Ecoacoustic approaches for monitoring sites, habitats and species

Dr Carlos Abrahams

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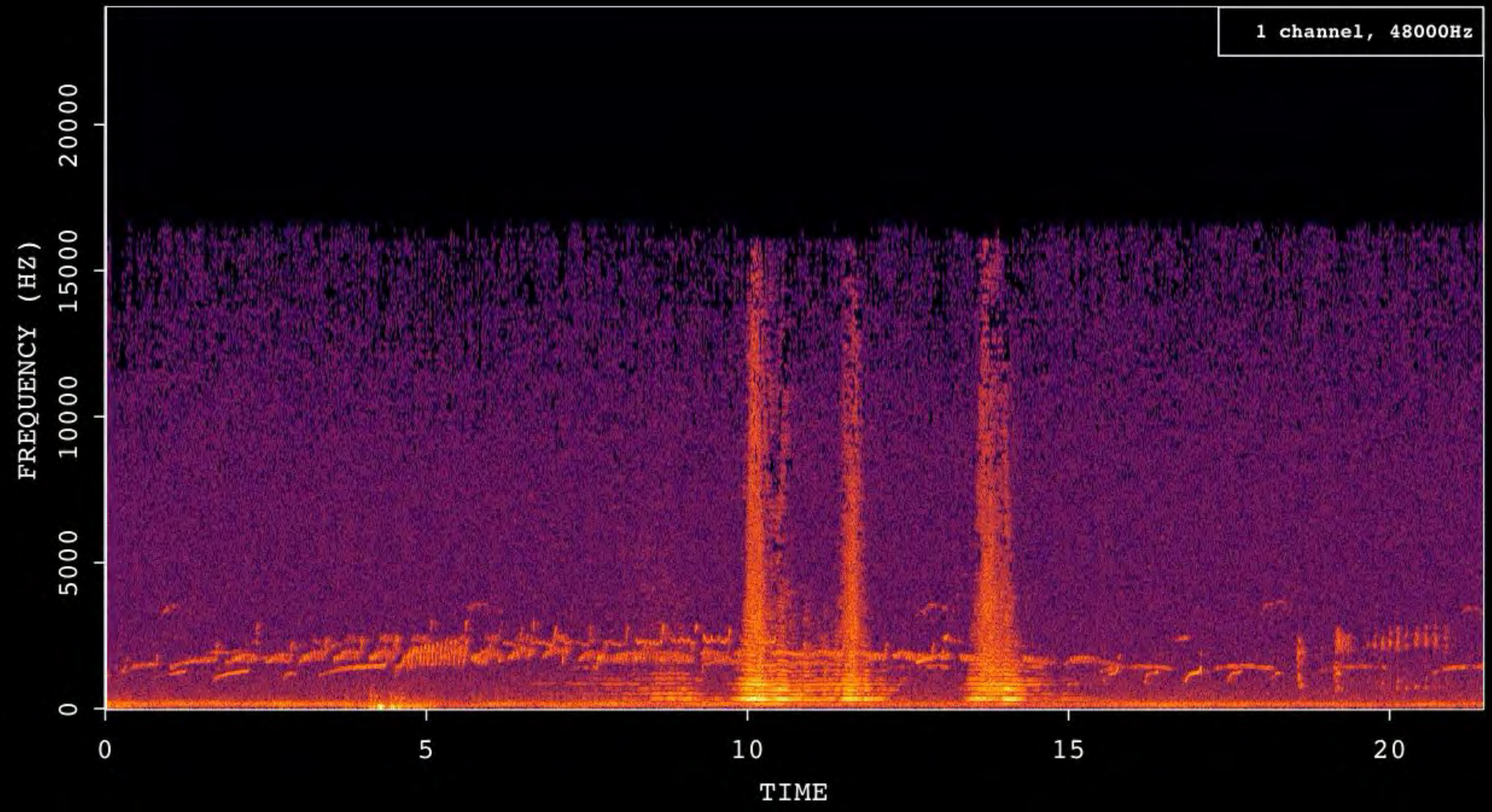
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TIME

Monitoring & new technologies

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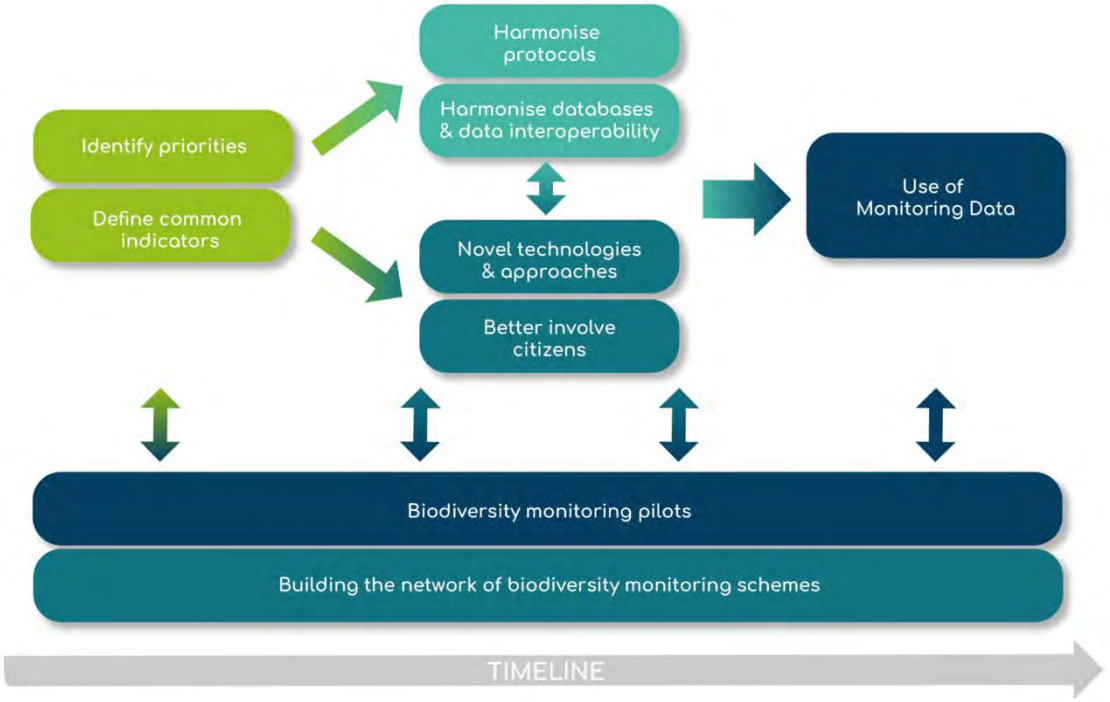
Home | About us | Action areas | Research funding | Actionable knowledge | Engagement | Resources

What are our actions in the field?

Biodiversa+ is working on six main areas:



Ramilo-Henry et al. (2024) Developing and deploying new technologies for biodiversity monitoring. in Biodiversa+. Biodiversa+ report. 29 + 34 p. URL: https://www.biodiversa.eu/

Bioacoustics

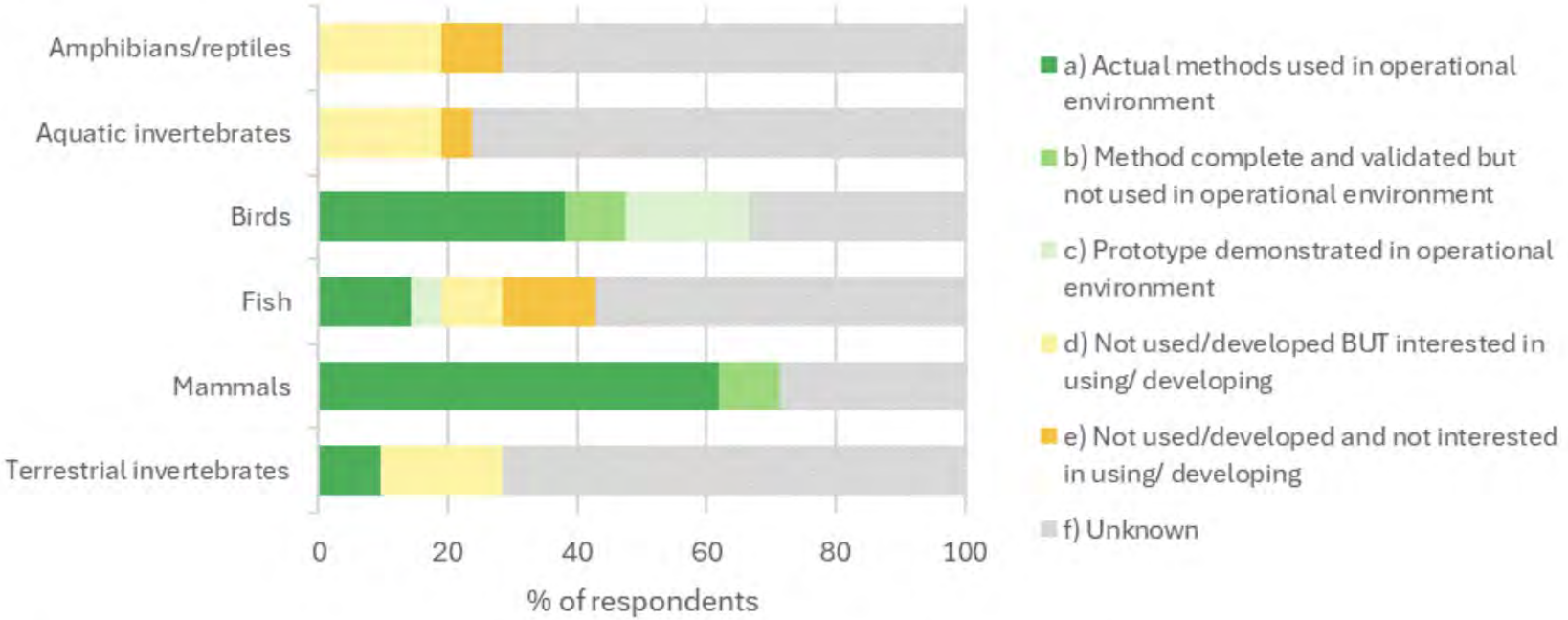
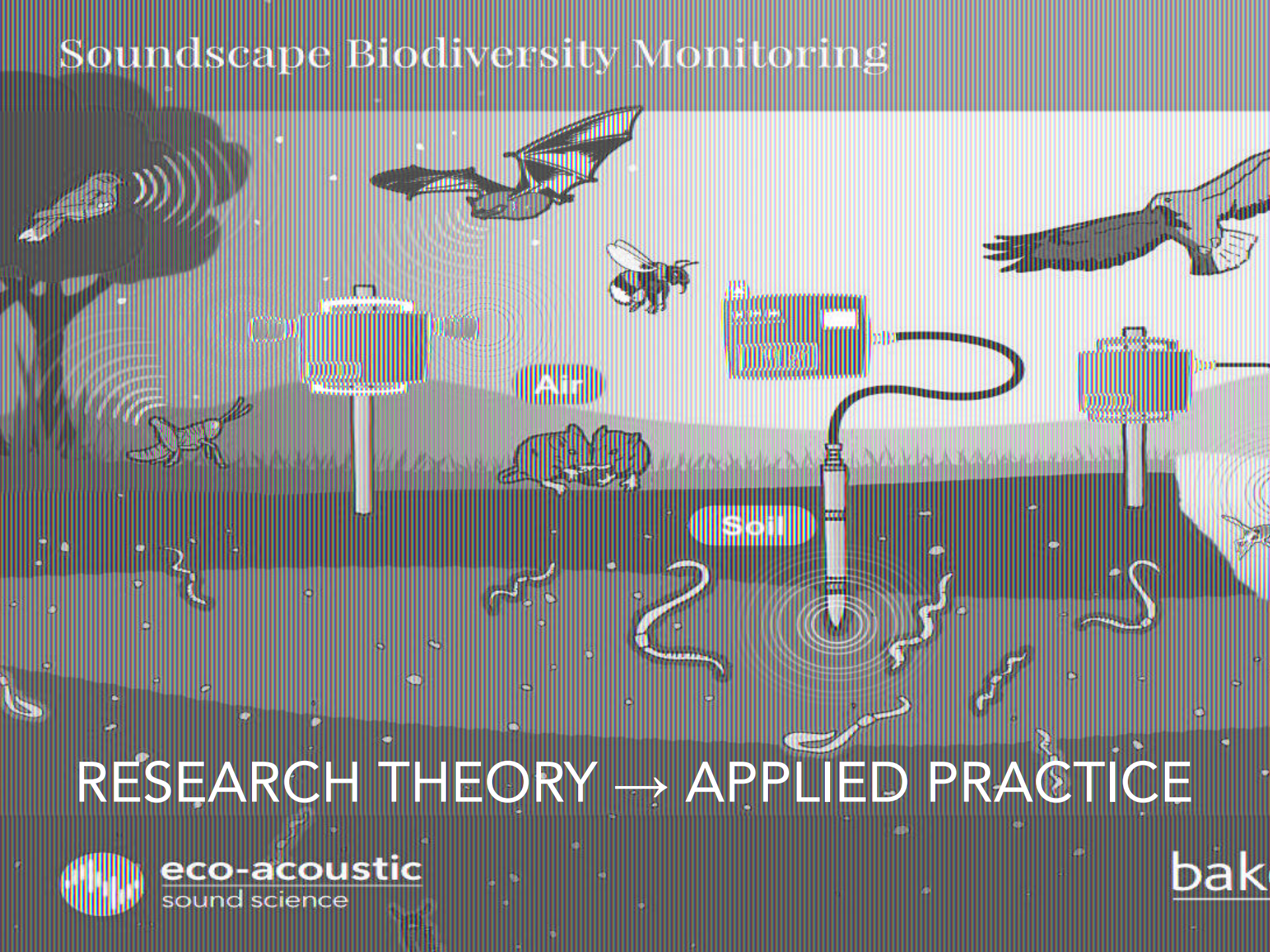
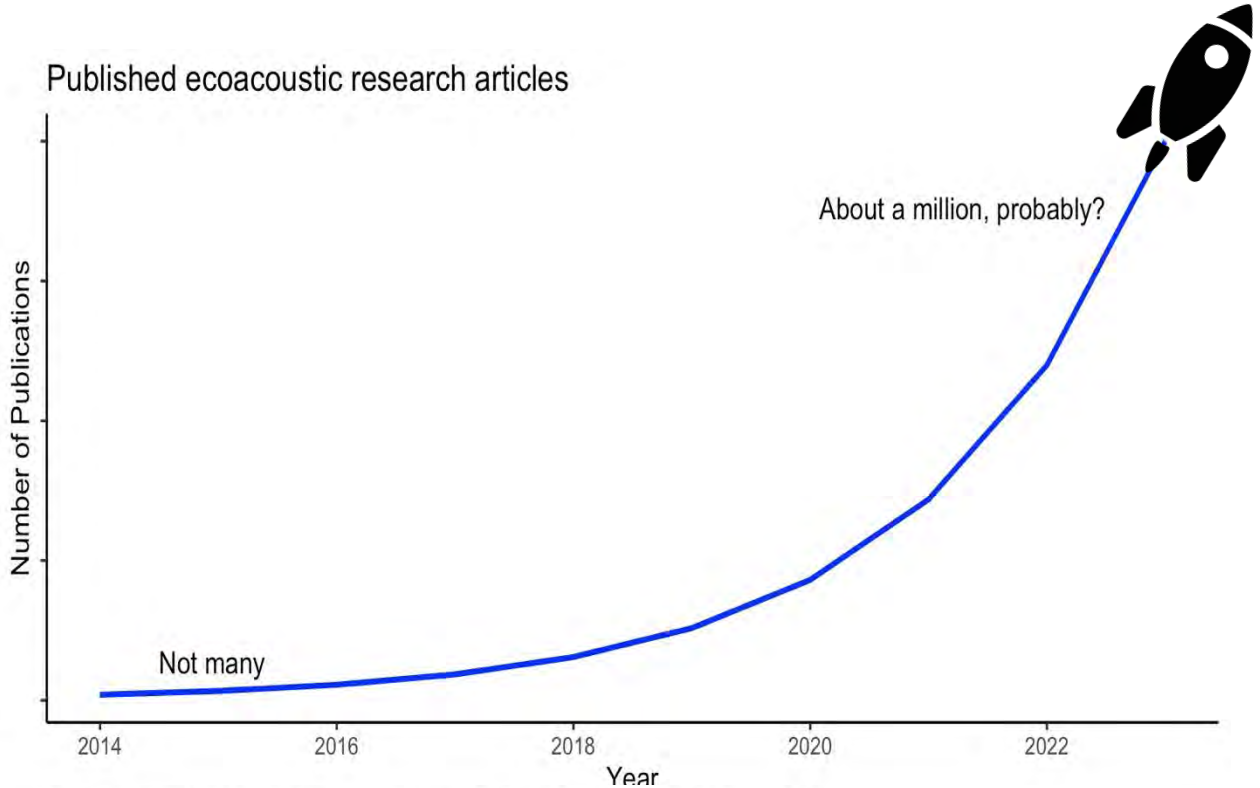
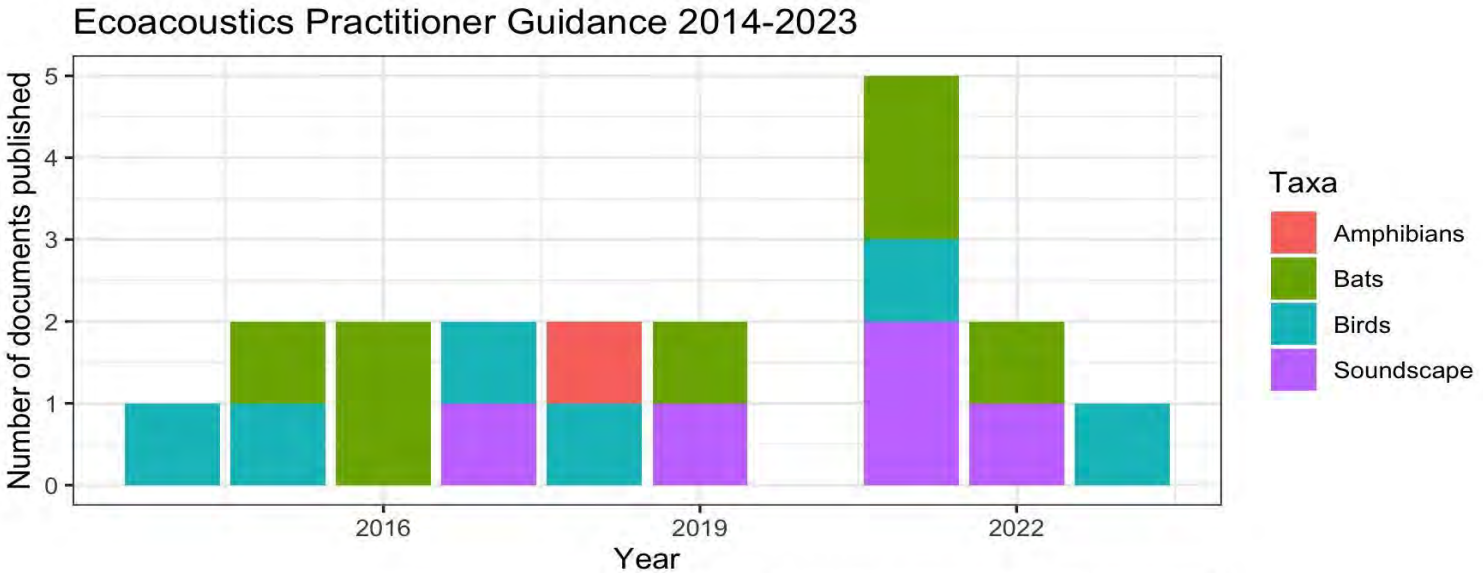


Fig. 3. Percentage of respondents from our survey that monitor the above taxa with novel bioacoustics methods and their level of deployment.


Soundscape Biodiversity Monitoring
AIR
Soil
RESEARCH THEORY → APPLIED PRACTICE
eco-acoustic
sound science
bak





Not including marine guidance or academic papers!

UK Bats – 1989-2004, 2009, 2012, 2016, 2023

EuroBats – 2010, 2014, 2017

Increasing reliance on evidence... and PAM

Table 8.3. Minimum recommended number of repeats for activity surveys.

Survey type	Low suitability habitat for bats[a]	Moderate suitability habitat for bats	High suitability habitat for bats
NBW	One survey visit[b] per season (spring – April/May, summer – June/July/August, autumn – September/October)[c]. Further surveys may be required if these visits, or the results of static detector surveys, reveal activity of interest that requires more observation on site.		
Automated/static bat detector surveys[d] The same locations should be used for each survey for comparison.	Data to be collected for a minimum of five consecutive nights per season (spring – April/May, summer – June/July/ August, autumn – September/October)[c] in appropriate (or the best available) weather conditions for bats.	Data to be collected for a minimum of five consecutive nights per month (April to October)[c] in appropriate (or the best available) weather conditions for bats.	

- *The Technical Review Board for this 4th edition debated the ongoing use of transects (which were recommended as standard in the 3rd edition), bearing in mind prevailing practice at the time of writing and efficacy in relation to cost.*
- *There are a number of papers comparing different survey methods. Many suggest that static surveys are more effective (Stahlschimidt and Bruhl (2012), Braun de Torrezet al.(2017) and Teetset al. (2019), whilst others conclude that a combination of methods is important (Perks and Goodenough(2021).*

2018

Figure 1. Bird vocalisations can be recorded to identify presence/absence, assess sites, and understand aspects of ecology. Photo credit Ryk Naves on Unsplash.

Bird Bioacoustic Surveys – Developing a Standard Protocol

2023

Acoustic bird surveys

Why use acoustic survey methods?

The characteristic songs and calls of birds can be readily captured in the field using automated or handheld sound recording systems. This information can then be used to determine factors such as species presence, population levels and behaviour. Handheld or *focal* recording allows audio data to be gathered for targeted birds by an observer present in the field, while automated or *passive acoustic monitoring* equipment can be programmed to remotely capture long-term data from a fixed location over weeks or months. The audio files recorded with either method can be listened to by ornithologists or analysed using a range of machine learning techniques to generate high quality ecological data. The automated acoustic methods set out below, like the standard survey methods within the main body of this guidance, seek to measure the avian diversity and the species present within an area, allowing the potential impacts of a project proposal to be assessed.

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ECOLOGYDEVELOPMENTINNOVATION

Ecoacoustic Bird Surveys: Comparison with traditional survey methods

White Paper September 2023

Carlos Abrahams, James Longley, Oliver Metcalf

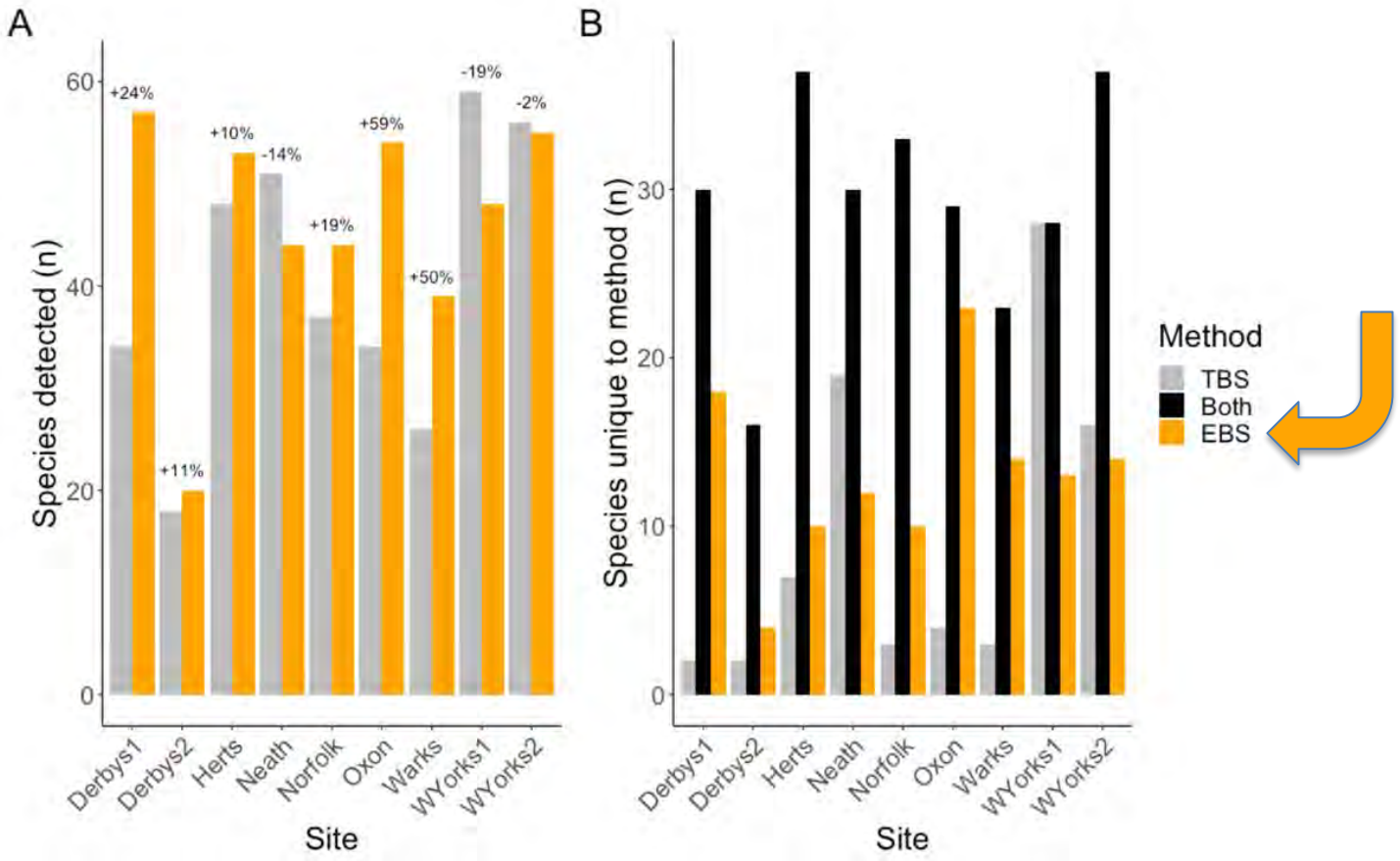

Figure 2. A comparison of bird species detected using traditional bird survey methods (TBS) and ecoacoustic bird survey methods (EBS).

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ECOLOGYDEVELOPMENTINNOVATION

Ecoacoustic Bird Surveys: Comparison with traditional survey methods

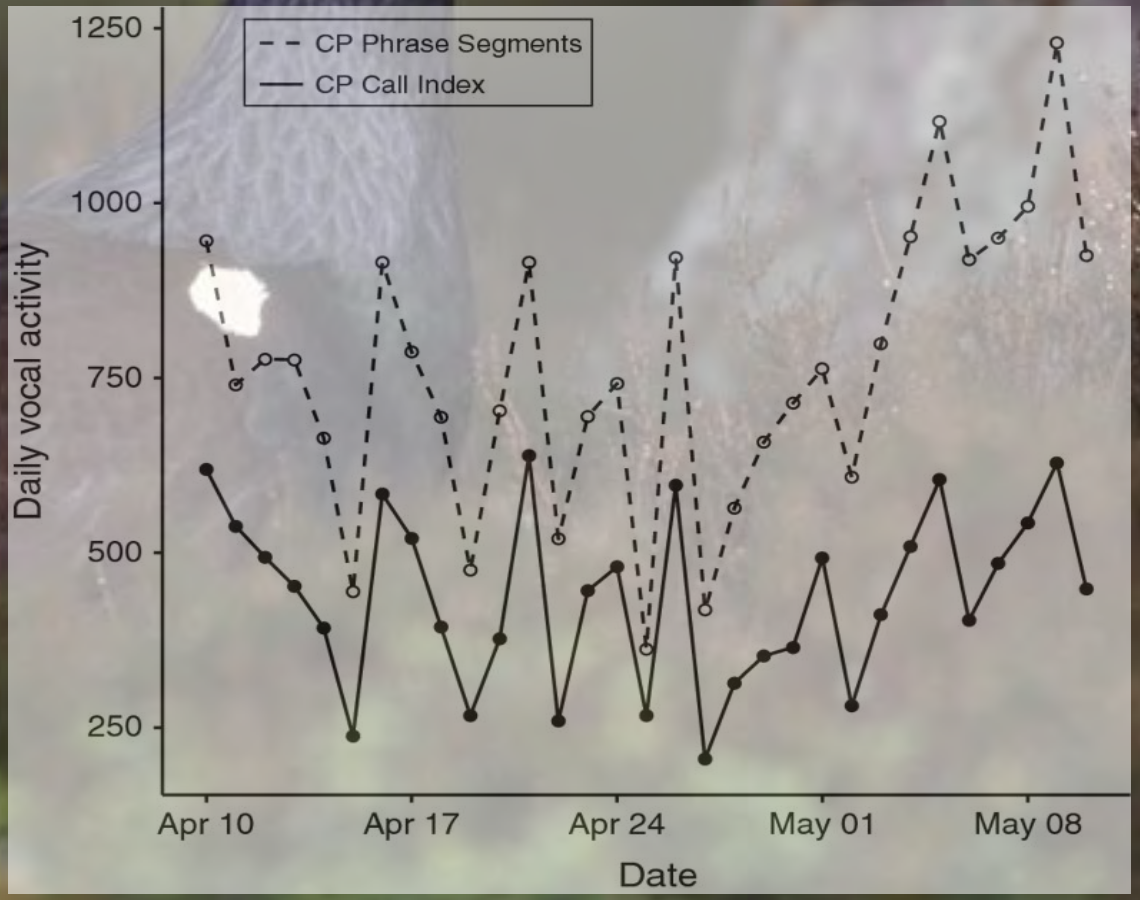
White Paper September 2023 Carlos Abrahams, James Longley, Oliver Metcalf

Table 1. Priority bird species only detected by ecoacoustic bird surveys

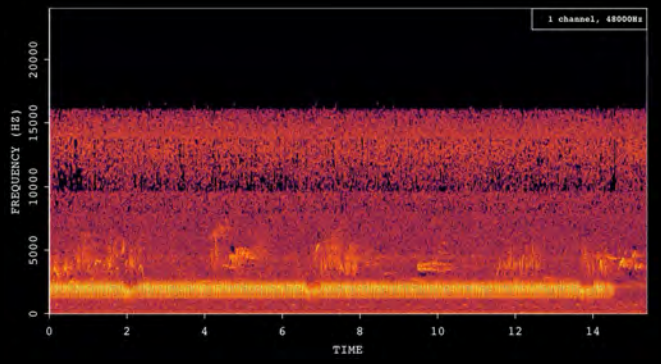
Site	Species detected only by ecoacoustic bird surveys Red/amber=status in *Birds of Conservation Concern 5*, black=Schedule 1 of the Wildlife and Countryside Act 1981
Derbyshire 1	Barn Owl, Grey Wagtail, Hawfinch, Lapwing, Lesser Redpoll, Linnet, Mallard, Mistle Thrush, Oystercatcher, Stock Dove, Teal, Whitethroat
Derbyshire 2	None
Herts	Firecrest, Hawfinch, House Sparrow, Lesser Spotted Woodpecker, Meadow Pipit, Mistle Thrush, Redwing, Tree Pipit,
Neath	Barn Owl, Great Black-backed Gull, Lapwing, Lesser Redpoll, Oystercatcher, Snipe, Teal
Norfolk	Black-headed Gull, Common Sandpiper, Curlew, House Martin, House Sparrow, Meadow Pipit, Oystercatcher
Oxon	Bullfinch, Herring Gull, Kestrel, Meadow Pipit, Mistle Thrush, Moorhen, Reed Bunting, Spotted Flycatcher
Warks	Greenfinch, Herring Gull, Linnet, Swift
West Yorkshire 1	Barn Owl, Great Black-backed Gull, Grey Wagtail, Moorhen, Teal, Tree Pipit
West Yorkshire 2	Common Sandpiper, Greenfinch, Grey Wagtail, Lapwing, Moorhen, Redwing, Starling, Stock Dove, Tree Pipit, Whitethroat

https://www.britishecologicalsociety.org/applied-ecology-resources/document/20230445463/

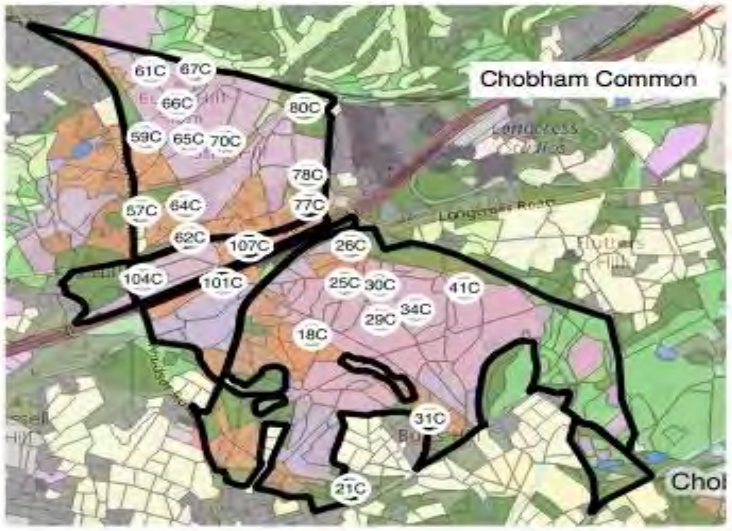
TEMPORAL PATTERNS

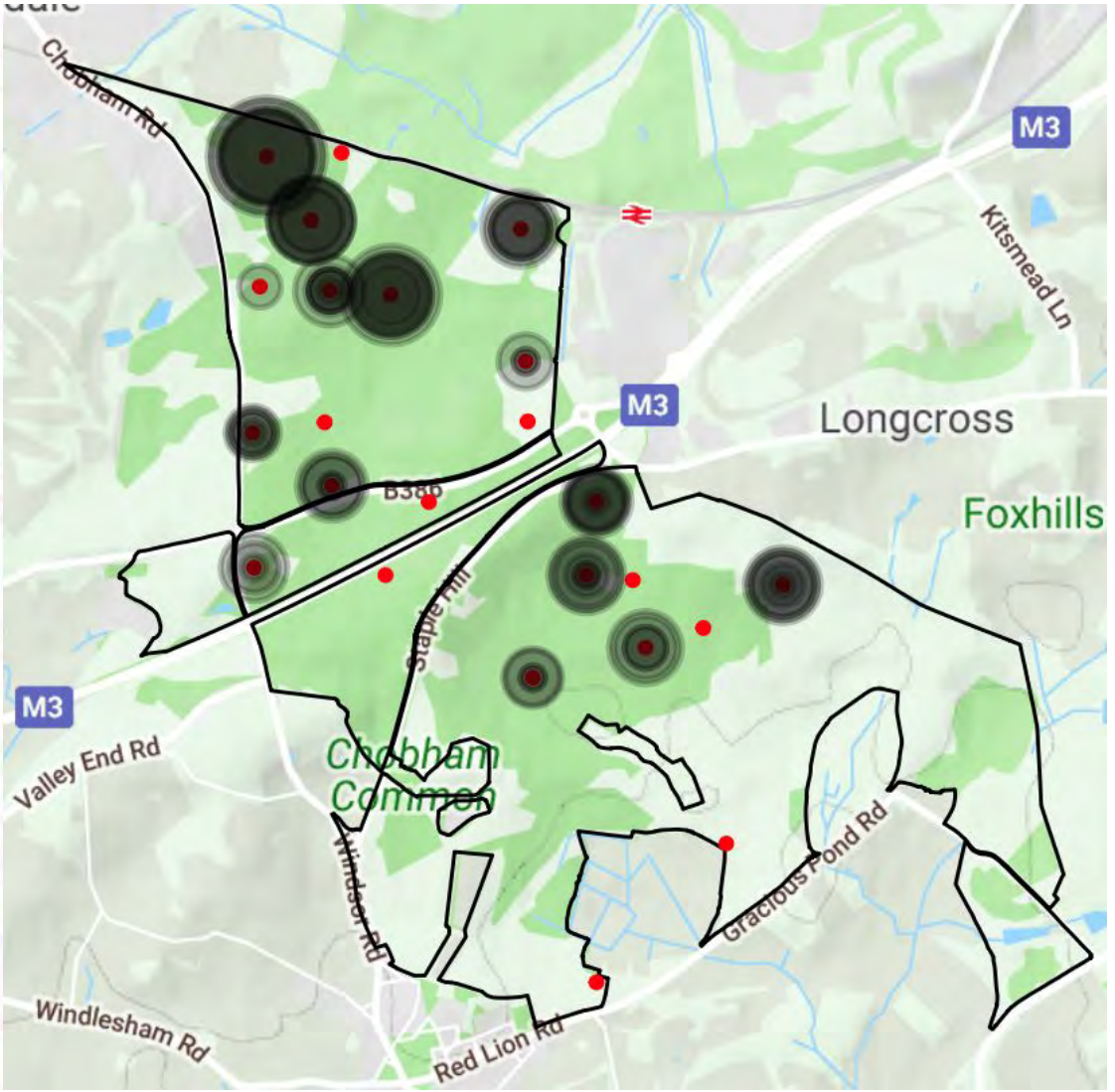


SPATIAL PATTERNS



SPATIAL PATTERNS





Received: 8 December 2020 | Revised: 17 March 2021 | Accepted: 23 March 2021

DOI: 10.1002/ece3.7585

ORIGINAL RESEARCH

Ecology and Evolution Open Access WILEY

Pond Acoustic Sampling Scheme: A draft protocol for rapid acoustic data collection in small waterbodies

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[1]Baker Consultants Ltd, Matlock, UK

[2]Nottingham Trent University, Nottingham, UK

[3]Behavioral and Molecular Ecology Group, Department of Biological Sciences, University of Wisconsin-Milwaukee, Milwaukee, WI, USA

[4]School of Biological Sciences, University of Bristol, Bristol, UK

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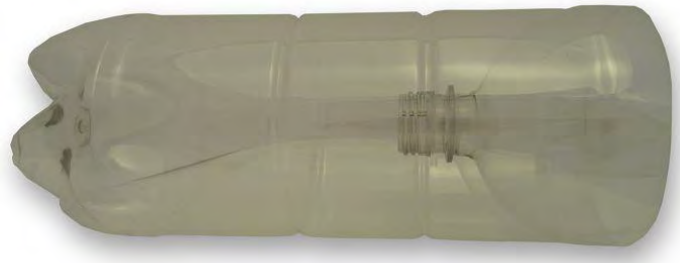
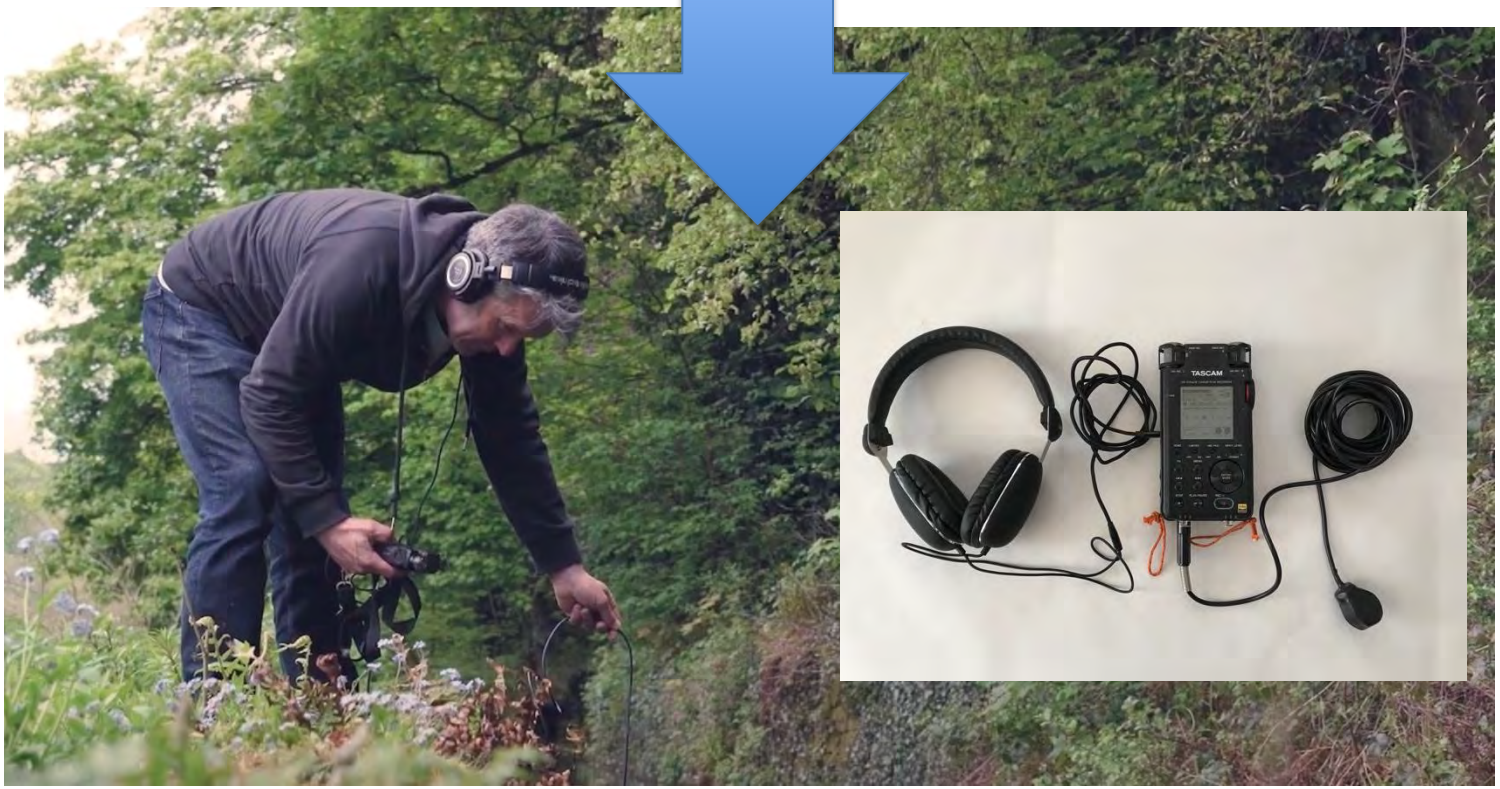
Email: carlos.abrahams@ntu.ac.uk

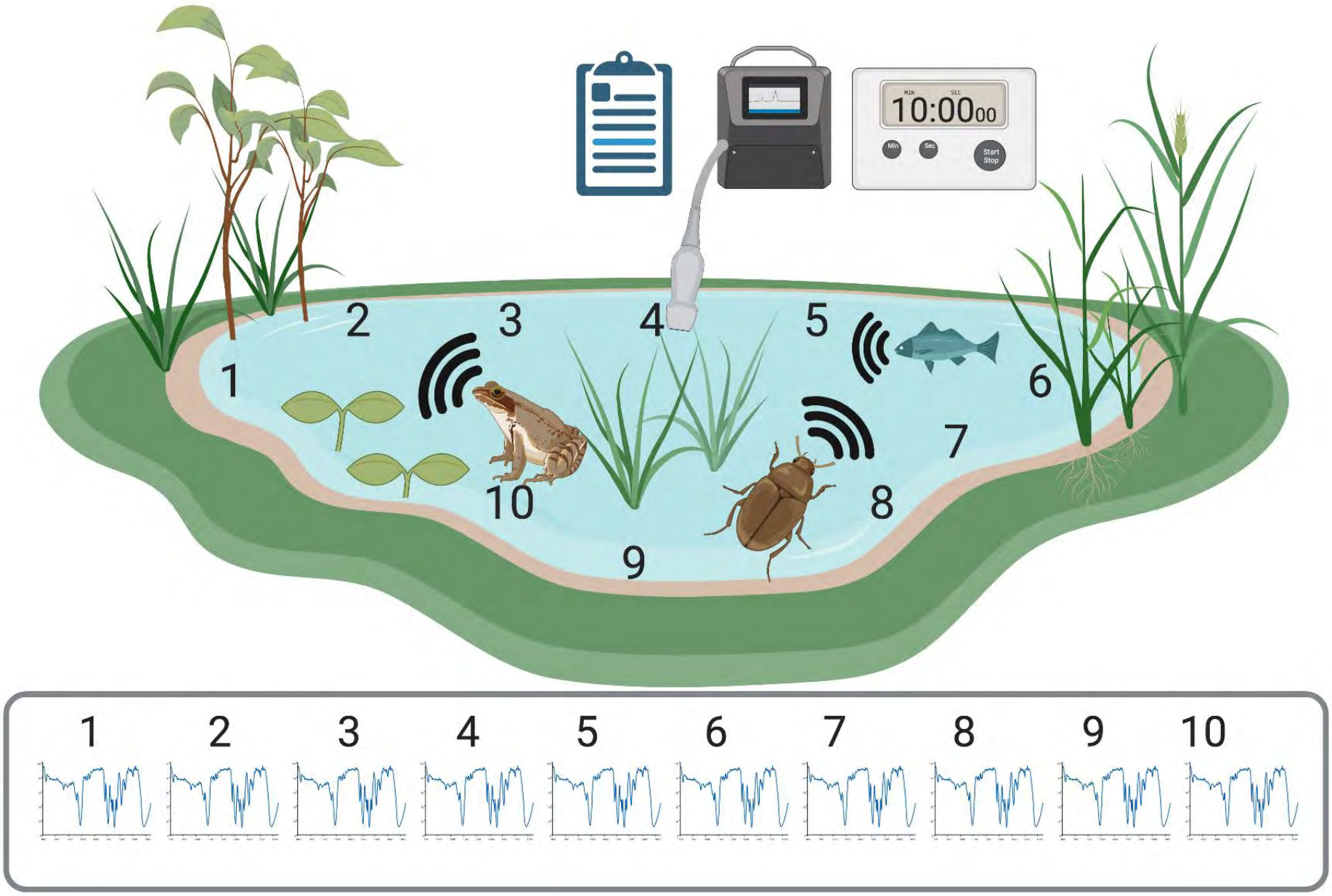
Abstract

1. Freshwater conservation is vital to the maintenance of global biodiversity. Ponds are a critical, yet often under-recognized, part of this, contributing to overall ecosystem functioning and diversity. They provide habitats for a range of aquatic, terrestrial, and amphibious life, often including rare and declining species.
2. Effective, rapid, and accessible survey methods are needed to enable evidence-based conservation action, but freshwater taxa are often viewed as "difficult"—and few specialist surveyors are available. Datasets on ponds are therefore limited in their spatiotemporal coverage.
3. With the advent of new recording technologies, acoustic survey methods are becoming increasingly available to researchers, citizen scientists, and conservation practitioners. They can be an effective and noninvasive approach for gathering data on target species, assemblages, and environmental variables. However, freshwater applications are lagging behind those in terrestrial and marine spheres, and as an emergent method, research studies have employed a multitude of different sampling protocols.





TASCAM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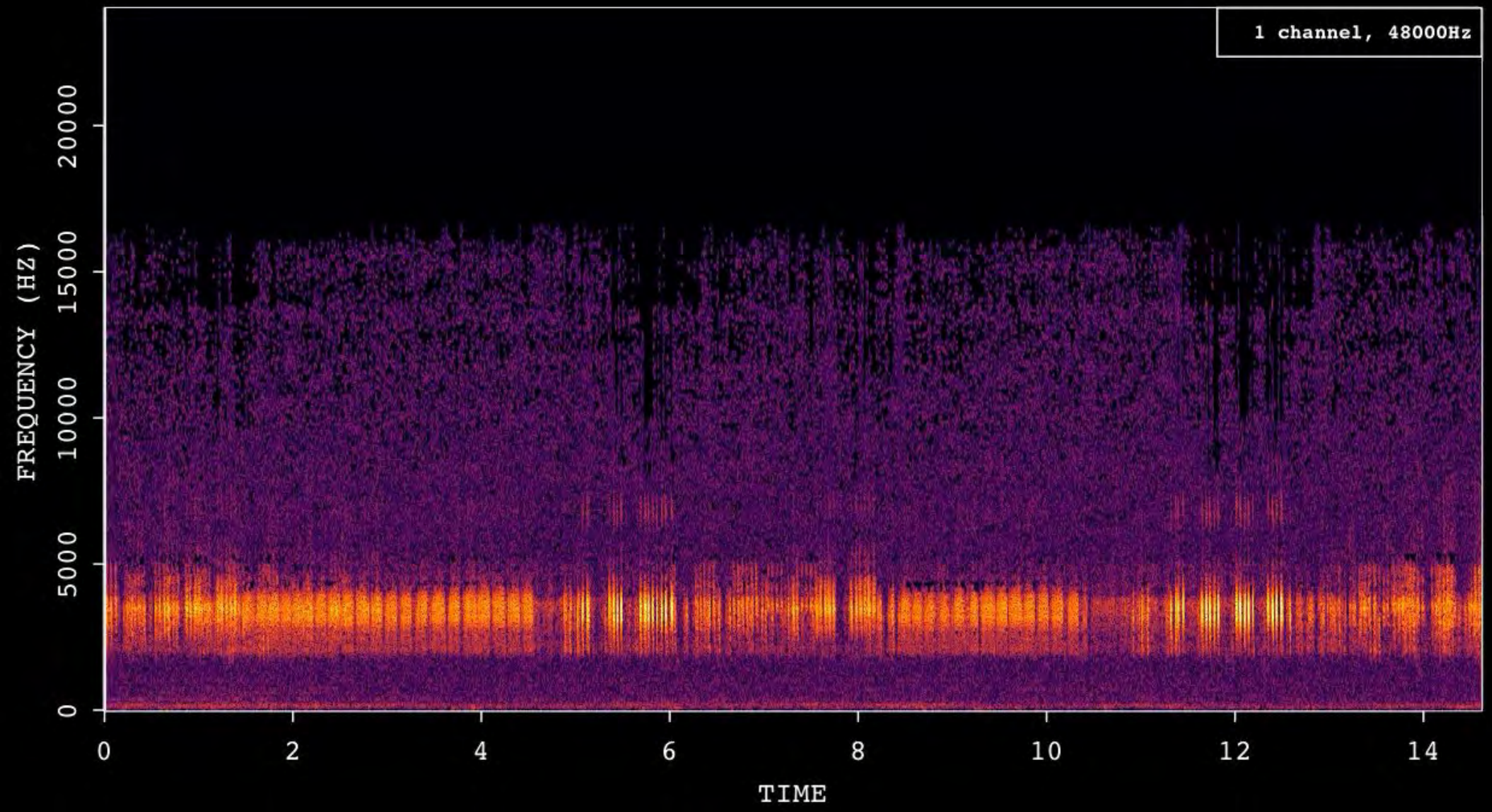
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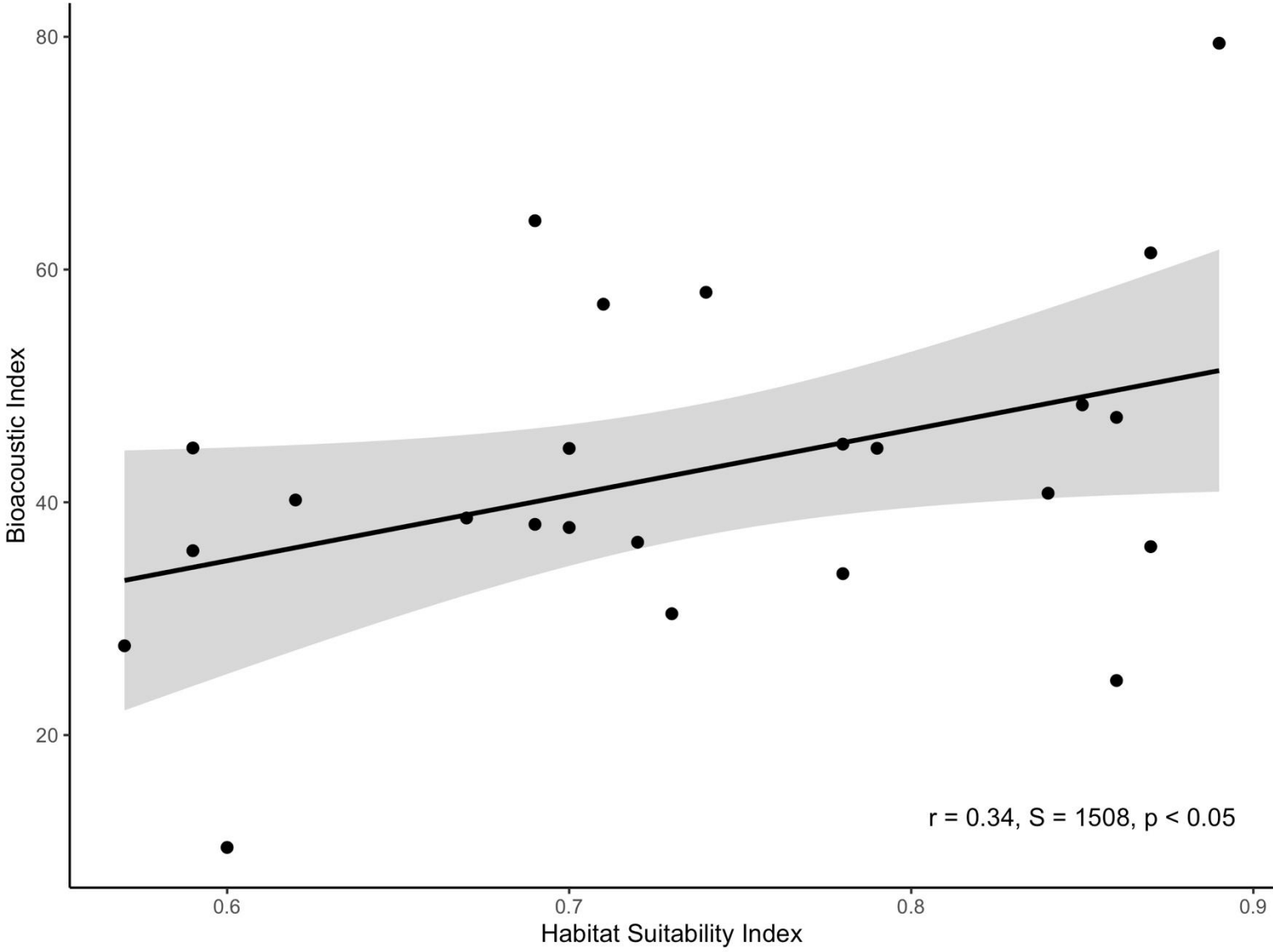


Summary of scoring system

SI_1 Location

Field score	SI
A (optimal)	1
B (marginal)	0.5
C (unsuitable)	0.01

SI_2 Pond area

Field score
Measure pond surface area (m^2) and round t

SI_3 Pond drying

Field score	SI	Criteria
Never	0.9	Never dries
Rarely	1.0	Dries no more
Sometimes	0.5	Dries between
Annually	0.1	Dries annually

SI_4 Water quality

Field score	SI	Criteria
Good	1.0	Abundant and
Moderate	0.67	Moderate inve
Poor	0.33	Low invertebr
Bad	0.01	Clearly pollute

SI_5 Shade

Field score
Estimate percentage perimeter shaded to a l

SI_6 Fowl

Field score	SI	Criteria
Absent	1	No evidence o
Minor	0.67	Waterfowl pre
Major	0.01	Severe impact

SI_7 Fish

Category	SI	Criteria
Absent	1	No records of
Possible	0.67	No evidence o
Minor	0.33	Small numbers
Major	0.01	Dense populat

SI_8 Pond count

Field score
Count the number of ponds within 1 km of t
barriers) and divide by 3.14. This can be don

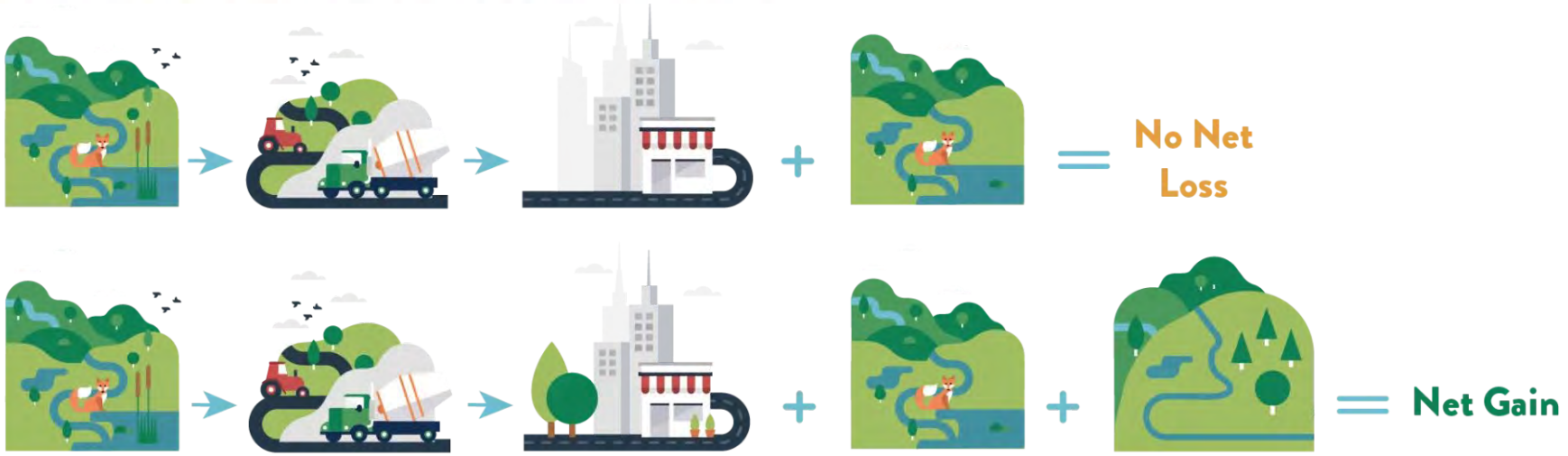
SI_9 Terrestrial habitat

Category	SI
Good	1
Moderate	0.67
Poor	0.33
None	0.01

SI_{10} Macrophytes

Field score
Estimate the percentage of the pond surface
(between May and the end of September)

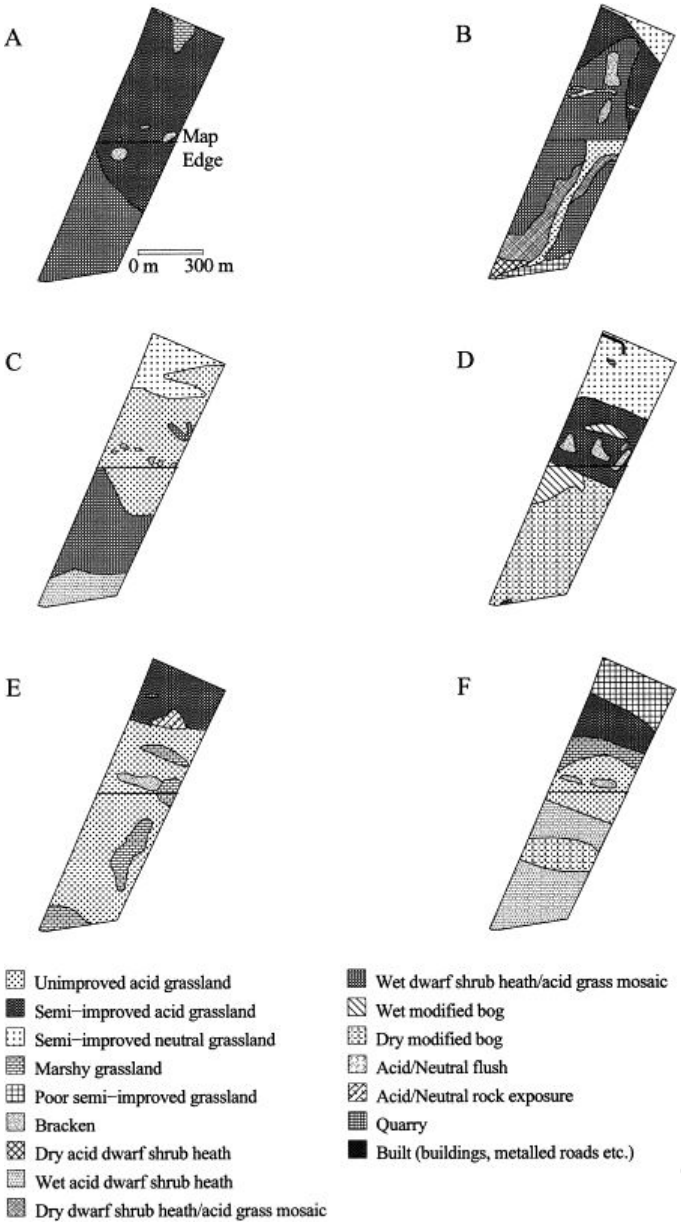
Monitoring Biodiversity Net Gain:
Potential Contributions from Ecoacoustics



Legal requirement for 30yrs management & monitoring – including habitat 'condition'

> "We recommend that good practice monitoring of BNG schemes accepts multiples lines of biodiversity evidence, including more detailed species assessments alongside habitat mapping."

Observer bias in habitat mapping…



Cherrill & McLean (1999)


TASCAM

SIGNALS

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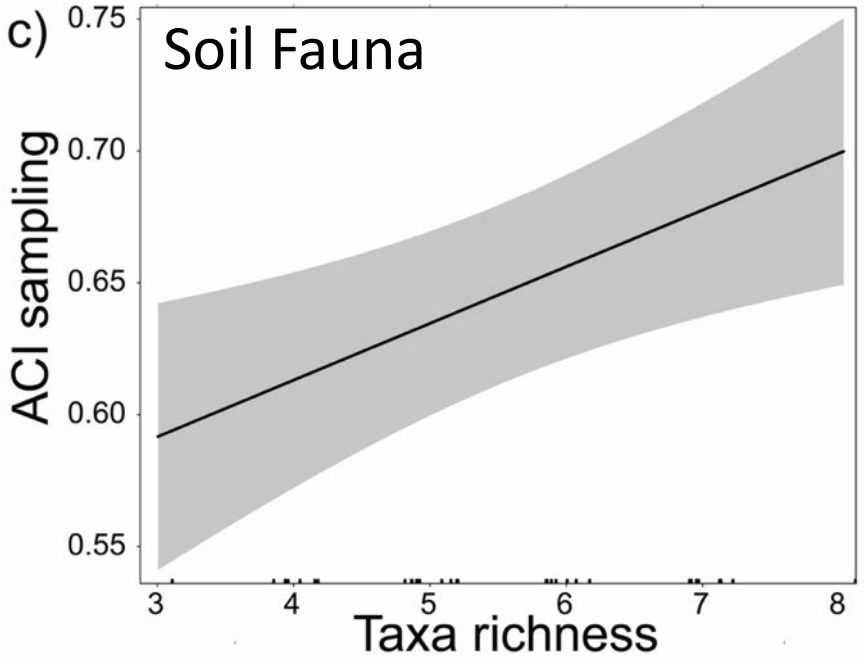
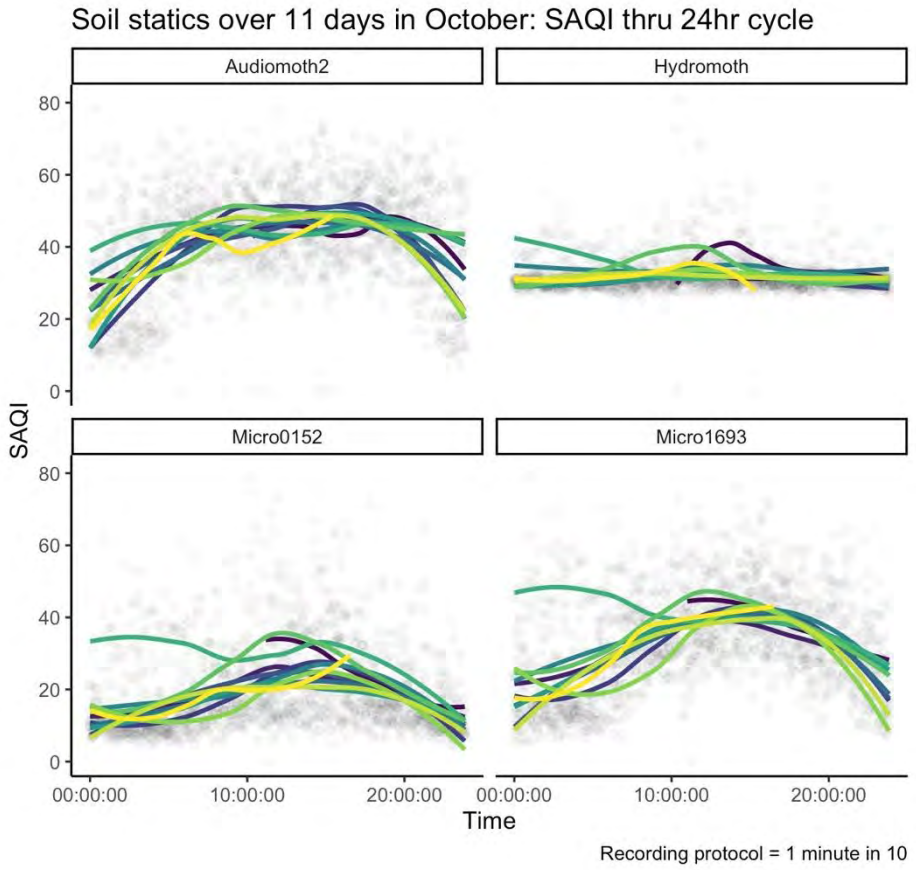
TIME

ACOUSTIC INDICES

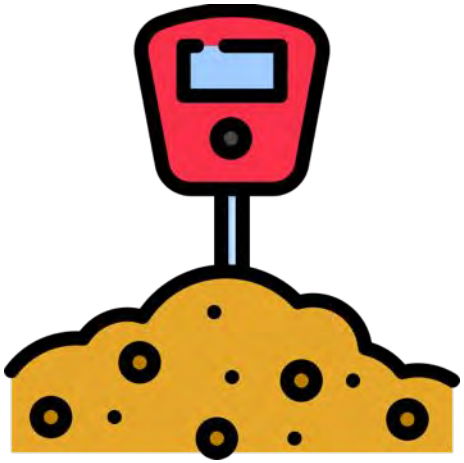


Maeder M, Guo X, Neff F, Schneider Mathis D, Gossner MM (2022) Temporal and spatial dynamics in soil acoustics and their relation to soil animal diversity. PLoS ONE 17(3): e0263618. https://doi.org/10.1371/journal.pone.0263618

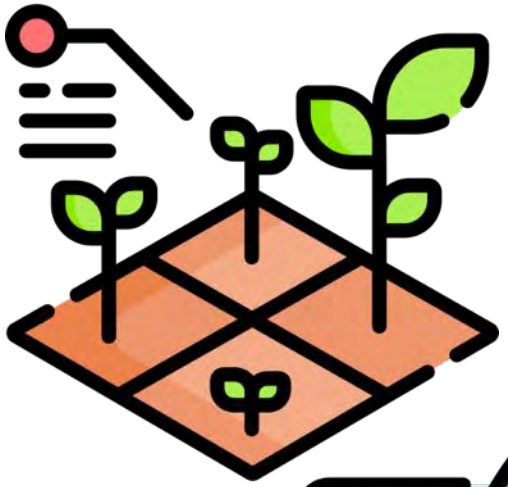
Time of Day



FARMING INNOVATION PROGRAMME

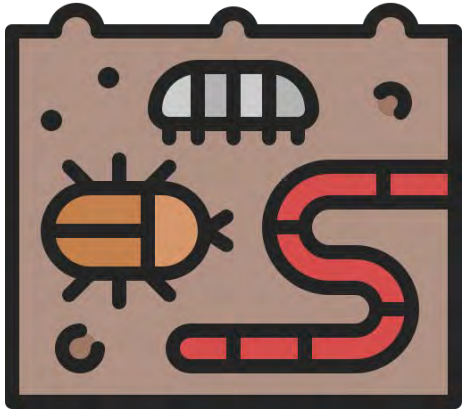


Develop prototype



Sound library

Field recordings



Construct algorithm

WWF

2 CONSERVATION TECHNOLOGY

ACOUSTIC MONITORING

Passive acoustic monitoring in ecology and conservation

Ella Browning, Rory Gibb, Paul Glover-Kapfer & Kate E. Jones. 2017.
WWF Conservation Technology Series 1(2). WWF-UK, Woking, United Kingdom.

https://www.wwf.org.uk/project/conservationtechnology/acoustic-monitoring

Manchester Metropolitan University

baker consultants
ECOLOGY DEVELOPMENT INNOVATION

acoustics.ac.uk
THE UK ACOUSTICS NETWORK

Good practice guidelines for long-term ecoacoustic monitoring in the UK

With a particular focus on terrestrial biodiversity at the human-audible frequency range

https://www.britishecologicalsociety.org/applied-ecology-resources/document/20230136742/

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Acoustics in the Automated Biodiversity Monitoring Stations (ABMS) pilot

Jamie Alison, Jarek Scanferla

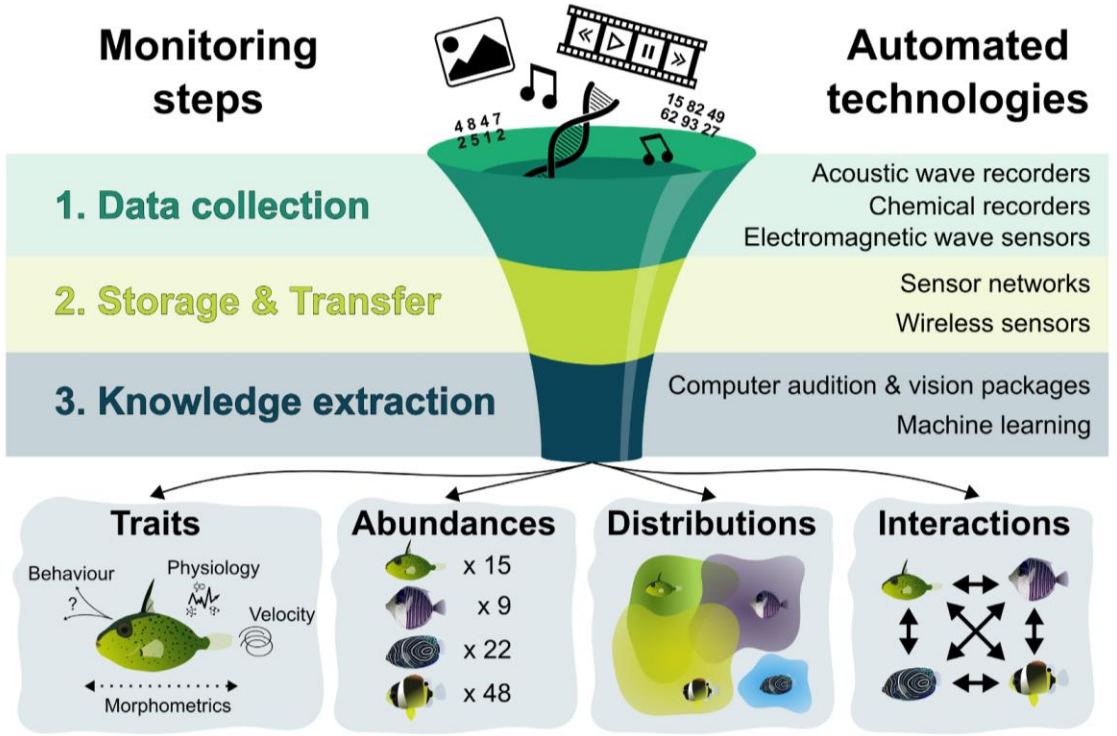
& Toke Thomas Høye

Rationale for the ABMS

Alarming trends in nature, but obscured by spatial, temporal and taxonomic bias

- ✓ We need **scalable** solutions…
- ✓ … that **operate continuously**…
- ✓ … that are **highly standardized**.

Does the hype of automation and AI convert to useful data under pressure and across borders?



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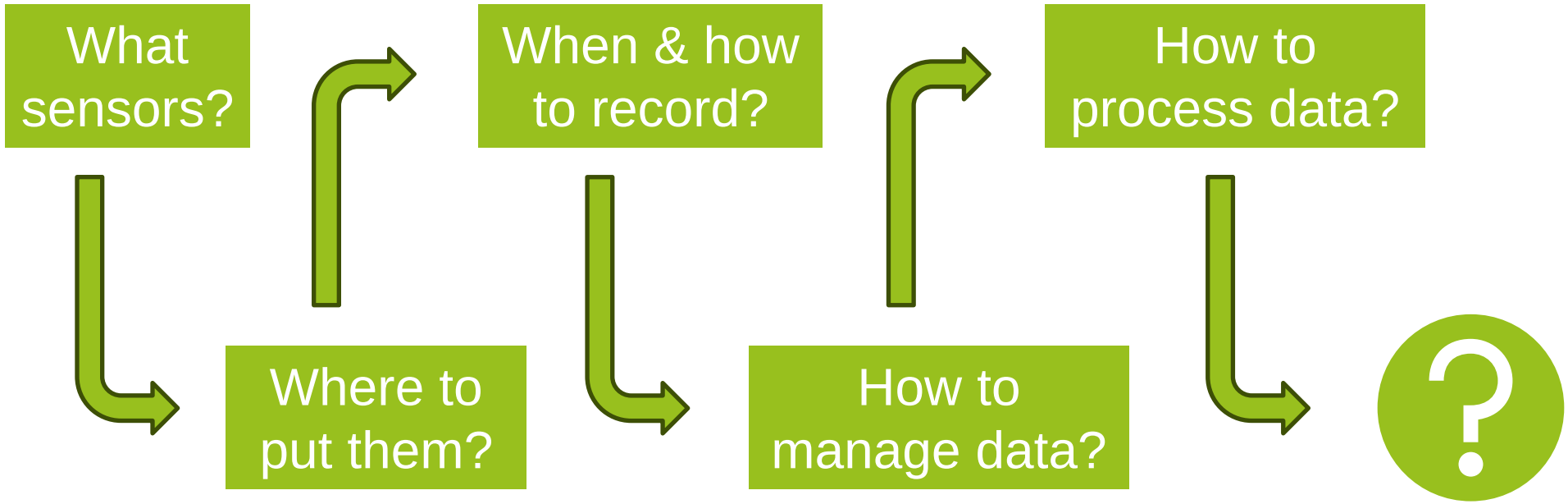
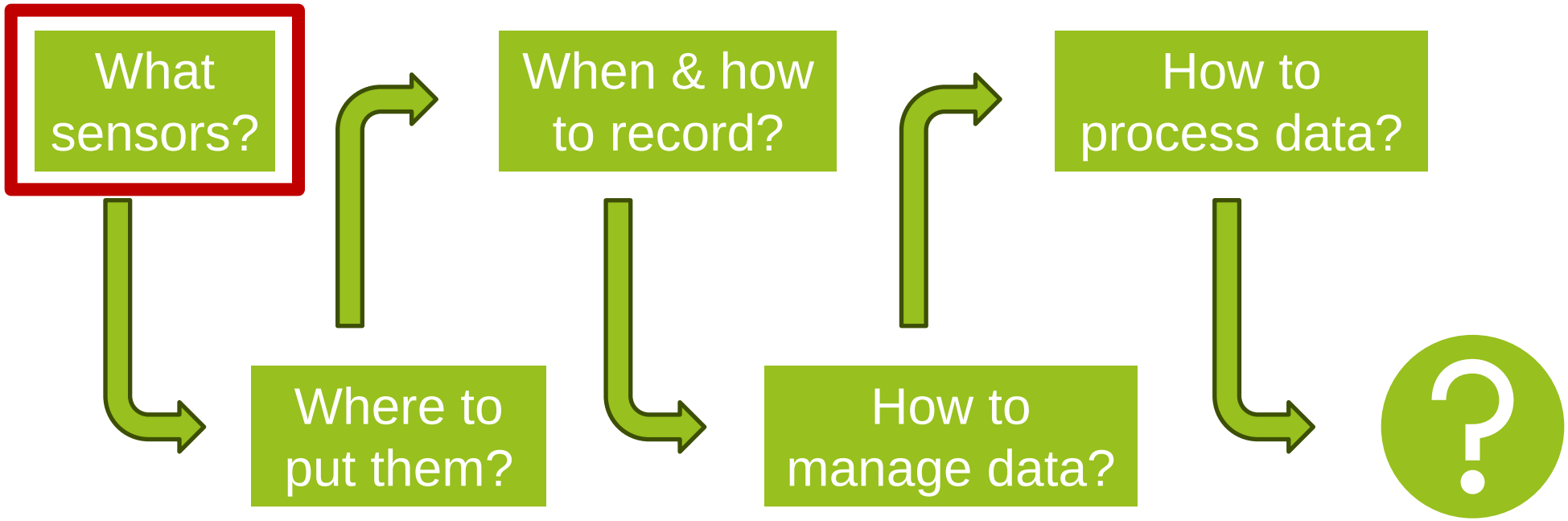
Besson *et al.* (2023) *Ecology Letters*

Creating a sensor-based monitoring scheme



Creating a sensor-based monitoring scheme



What sensors?

- ✓ Birds, bats & nocturnal insects
- ✓ Available, established & reliable
- ✓ Off-grid & portable
- ✓ Maintained at most once a month

AMI system TOMST logger Song Meter Mini 2

What sensors?

- ✓ ~~Birds, bats~~ & nocturnal insects
- ✓ Available, established & reliable
- ✓ Off-grid & portable
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AMI system TOMST logger Song Meter Mini 2

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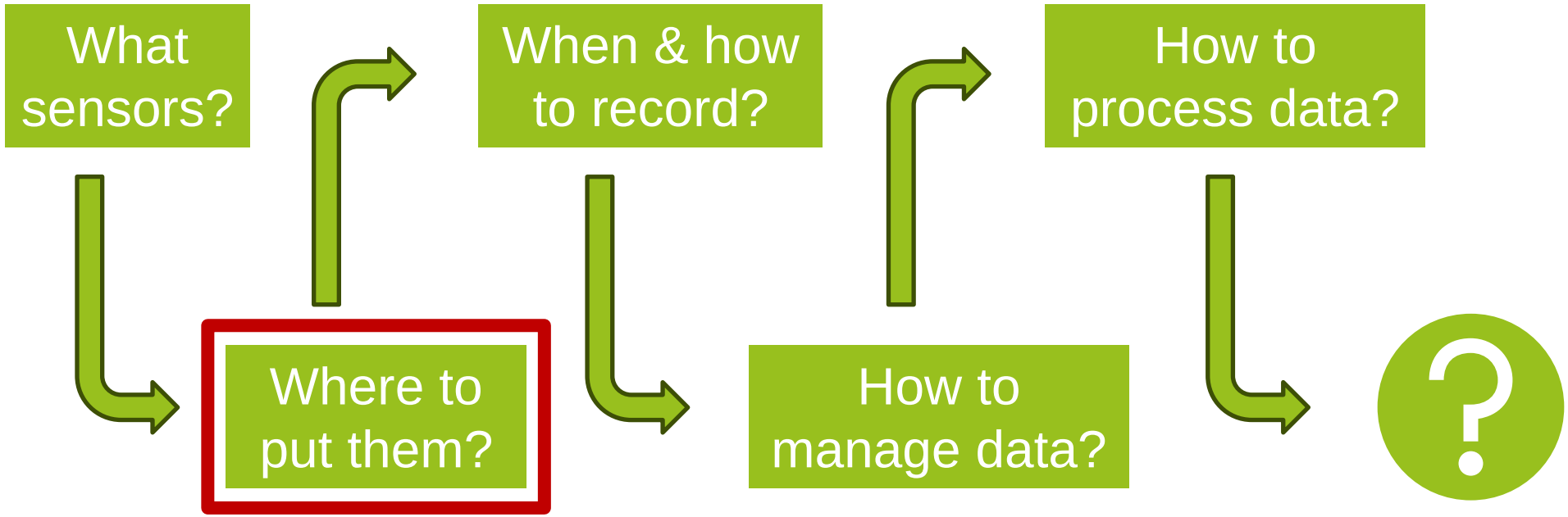
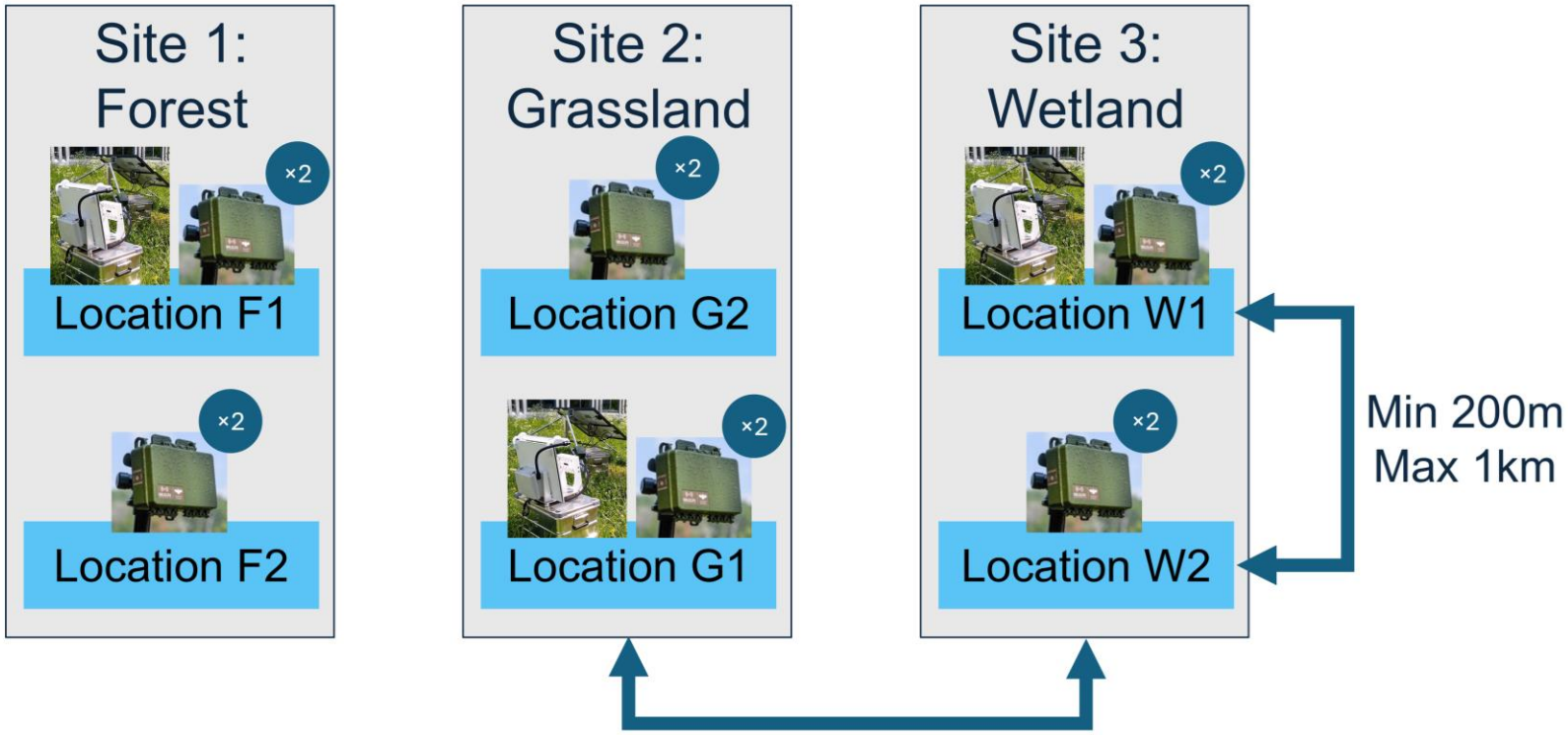
AMI system TOMST logger Song Meter Mini 2

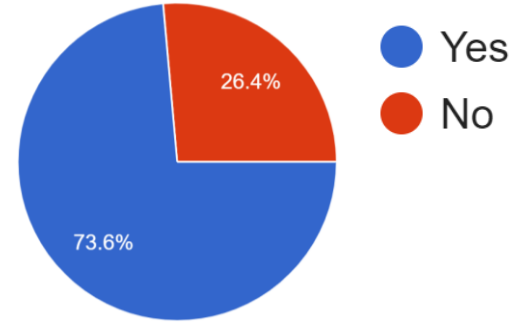
Creating a sensor-based monitoring scheme



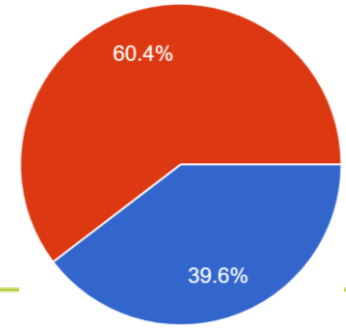
Where to put them?

- ✓ Forest, grassland & wetland
- ✓ Natura 2000 sites
- ✓ Nested sampling design
- ✓ Aligned with 100m sampling grid



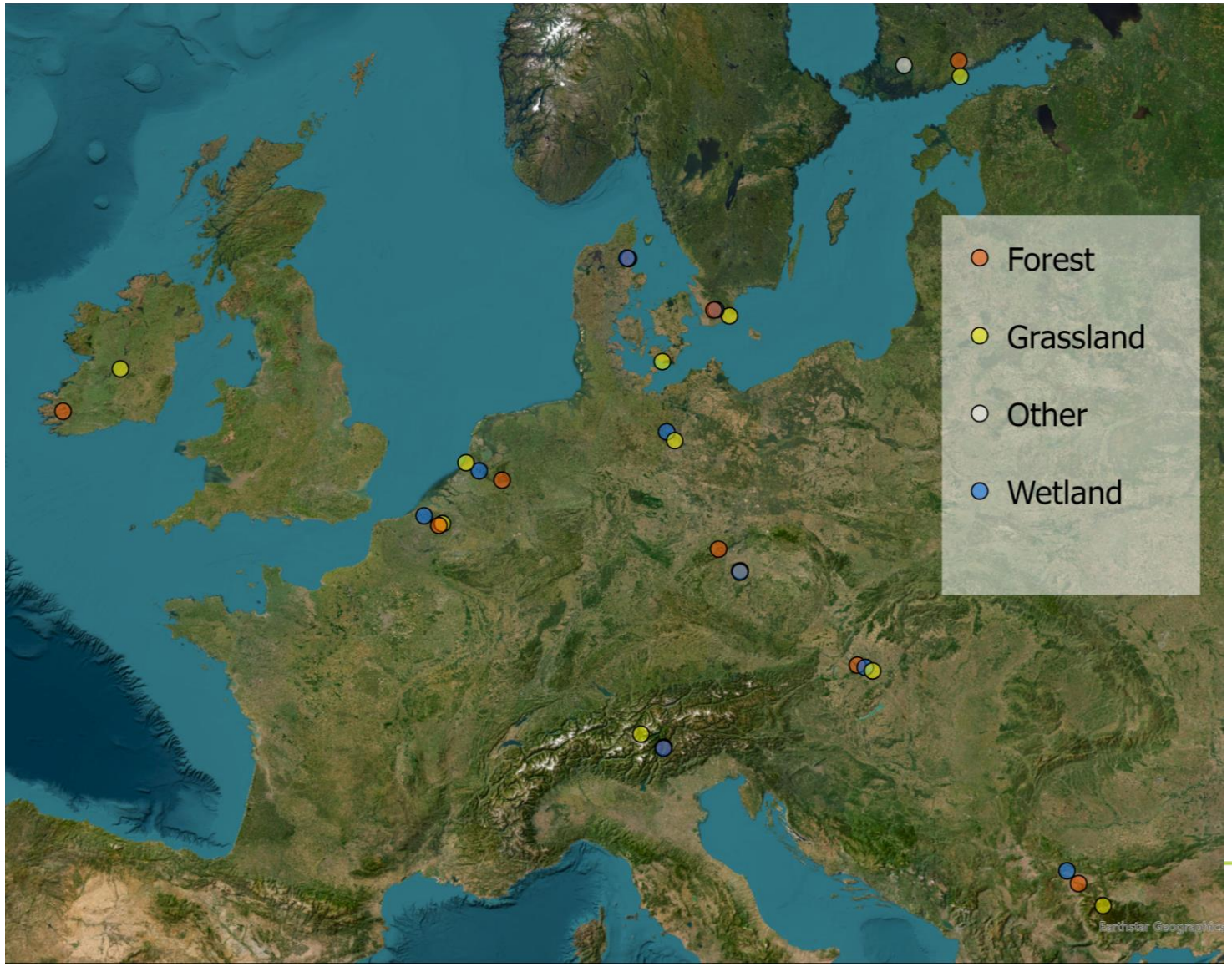


Inside Natura 2000 site?



Aligned with 100m grid?

Where to put them?

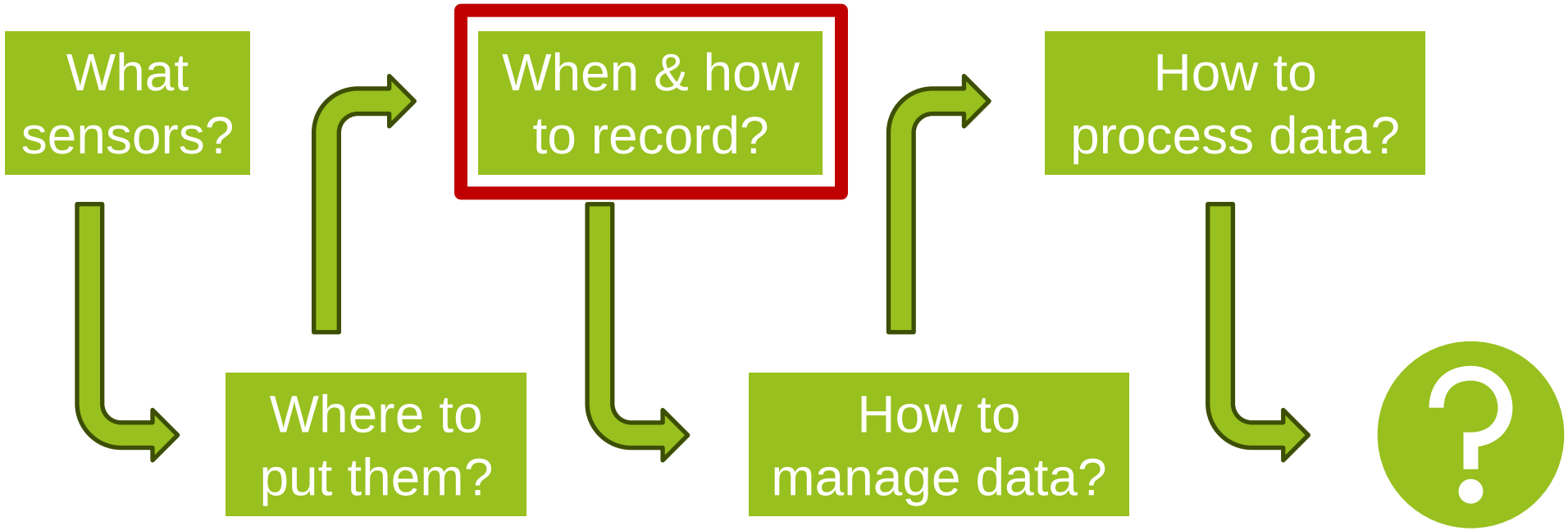


- 13 partners
- 3 sites per partner
- 1 AMI trap + 2 sets of Song Meters per site

  = 39 AMI systems

  = 156 Song Meters

Creating a sensor-based monitoring scheme



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When & how to record?

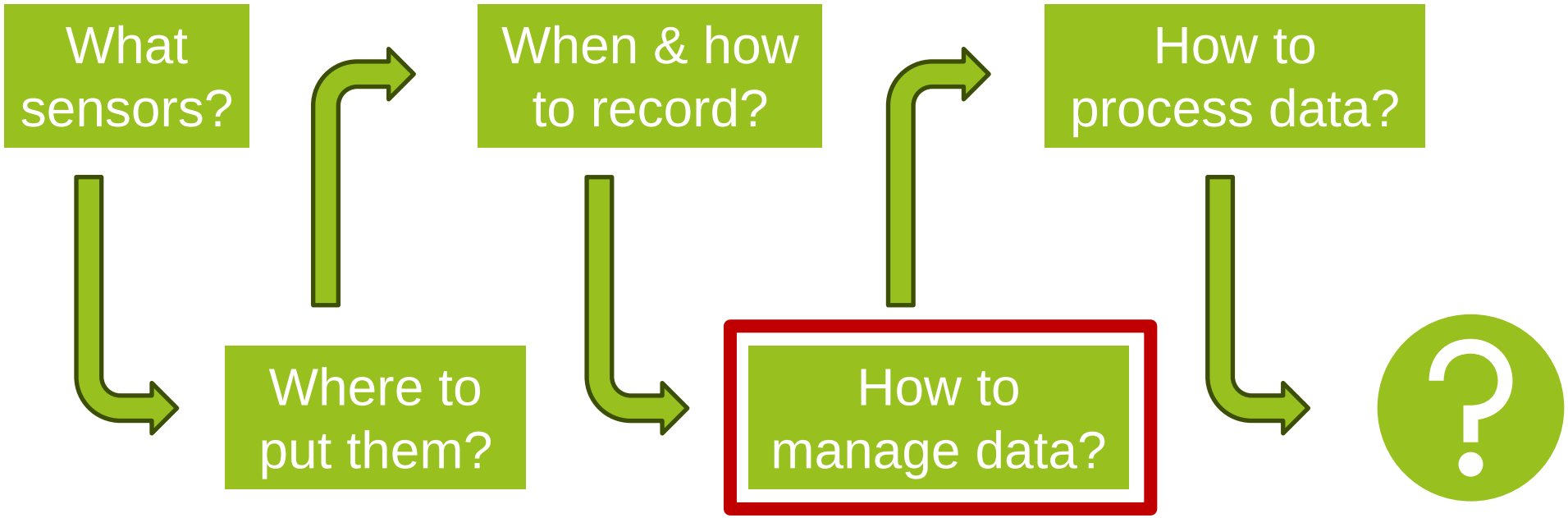
- ✓ Maximum temporal resolution
- ✓ Continuous (or representative)
- ✓ Standard protocol
- ✓ Triggered recording (with caution)

Parameter	Audible	Ultrasound
Use triggering	No	Yes (bats, 3 seconds)
Max recording length	1 minute	15 seconds
Schedule	1 minute in 5	Continuous triggered
Recording window	Continuous	Dusk -1h to dawn +1h
Sample rate	48kHz	256kHz

Short season in 2024 – still 260,000 recordings per active partner

Metcalf *et al.* (2022) *UK Acoustics Network*

Creating a sensor-based monitoring scheme

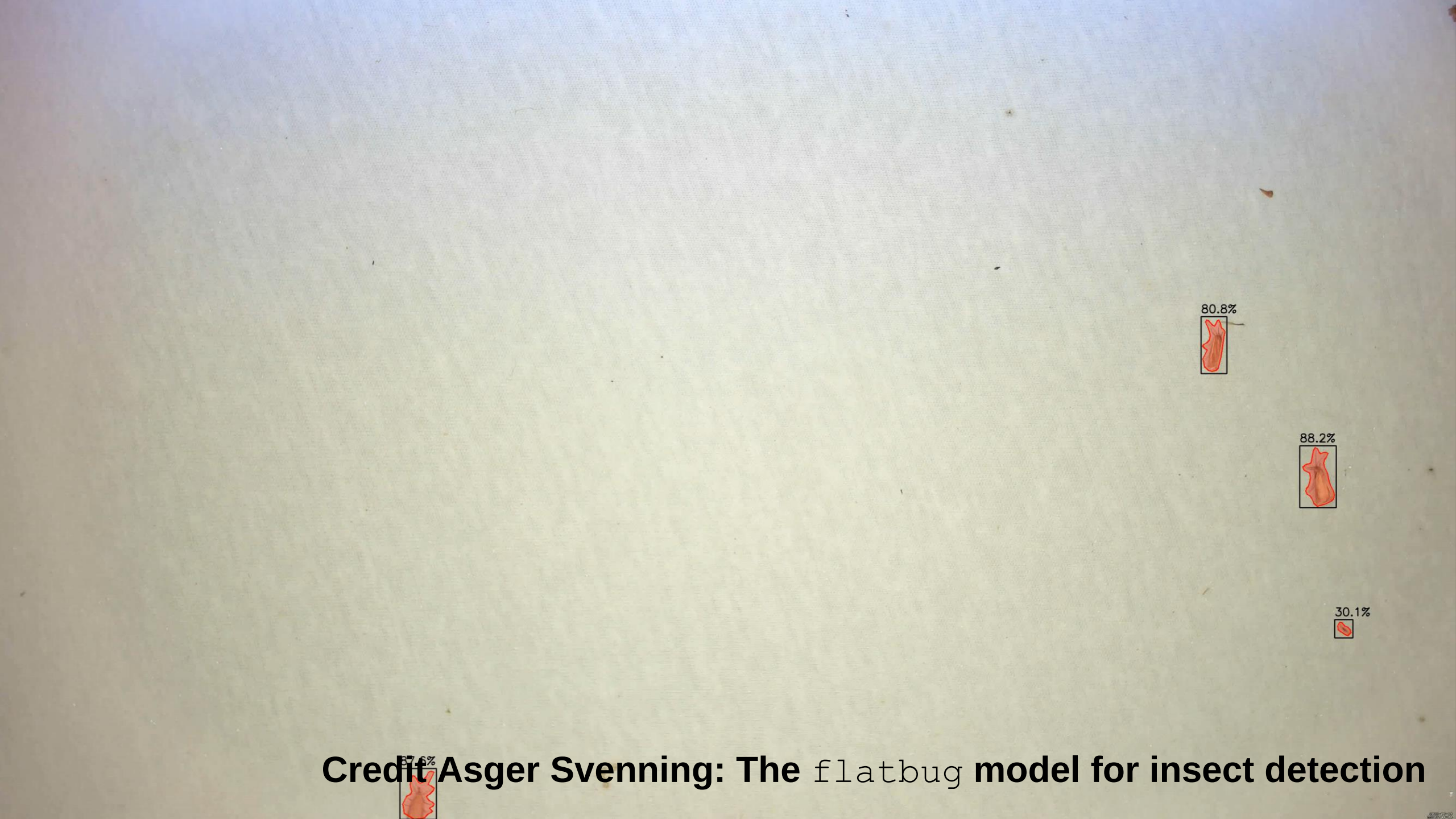


How to manage data?

- Manual retrieval (SD/SSD)
- SFTP transfer to DK database
- Retain local copies

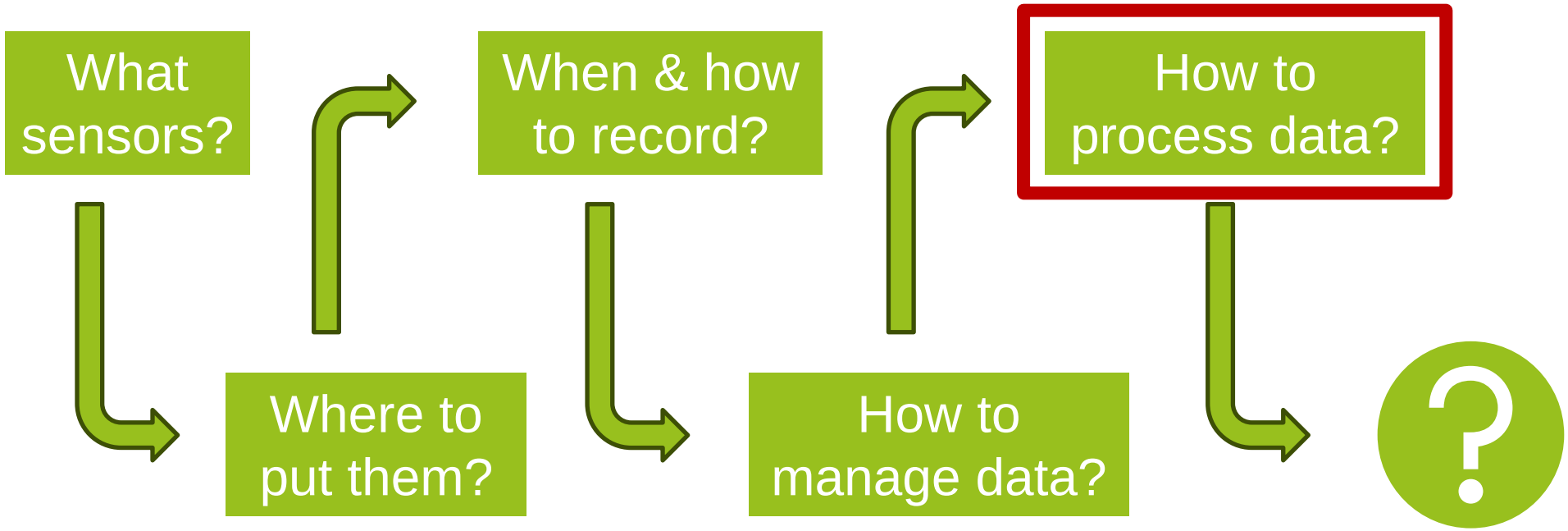
- Deployment metadata
- … linked to location metadata and file IDs
- Metadata fields named to match standards

Silva del Pozo *et al.* (2022) Guide on harmonising biodiversity monitoring protocols across scales. *Biodiversa+ report*



Credit Asger Svenning: The `flatbug` model for insect detection

Creating a sensor-based monitoring scheme



How to process data?

✓ Models must be available

✓ Accurate (at least well evaluated)

✓ Rapid data processing…

× With error! The work is not over.

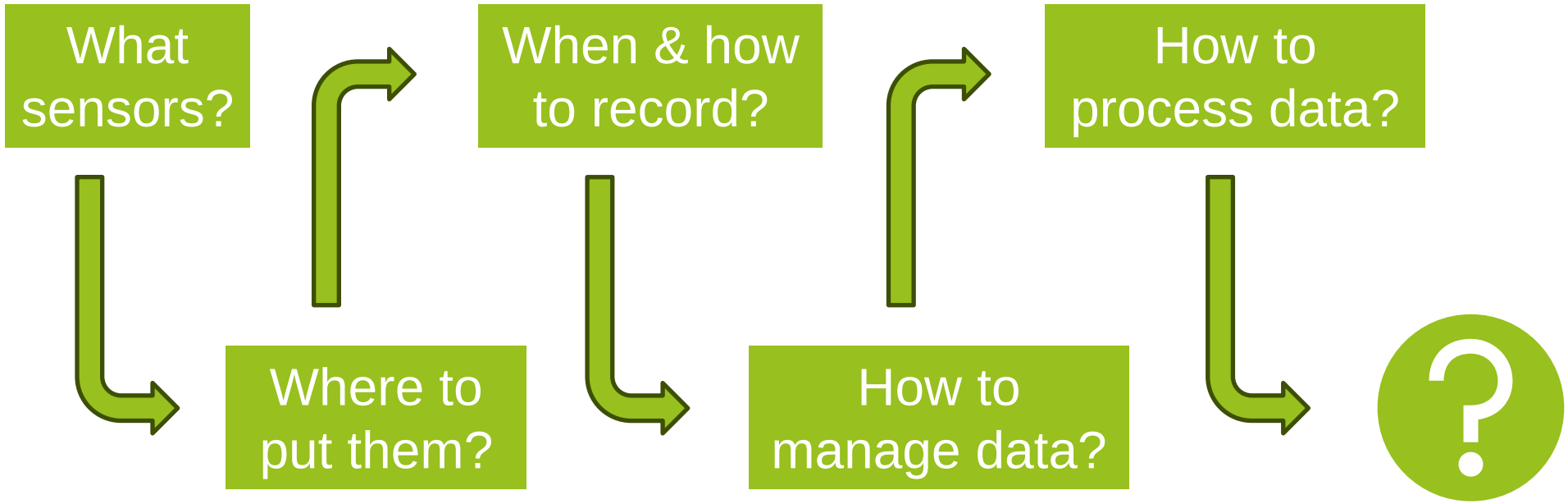
BirdNET

Batdetect2

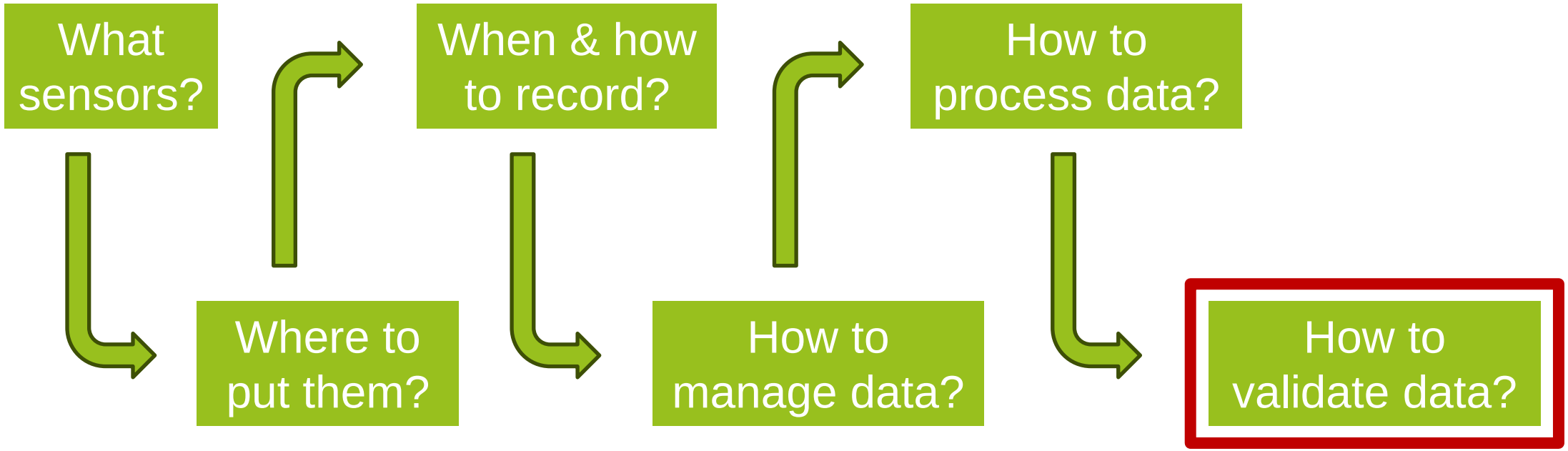
Dealing with classification error:

- Understand the model's weaknesses
- Aggregate taxa if meaningful
- Confidence-based post-processing
- **Validation for your use case**

Creating a sensor-based monitoring scheme



Creating a sensor-based monitoring scheme



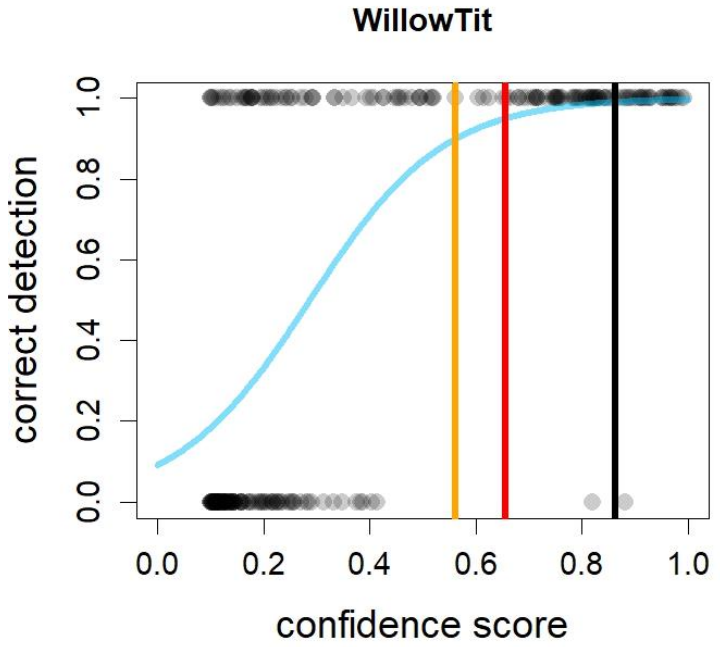
How to validate data?

- ✓ Correct for false positives & bias
- ✓ Generate useful training data
- ✓ Strategic & systematic
- × False negatives also crucial

Birds at Bolzano ABMS stations, 2024

Processed by Jarek Scanferla

Site	Unfiltered detections	Unfiltered species	Confidence > 0.2	Confidence > 0.5	Confidence > 0.9	Confidence > 0.9 Detections > 5
Grassland	20778	205	171	109	42	20
Wetland	30395	204	174	106	47	24
Forest	56061	160	128	87	42	27



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Wood & Kahl (2024) *Journal of Ornithology*

Take home messages

- ✓ At scale, availability of standardized equipment is crucial
- ✓ “Old” challenges of systematic monitoring and site selection are still extremely relevant for sensors, if not more
- ✓ Centralized data processing may be a good model, if supported by local data processing case studies
- ✓ Data processing does not end with AI (yet!)

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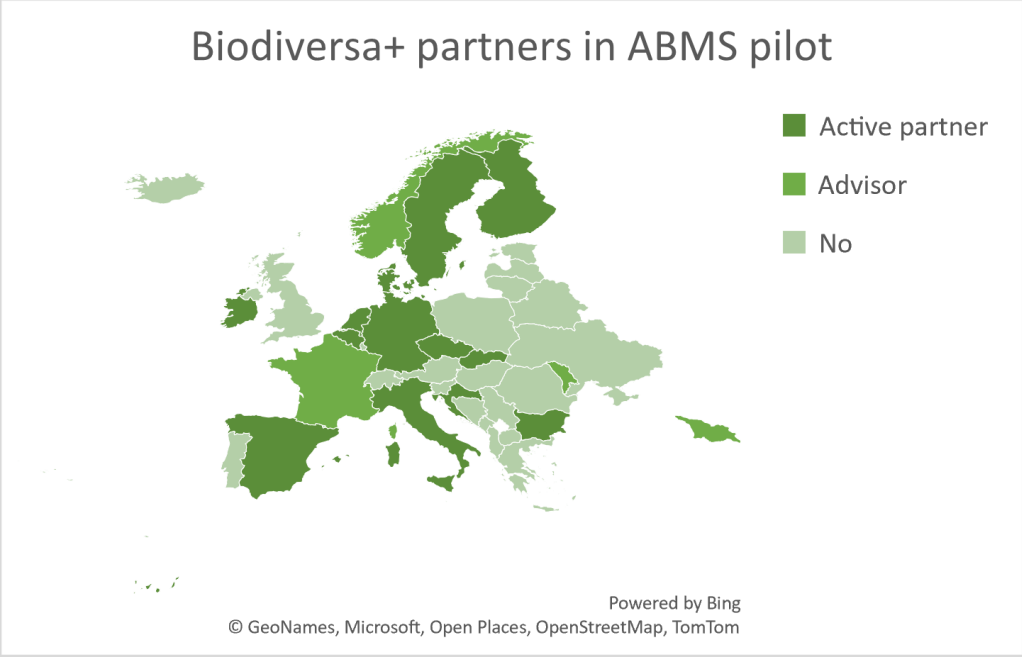
Thank you!



Country	Organization	Role
Germany	Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucherschutz,	Active partner
Italy - South Tyrol	Eurac Research	Active partner
Spain	Departament d'Acció Climàtica, Alimentació i Agenda Rural	Active partner
Bulgaria	Executive Environment Agency	Active partner
Croatia	Ministry of Economy and Sustainable Development	Active partner
Denmark	Ministry of Environment of Denmark	Active partner
Finland	Ministry of the Environment	Active partner
Czech Republic	Národní klastrová asociace	Active partner
Republic of Ireland	National Parks & Wildlife Service	Active partner
Netherlands	The Dutch Research Council	Active partner
Slovakia	Slovak Academy of Sciences	Active partner
Sweden	Swedish Environmental Protection Agency	Active partner
Belgium	Vlaams gewest / Flemish region	Active partner
Georgia		Advisor
Moldova		Advisor
Norway		Advisor
France		Advisor