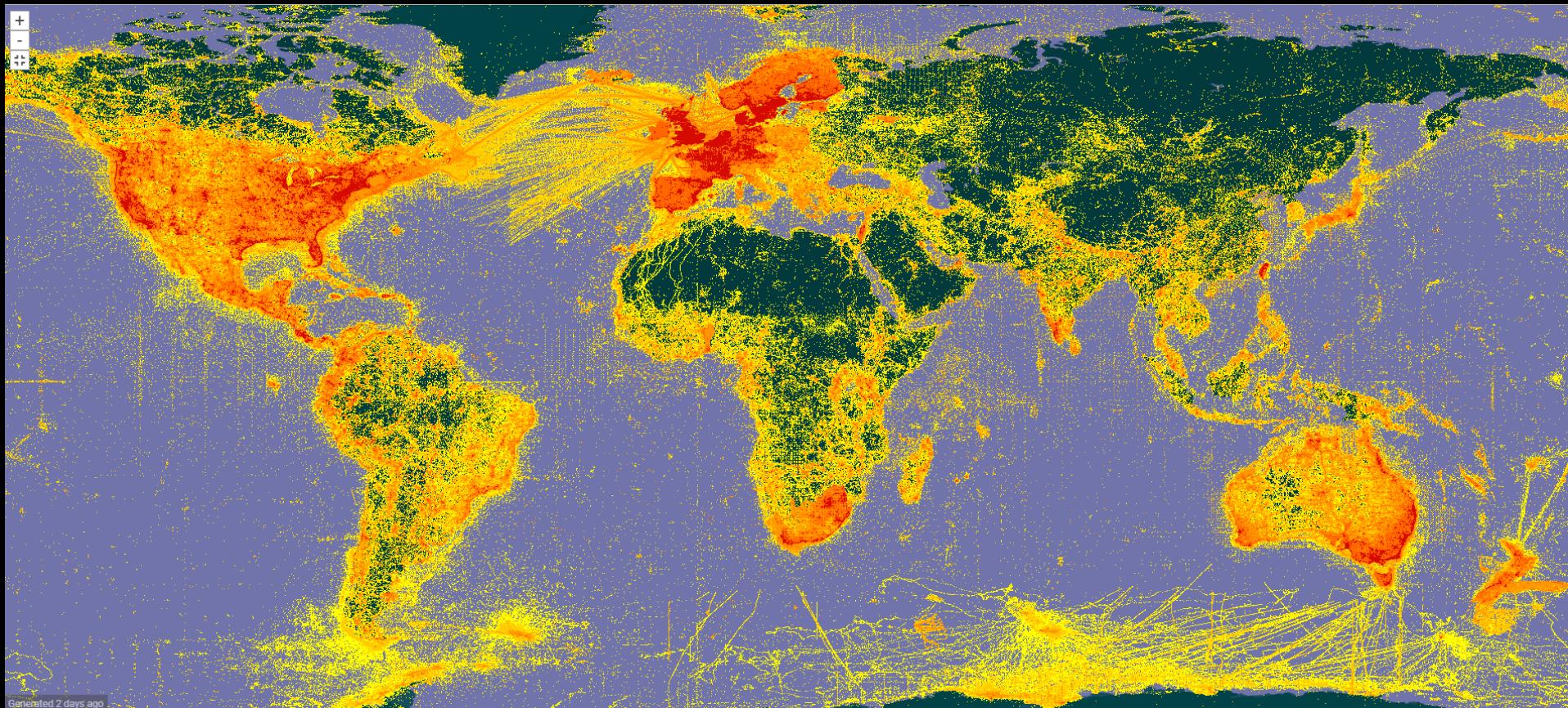
150 million data

1000 million reads







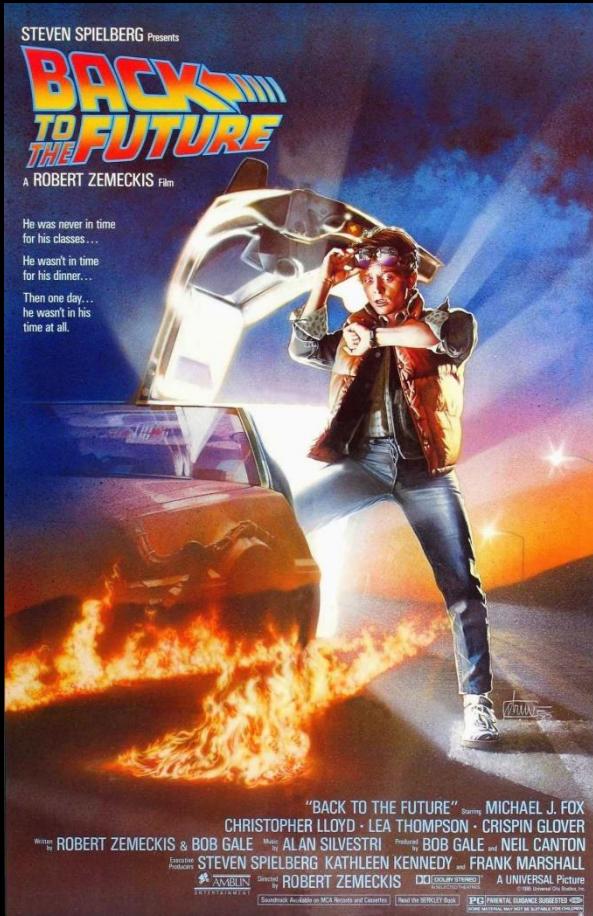


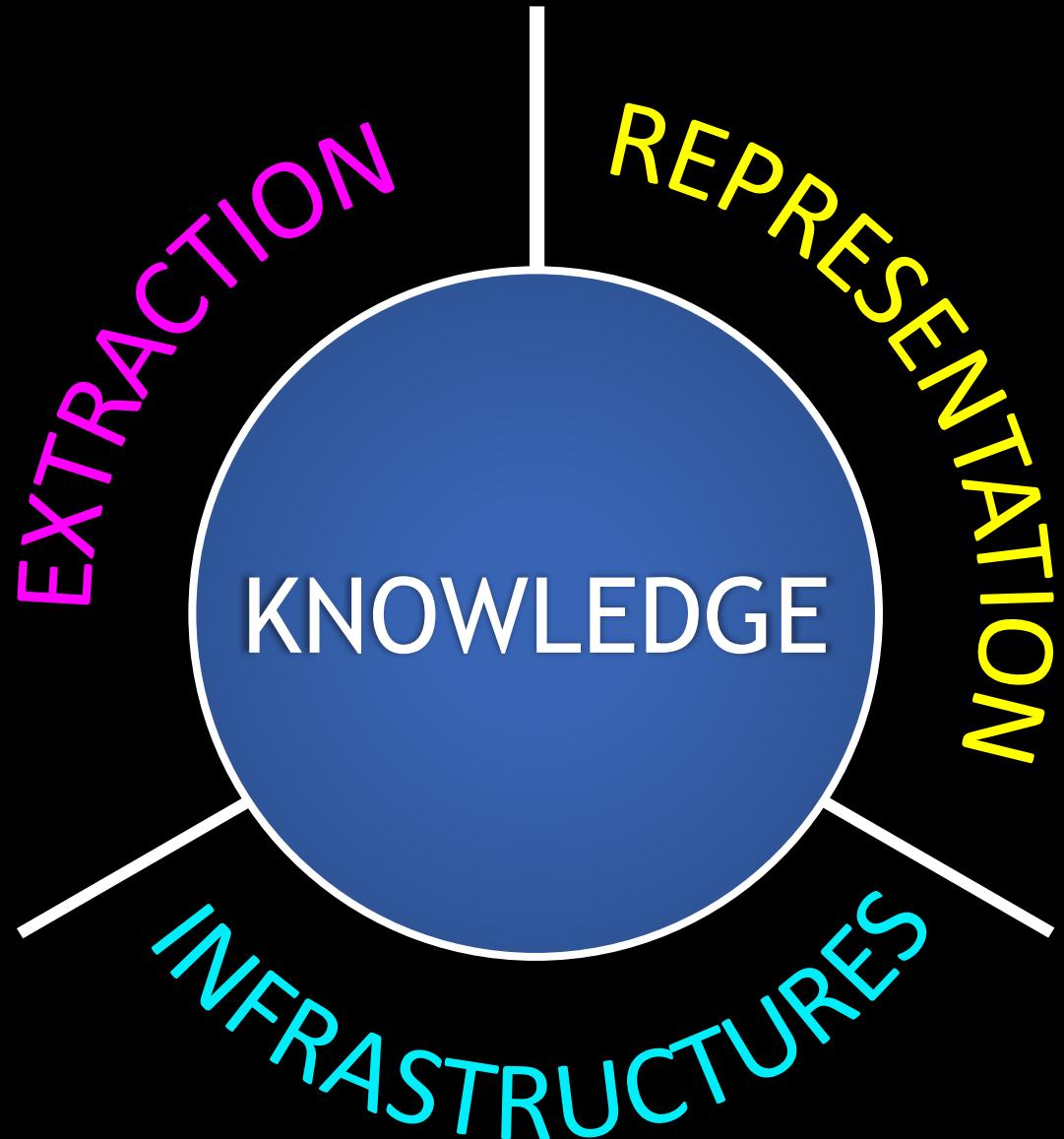
LIFE+RESPIRA:  
LOCAL PROJECT  
150 M GEOLOCATED TUPLES

EARLY GBIF (2008):  
GLOBAL PROJECT  
150 M 236-FIELD RECORDS

# THE FUTURE

# DS: THREE FUTURE FACETS





# DS: SEVEN BIG QUESTIONS



# DS: SEVEN BIG QUESTIONS

1. Data flooding
2. Quality, trust, and fitness (QTF)
3. Transversal de-siloing
4. Reproducibility and recall
5. Data stewardship
6. Automation and services
7. Development and evolution



# THE K-D MATRIX

Under-developed

developing

established

NOW

	K-EXTRACTION	K-REPRESENTATION	K-INFRASTRUCTURES
D-FLOODING			
D-QTF			
D-DESILOING			
D-REPLICABILITY			
D-STEWARDSHIP			
D-AUTOMATION			
D-EVOLUTION			

[Explora](#)[Comunidad](#) ▾[Más](#) ▾

iNaturalist encourages everyone to take appropriate precautions (both indoors and outdoors) during the COVID-19 pandemic for personal safety and public health. There are still plenty of ways to explore nature from home. Click [here](#) for ideas!



Faerthen Felix - Western Snakeroot de Sagehen Creek, California, USA



CALIFORNIA  
ACADEMY OF  
SCIENCES



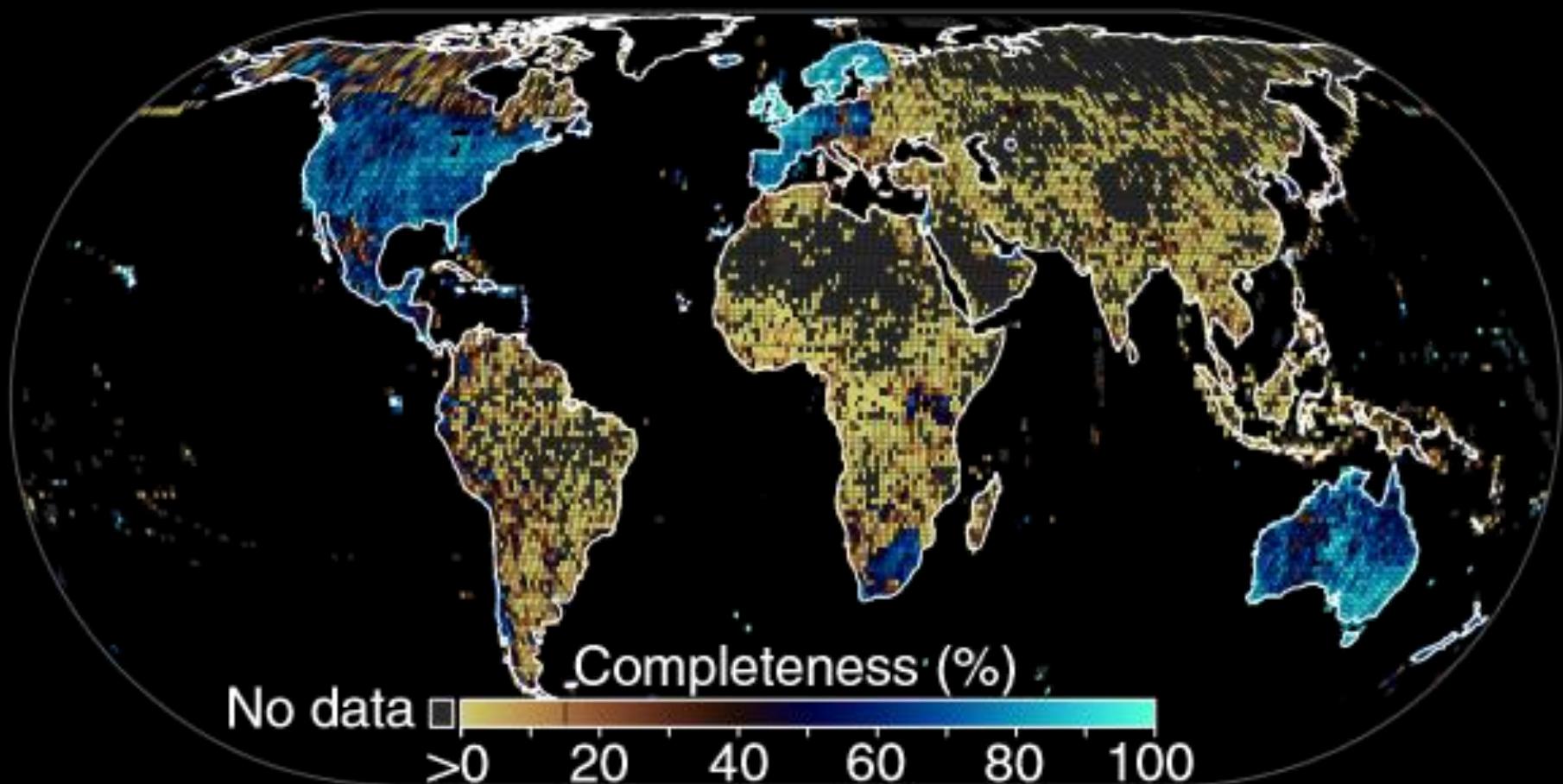
NATIONAL  
GEOGRAPHIC

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# THE K-D MATRIX

NOW

	K-EXTRACTION	K-REPRESENTATION	K-INFRASTRUCTURES
D-FLOODING	CS, crowdsourcing	maps, summary plots	CS platforms
D-QTF	Mostly ad-hoc	developing: ignorance maps	annotations
D-DESILOING	Test-level	underdeveloped	Aggregators, crawlers e.g. EoL, openUP
D-REPLICABILITY	n/a or problematic	doi for datasets, standards, metadata	doi, persistent repositories
D-STEWARDSHIP	IPT	Virtual notebooks	GBIF
D-AUTOMATION	opportunistic	plugins, dashboards	DOIP, GHR
D-EVOLUTION	CS: iNaturalist	EOL	Post-GBIF?



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Global access to knowledge about life on Earth



Convergent Lady Beetle



Cliff Chipmunk



Ostrich fern



Greater Blue-ringed  
Octopus



*Nostoc linckia*



*Eucyclops speratus*  
(Lilljeborg 1901)



Christmas tree worm



Spined Micrathena



octopus stinger



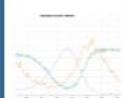
Join the  
discussion!  
feedback and  
bio-chatter



Biodiversity  
Cards  
View, print or  
make cards



Try a Data  
Search  
nocturnal fruit-  
feeders



Trait based  
models  
in the VERA  
modeling tool

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EOL is hosted by:

NATIONAL  
MUSEUM of  
**NATURAL  
HISTORY**  
Smithsonian

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# Darwin Core quick reference guide

This page provides a list of all currently recommended terms of the Darwin Core standard. Categories such as `Occurrence` or `Event` correspond to Darwin Core classes which group other terms. Convenient [files of these terms](#) and [their full history](#) can be found in the [Darwin Core repository](#).

## Record-level

<code>type</code>	<code>modified</code>	<code>language</code>	<code>license</code>	<code>rightsHolder</code>	<code>accessRights</code>	<code>bibliographicCitation</code>	<code>references</code>	<code>institutionID</code>	<code>collectionID</code>
<code>datasetID</code>	<code>institutionCode</code>	<code>collectionCode</code>	<code>datasetName</code>	<code>ownerInstitutionCode</code>	<code>basisOfRecord</code>	<code>informationWithheld</code>			
<code>dataGeneralizations</code>	<code>dynamicProperties</code>								

<b>type</b>		Property
Identifier	<a href="http://purl.org/dc/terms/type">http://purl.org/dc/terms/type</a>	
Definition	The nature or genre of the resource.	
Comments	Must be populated with a value from the DCMI type vocabulary ( <a href="http://dublincore.org/documents/2010/10/11/dcmi-type-vocabulary/">http://dublincore.org/documents/2010/10/11/dcmi-type-vocabulary/</a> ).	
Examples	<code>StillImage</code> , <code>MovingImage</code> , <code>Sound</code> , <code>PhysicalObject</code> , <code>Event</code> , <code>Text</code>	
<b>modified</b>		Property
Identifier	<a href="http://purl.org/dc/terms/modified">http://purl.org/dc/terms/modified</a>	
Definition	The most recent date-time on which the resource was changed.	
Comments	Recommended best practice is to use a date that conforms to ISO 8601:2004(E).	
Examples	<code>1963-03-08T14:07-0600</code> (8 Mar 1963 at 2:07pm in the time zone six hours earlier than UTC). <code>2009-02-20T08:40z</code> (20 February 2009 8:40am UTC). <code>2018-08-29T15:19</code> (3:19pm local time on 29 August 2018). <code>1809-02-12</code> (some time during 12 February 1809). <code>1906-06</code> (some time in June 1906). <code>1971</code> (some time in the year 1971). <code>2007-03-01T13:00:00Z/2008-05-11T15:30:00Z</code> (some time during the interval between 1 March 2007 1pm UTC and 11 May 2008 3:30pm UTC). <code>1900/1909</code> (some time during the	

Record-level  
 Occurrence  
 Organism  
 MaterialSample  
 Event  
 Location  
 GeologicalContext  
 Identification  
 Taxon  
 MeasurementOrFact  
 ResourceRelationship  
 UseWithIRI

LivingSpecimen  
 PreservedSpecimen  
 FossilSpecimen  
 HumanObservation  
 MachineObservation

# THE K-D MATRIX

NOW

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GBIF | Global Biodiversity Information Facility

# Acceso libre y gratuito a los datos de biodiversidad

[OCCURRENCES](#)[SPECIES](#)[DATASETS](#)[PUBLISHERS](#)[RESOURCES](#)Search[WHAT IS GBIF?](#)[ABOUT GBIF SPAIN](#)*Labrador tea (*Rhododendron groenlandicum*) collected in Saint Pierre and Miquelon. Photo: Muséum national d'Histoire Naturelle - Paris.*

## Occurrence records

1.400.658.738

## Datasets

51.862

## Publishing institutions

1587

## Peer-reviewed papers using data

4372



News



Data use

Call for nominations to the 2020  
GBIF Young Researchers Award

Relying on biodiversity science to  
inform art history



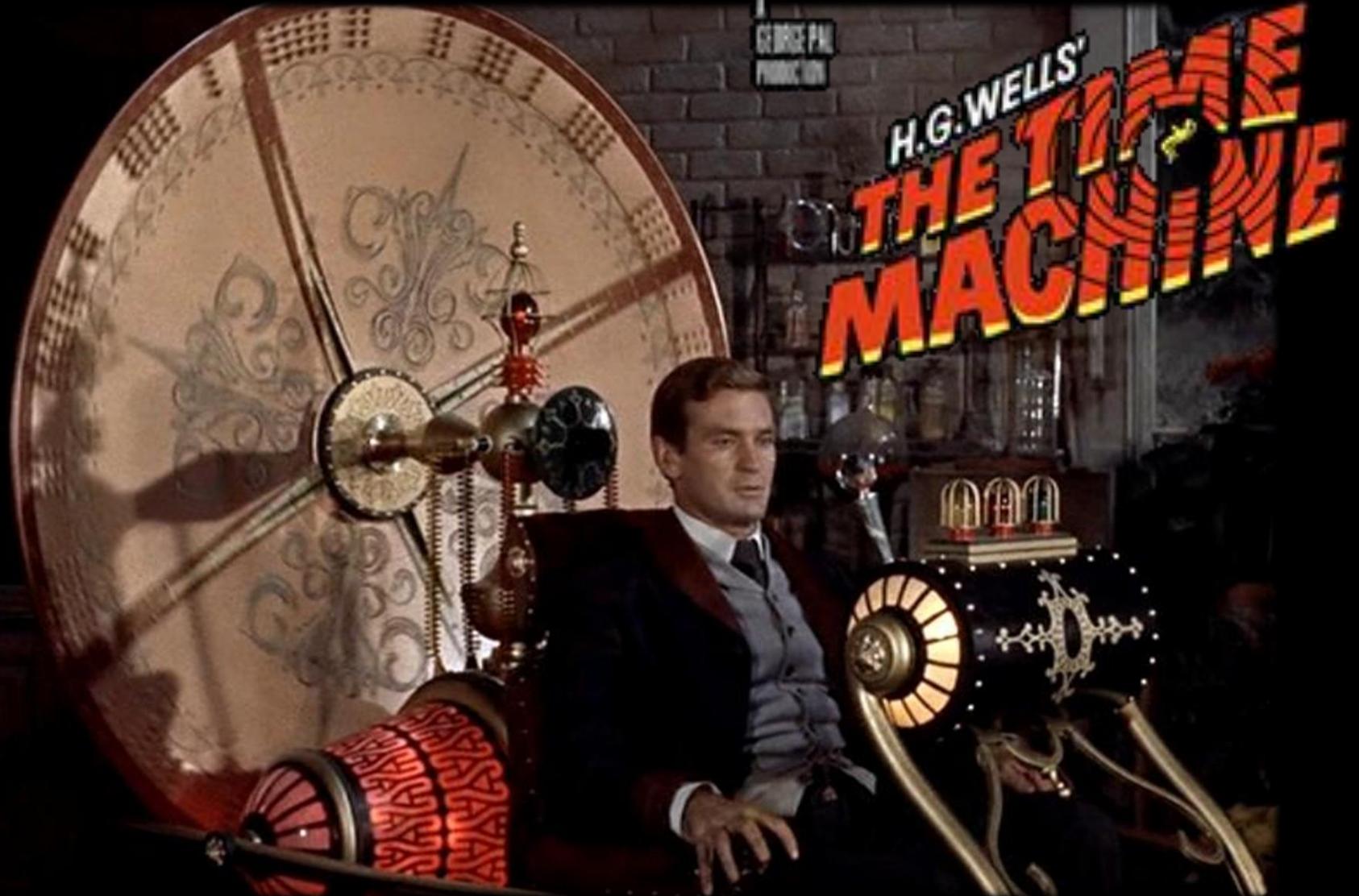
News

2020 Ebbe Nielsen Challenge  
seeks open-data innovations for  
biodiversity



News

Biodiversity Summit 2020  
postponed



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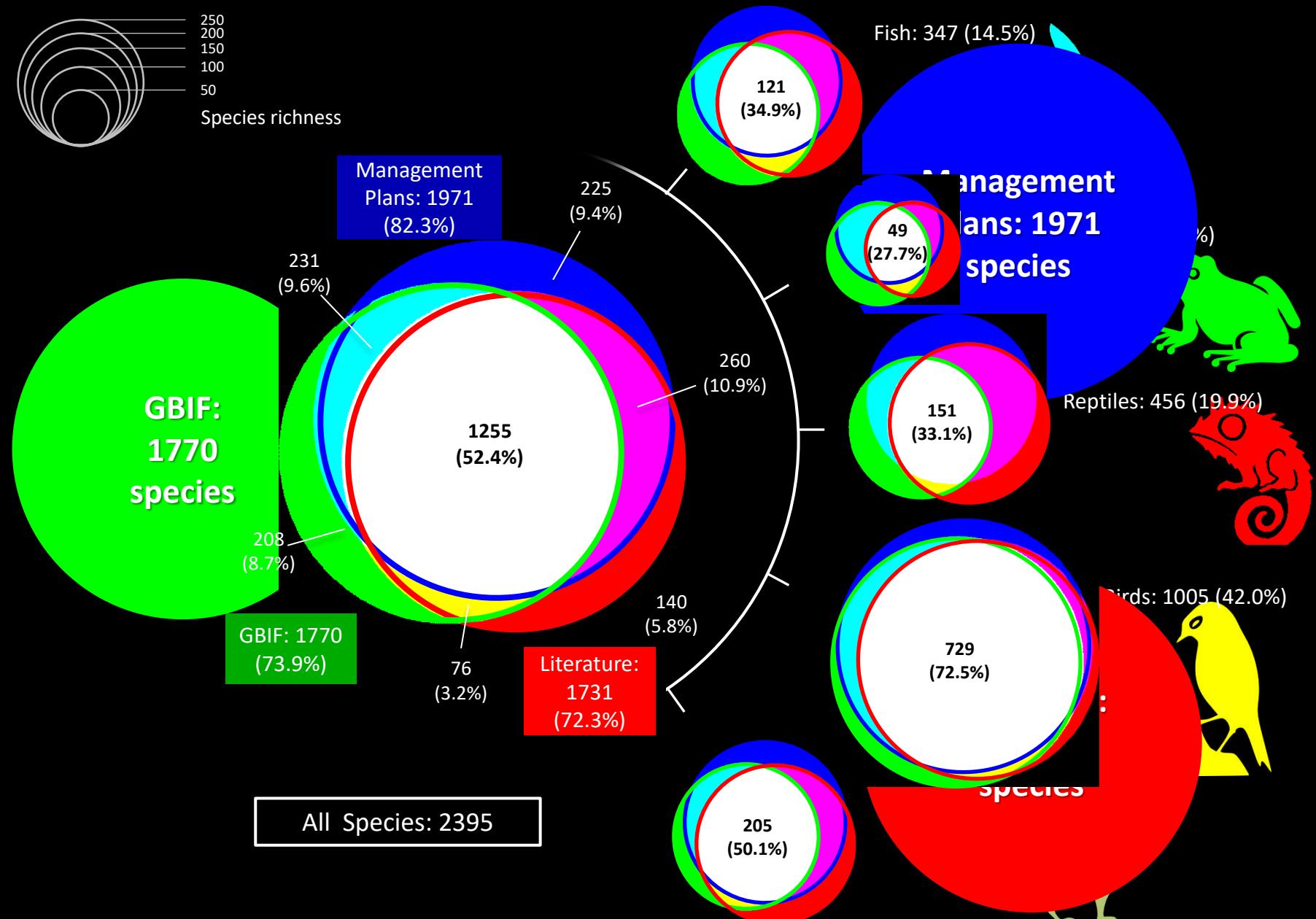
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D-REPLICABILITY	AI-enabled proxying	Automated provenance plotting	Open Science Peerage
D-STEWARDSHIP	AI-enabled semantics	Embedded analytics	EOSC/EUDAT, DiSSCo
D-AUTOMATION	IoT, RS, Intelligent Assistants	LW-ERIC and the like	PAAS
D-EVOLUTION	AAAS?		Autonomous AAAS?

sooner

later



## MEXICO : BIOSPHERE RESERVES : VERTEBRATES



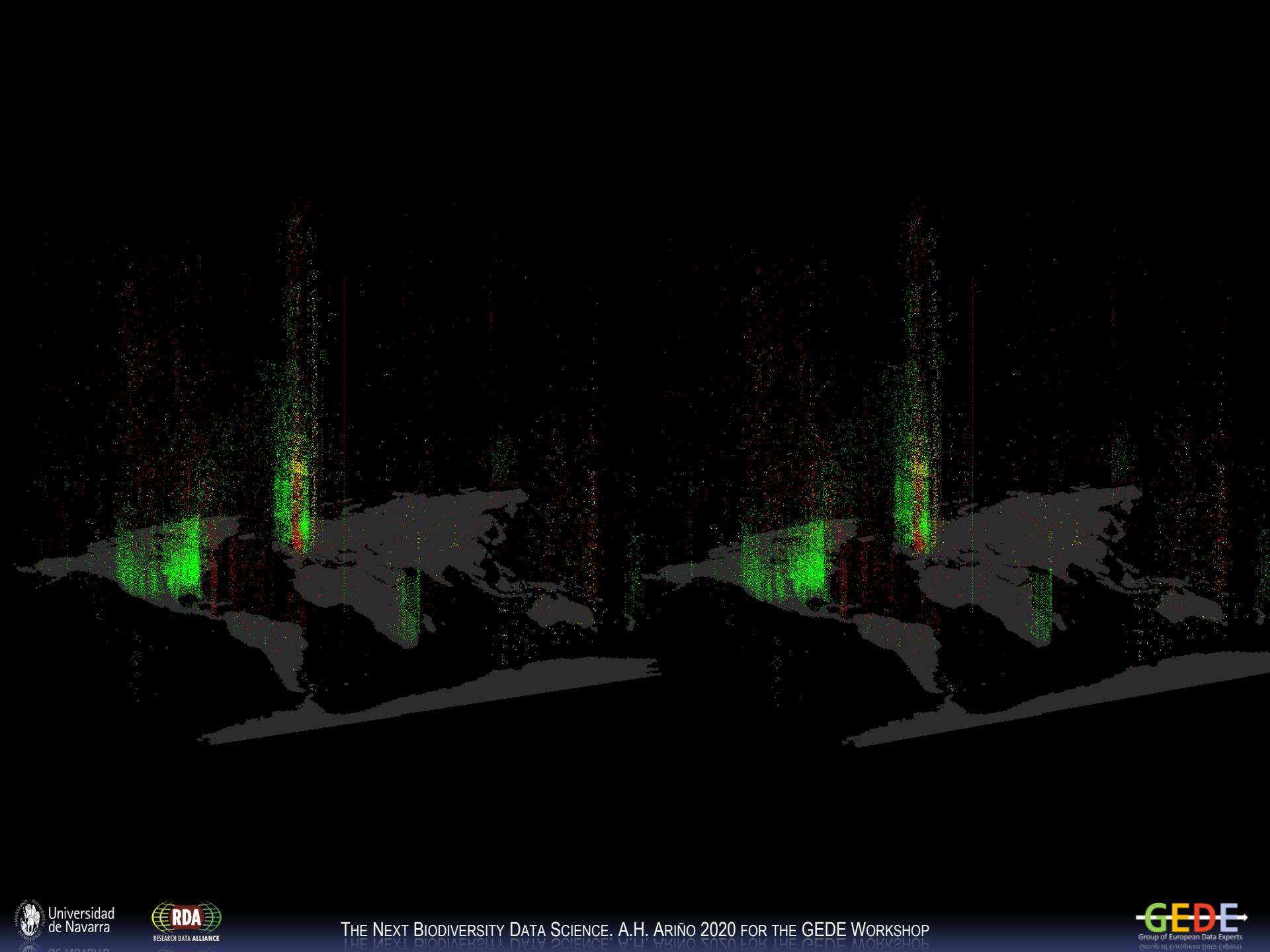
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## Use cases

[Home](#) » Use cases

All

Basic Medicine

Biological Sciences

Clinical Medicine

Earth and related environmental sciences

Languages & Literature

Mathematics and computer sciences

Media and communications

Medical biotechnology

Multi-disciplinary

Nano-technology

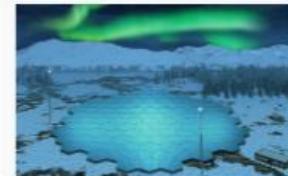
Physical Sciences



EUDAT services to guarantee long time archiving and visibility to the repository of IST Austria



Central online location for data sharing for all Aalto University researchers



Unified Access to EISCAT radar data



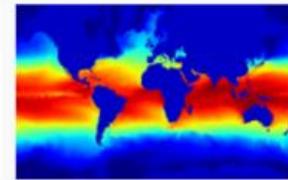
Long-term preservation of herbarium specimen images



High resolution simulations for Precision Cosmology



European Long Term Ecological Research Network



Support to scientific research on seasonal-to-decadal climate and air quality modelling



An EUDAT-based FAIR Data Approach for Data Interoperability



## COVID19 | Epidemiology & data support

The COVID-19 pandemic is hitting our society and citizens hard, in Europe and all over the world, generating a health crisis whose proportions and impacts have no precedent in recent ...

[Read More...](#)

## Resources & Services

### Virtual Labs



### Data Portal



### Catalogue of Services



# Distributed System of Scientific Collections

Providing hard evidence on our planet's  
natural diversity

[Read on »](#)

The DiSSCo environment  
**A worldwide infrastructure**



# THE CAVEATS

# (B)DS: 12 CRITICAL ISSUES



©MGM

# (B)DS: 12 CRITICAL ISSUES

1. Opportunistic data
2. Critical data mass
3. Remote sensing
4. OMICs inflow
5. Non-primary data
6. Data loops
7. Data persistence
8. FAIRness
9. Sensitive data
10. Artificial Inference
11. Exchange standards
12. Dark data



# THE K-D MATRIX

low impact/  
on track/  
n/a

development  
required

critical

	Flooding	QTF	De-siloing	Replicability	Stewardship	Automation	Evolution
Opportunistic data		confidence					
Critical data mass	inference	crosschecks					
Remote sensing			harvesting		repo dispersion		IOT
OMICs inflow							meta genomics
Non-primary data		uncertainty	discipline mistrust				
Data loops	secondary PBR				ad-hoc	intensive analytics	long shot
Data persistence			own silos	LSID, DOs	DOIP		
FAIRness				increase metadata	attribution	enforce compliance	
Sensitive data	new in game	generalization	regulations				increased concerns
Artificial Inference		reliability	data source identification			strict dependency	
Standards		Need expansion		indispensable		necessary	
Dark data					digitization		Time-critical

### List the ways in which you use Primary Biodiversity Data

[You do] acces primary biodiversity data [through:]

	Your own field works/surveys	Hardcopy, literature survey (non-digital form)	Primary Publications (e.g. taxonomic monographs, maps of species observations)	Other web based data portals	The GBIF Data Portal ( <a href="http://data.gbif.org">http://data.gbif.org</a> )	Access to offline digital data sets (CDROM/DVD/Tapes etc.)	Free and open datasets within and outside of your institution	Reciprocal agreements with other groups/individuals	Institutional agreements	Payment basis	Others	FTP sites
Species diversity and populations	370	335	320	172	157	126	120	104	70	20	22	8
Taxonomy	369	335	328	172	158	122	120	100	65	18	23	8
Life histories and phenologies	366	318	310	176	140	146	128	106	70	20	26	8
Biogeographic studies	337	310	309	162	150	117	109	101	63	14	20	6
Endangered, migratory and invasive Species	270	250	243	136	124	107	108	84	60	19	21	9
Ecology, Evolution and Genetics	269	235	229	124	108	87	83	72	49	16	16	5
Conservation Planning	194	183	173	98	87	86	86	66	49	14	9	5
Natural Resources Management	171	154	149	77	68	84	68	60	50	14	9	5
Education and Public Outreach	159	149	151	91	73	73	68	55	41	13	16	4
Impact of Climate Change	160	150	150	75	77	73	65	65	45	11	7	3
Environmental Impact Management	139	128	131	62	51	62	61	52	35	9	8	5
Sustainable Use	98	98	86	51	52	51	44	33	33	11	7	4
Agriculture, Fisheries, Forestry and Mining	98	89	89	42	42	42	41	33	24	10	1	2
Environmental regionalisation	77	76	76	40	40	39	36	34	24	4	3	3
Ecotourism	71	64	58	26	23	38	29	24	22	7	5	2
Bioprospecting	45	41	42	18	23	21	19	15	12	4	3	2
Forensics	40	32	30	16	15	11	17	11	8	4	1	
Recreation	30	30	23	16	12	18	16	7	10	3	1	
Border Control and Wildlife Trade	22	22	24	12	9	14	12	8	10	3	1	1
Health and Public Safety	24	24	19	11	9	11	10	10	7	5	3	1
Society and Politics	18	18	18	12	13	19	11	10	9	1	1	1
Human Infrastructure Planning	19	17	18	13	8	14	13	10	9	3		
Industrial Use	7	11	10	7	8	6	7	2	2	1		
Nursery and Pet Industry	12	11	11	7	1	4	5	2	3	1	2	1
Others (please specify)	3	5	2	6	2	1	3	2	1			



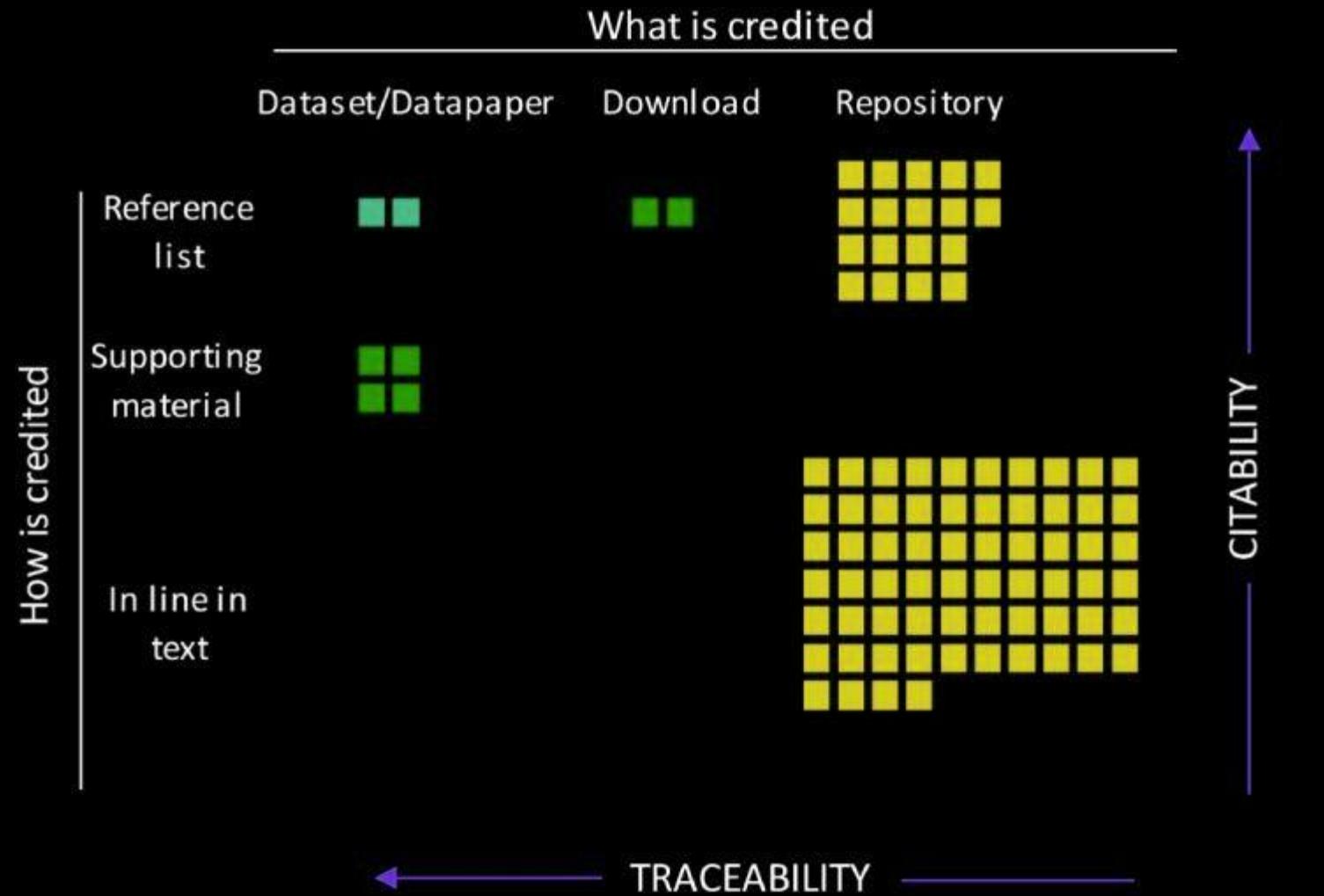
# THE K-D MATRIX

low impact/  
on track/  
n/a

development  
required

critical

	Flooding	QTF	De-siloing	Replicability	Stewardship	Automation	Evolution
Opportunistic data		confidence					
Critical data mass	inference	crosschecks					
Remote sensing			harvesting		repo dispersion		IOT
OMICs inflow							meta genomics
Non-primary data		uncertainty	discipline mistrust				
Data loops	secondary PBR				ad-hoc	intensive analytics	long shot
Data persistence			own silos	LSID, DOs	DOIP		
FAIRness				increase metadata	attribution	enforce compliance	
Sensitive data	new in game	generalization	regulations				increased concerns
Artificial Inference		reliability	data source identification			strict dependency	
Standards		Need expansion		indispensable		necessary	
Dark data					digitization		Time-critical



# THE K-D MATRIX

low impact/  
on track/  
n/a

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THE END

THANK YOU

No bytes were seriously harmed while preparing this PPTX.  
(And copies exist of those who actually were, anyway).  
This file used 328 watt-hours, offset by riding a bike for many years.

All images, plots and analyses by the author or other sources where noted.

Full literature available on request.

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