NAU NORTHERN ARIZONA UNIVERSITY

School of Forestry

Environmental DNA (eDNA) applications for detecting bat species

SPECIES FROM FECES

Daniel E. Sanchez

BAT ECOLOGY & GENETICS LAB

NAU NORTHERN ARIZONA UNIVERSITY

Bat Ecology and Genetics Lab

Species from Feces | Search our Species From Feces Database | Frequently Asked Questions | Our Work | People | Contact Us

Who we serve

We use the newest genetic technologies to assist wildlife managers and researchers.

IN > Bat Ecology and Genetics Lab > Species from Feces

SPECIES FROM FECES

Our Genetic ID services:

Species from Feces

Bat Carcass ID for wind farms

Species detection via environmental DNA

We work with any taxon

Overview

DNA metabarcoding

eDNA assays

Consultation

Interpretation of results

>400 completed projects for agencies, consultants, universities, and NGO's

Broad taxonomic scope

>10 SFF publications

Who we are: wildlife geneticists, ecologists, and bioinformaticians

Our mission: to offer species identification services to further wildlife research, management, and conservation globally

Emma Federman

Savannah Marriott

Dr. Daniel Sanchez

Dr. Faith Walker

Dr. Carol Chambers

Ellen Liebig

Morgan Hughes

Emma Froehlich

Salix Scoresby

NAU

BAT ECOLOGY & GENETICS LAB

SPECIES FROM FECES

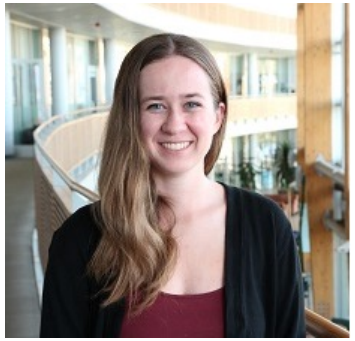
Colin Sobek

Austin Dikeman

Anna Riley

Jacque Lyman

Meagan Owens



Samantha Hershauer

Abby Tobin

Dr. José Gabriel Martinez-Fonseca

Jordyn Upton

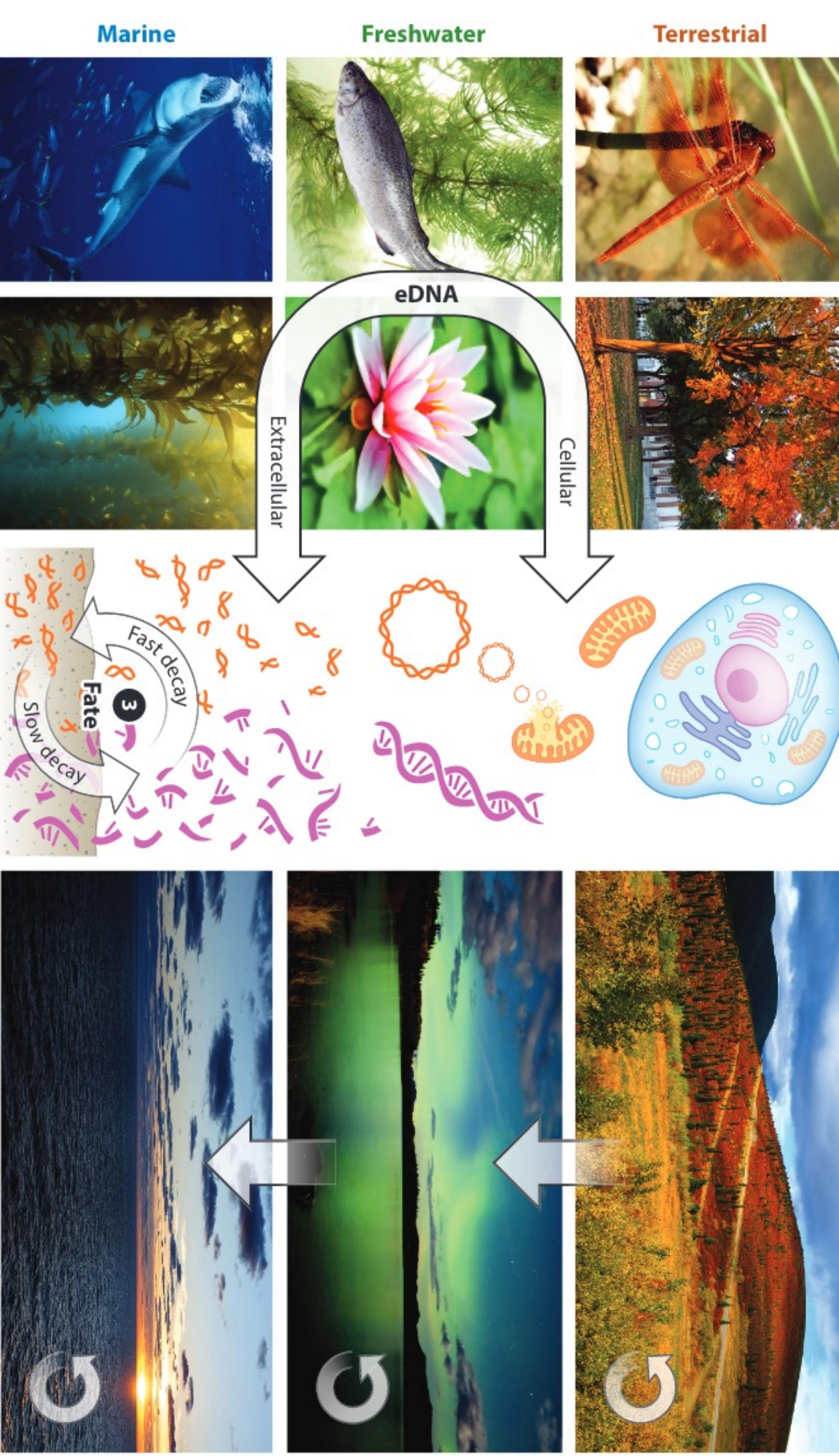
Kiera Majzner

Regina Go

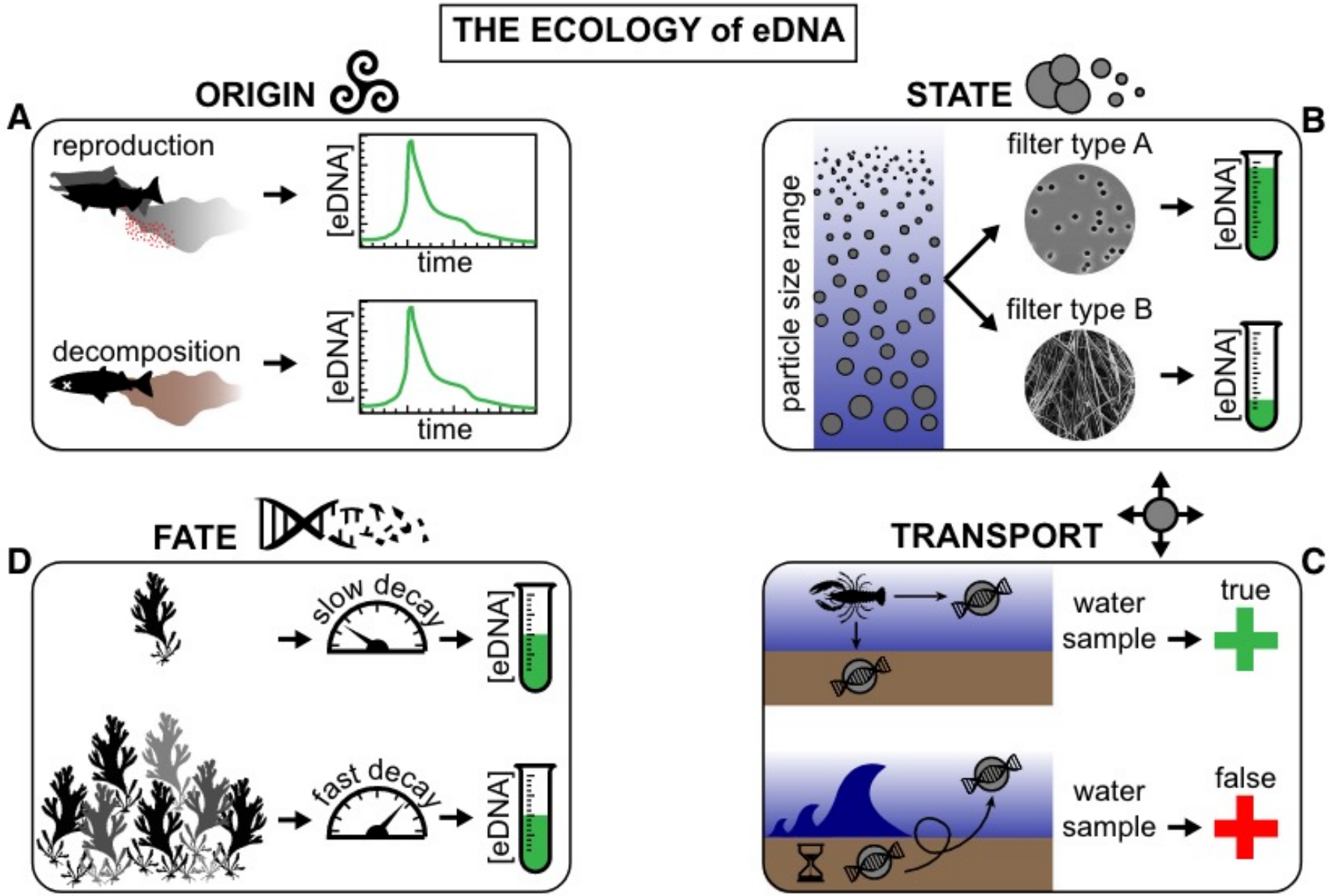
Outline

- **Field of eDNA**
  - Foundations and history
  - Concepts and considerations

- **eDNA methods for bat detection**
  - Where can we get it from?

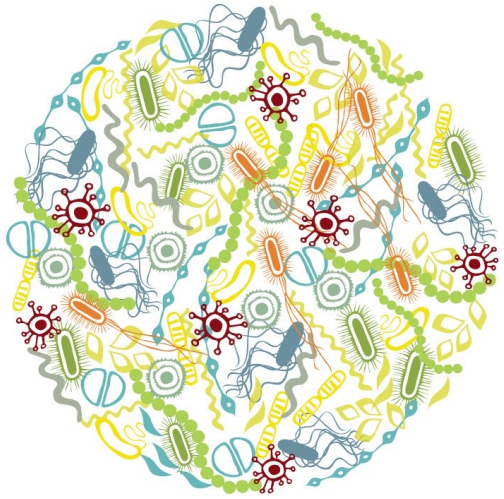


Cristecu & Hebert (2018)

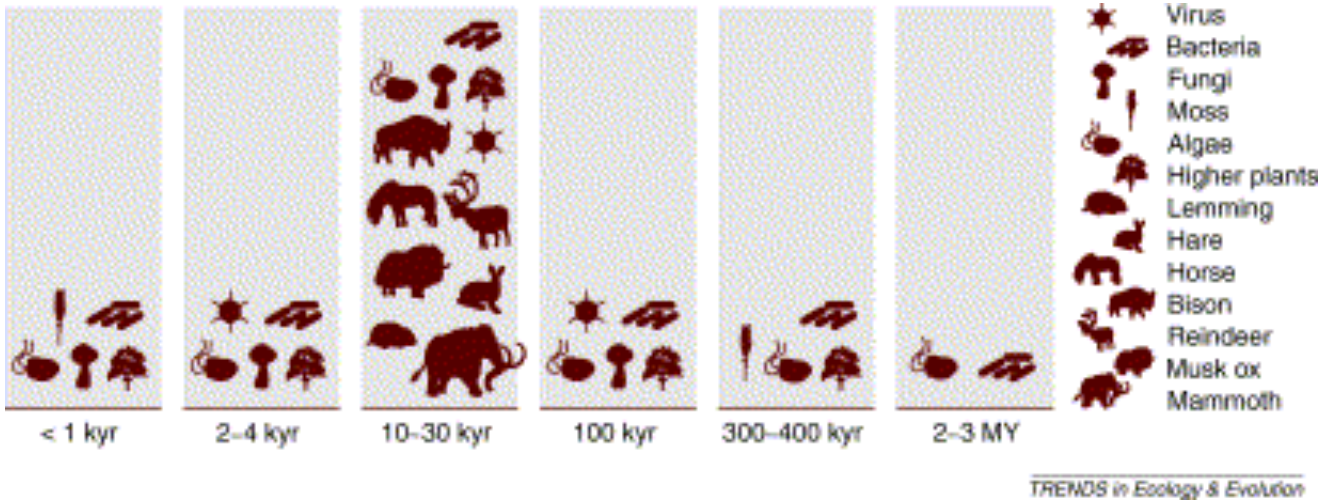


Barnes & Turner (2016)

Microbial eDNA (1983 – 1991)



Macrobial eDNA from ancient permafrost (Willerslev et al. 2004)



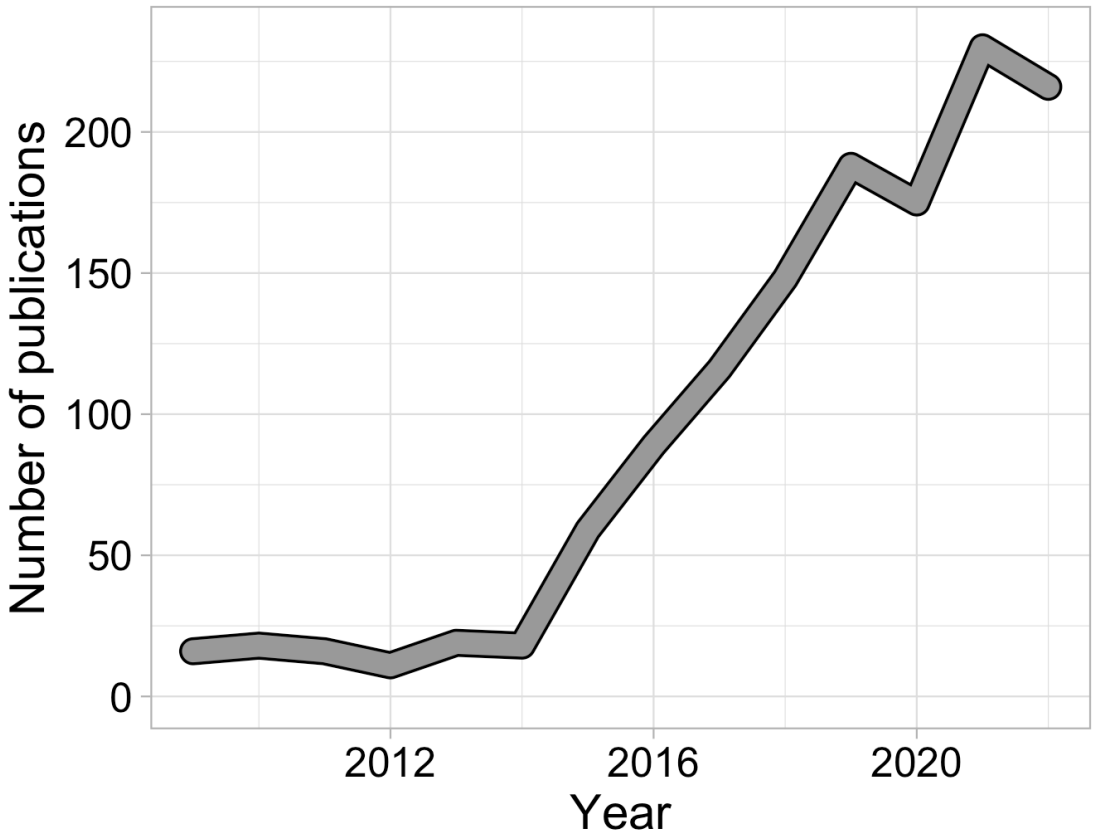
Community eDNA: the NGS-era (2006-2010)

Targeted eDNA: invasive species (Ficetola et al. 2008)

American bullfrog

First eDNA reviews (2012-2014)

eDNA: an exciting and developing field



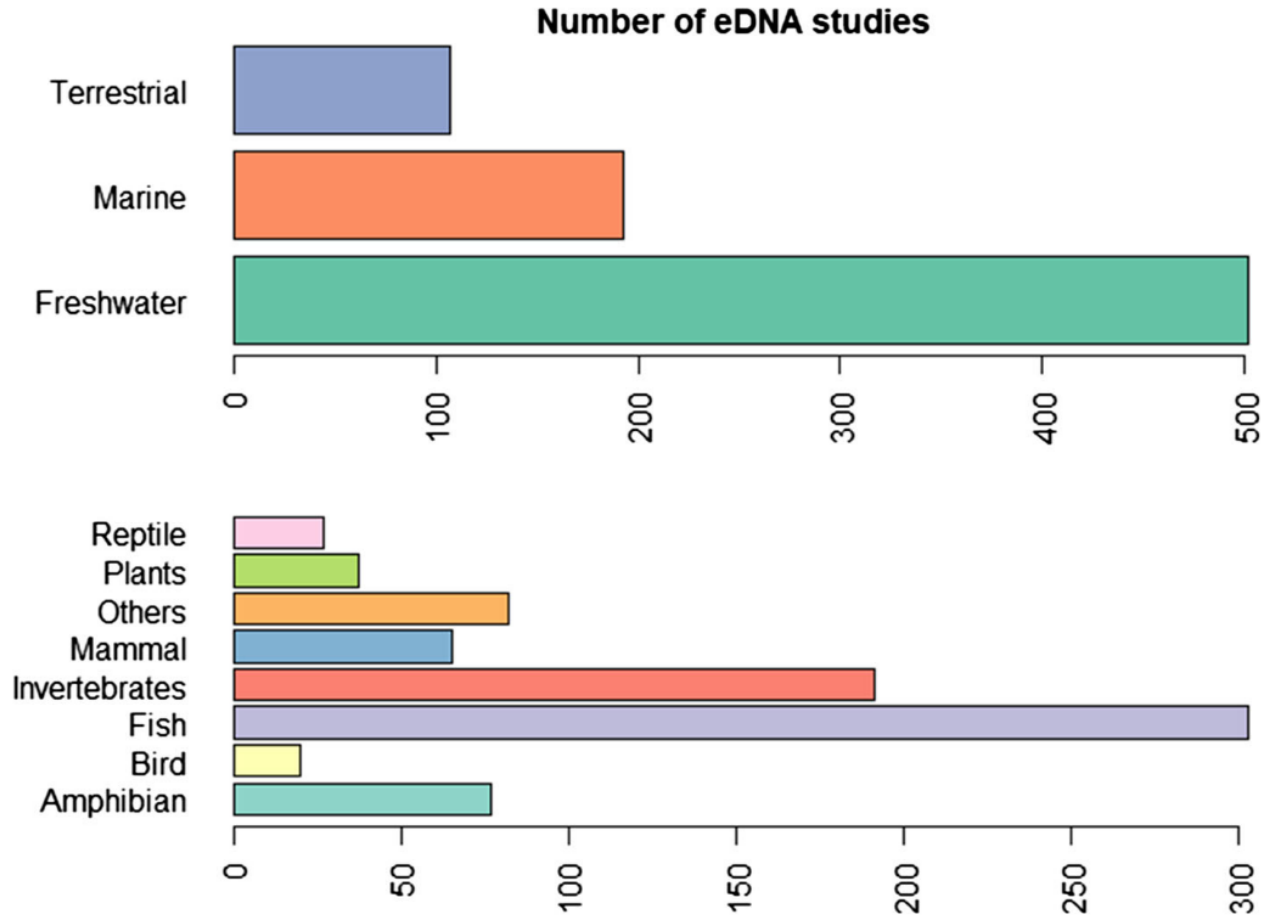


Fig. 2 Number of studies using environmental DNA (eDNA) recovered from a literature search with the words 'environmental DNA' OR 'eDNA' for the period between 1 January 2008 and 31 December 2019 that utilized a different organismal group and ecosystem

Beng & Corlett (2020)

eDNA: opportunities, challenges, solutions

Application	Promises	Challenges		Existing/promising solutions
Ecology & Biomonitoring	Quantify biodiversity Cost-effective Establish baselines Understand biotic and abiotic influences (turn-over, disturbance)	Abundance estimation Incomplete reference libraries	Spatial and temporal acuity False negatives False positives Skepticism Decision-making frameworks Cost-effective ≠ inexpensive Data turn-over	Shotgun metagenomics OTUs Continue to build and curate DNA reference libraries Study origin, state, transport, and fate eRNA Standardized protocols and guidelines from planning to field to lab to analysis Complement traditional survey Collaboration at every step (manager, laboratory, bioinformatician, statistician) Allow process to be iterative
Conservation biology	Cost-effective Non-invasive sampling	Population viability demography life-stage		
Invasion biology	Early surveillance Cost-effective Detect from low abundance			

Bioinformatician

Molecular ecologist/laboratory personnel

Statistician

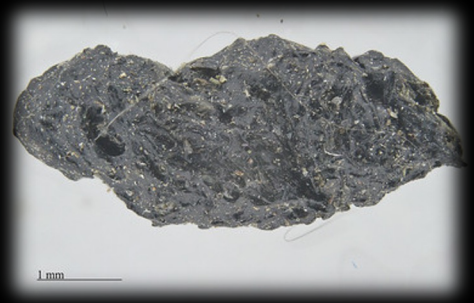
Management
partners/field biologists

Deiner et al. (2017)

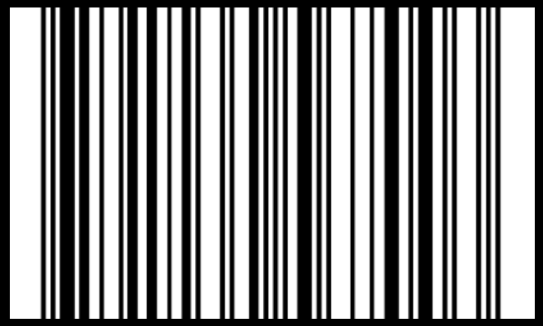
Common markers for DNA barcoding

Organism Group	Marker Gene
Animals	COI, Cyt B, 12S rRNA, 16S rRNA
Plants	ITS2, rbcL
Bacteria	16S rRNA (e.g., microbiomes)
Fungi	ITS1, ITS2

What bat species is this?



TTTCTTCATGGTCATACCTATTATAATC
GGAGGCTTCGGAAACTGATTAGTCCCC
TTAATGATTGGAGCTCCCGATATAGCT
TTCCCCCGAATGAATAATATGAGTTTC
TGACTCCTTCCACCCTCCTTCCTACTA
CTCTTGGCCTCTTCCACAGTAGAAGCC
GGGGCAGGTACTGGATGGACAGTATAC
CCCCCTTTAGCT



Query: unlabeled_sequence
Top Hit: Chordata, Mammalia, Chiroptera, Vespertilionidae, Corynorhinus, Corynorhinus townsendii (100%)

Search Result:

The submitted sequence has been matched to *Corynorhinus townsendii*. This identification is solid unless there is a very closely allied congeneric species that has not yet been analyzed. Such cases are rare.

A species page is available for this taxon: SPECIES PAGE

Closest matching BIN (within 3%): BIN PAGE

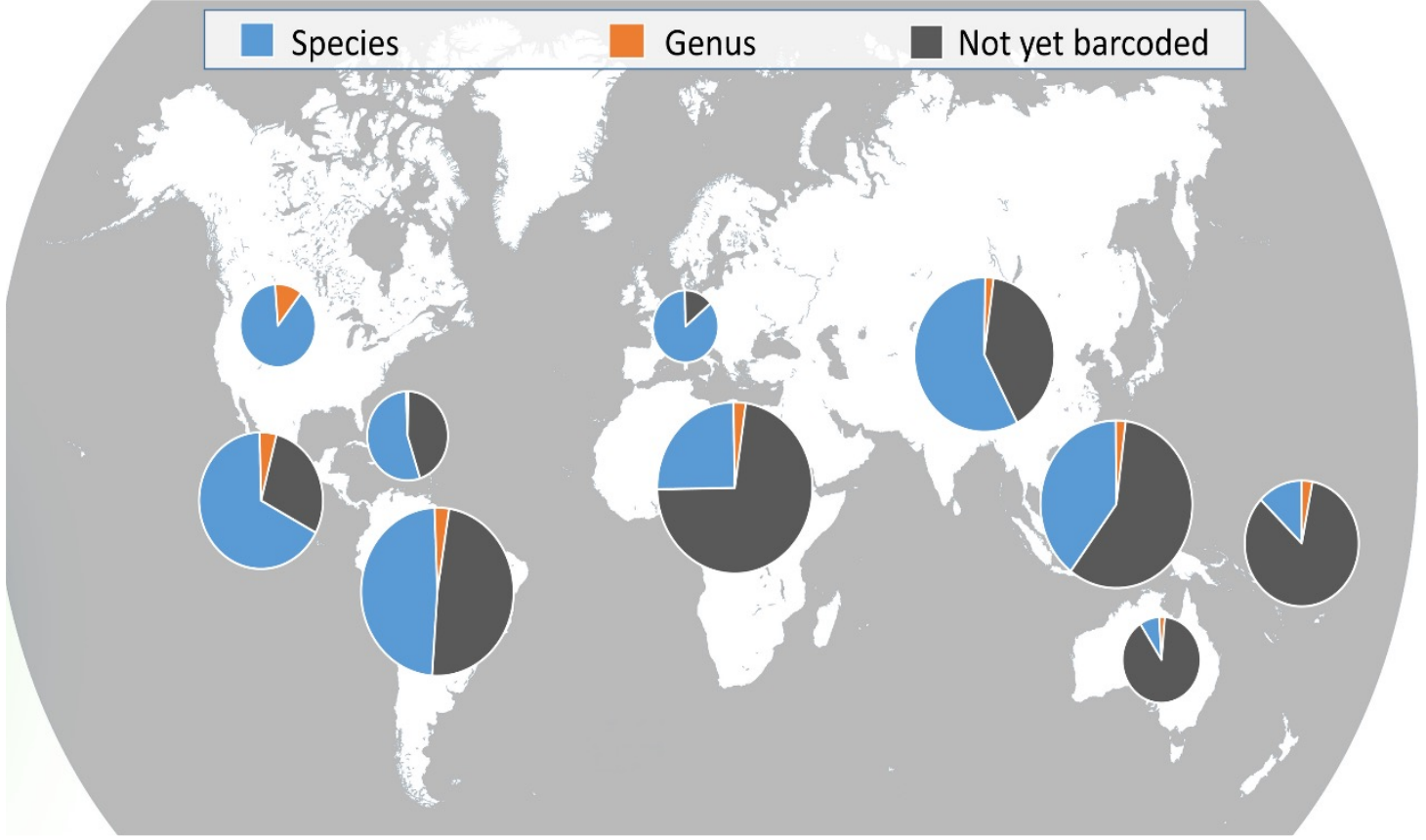
For a hierarchical placement - a neighbor-joining tree is provided: TREE BASED IDENTIFICATION

BOLD SYSTEMS

RESEARCH ARTICLE

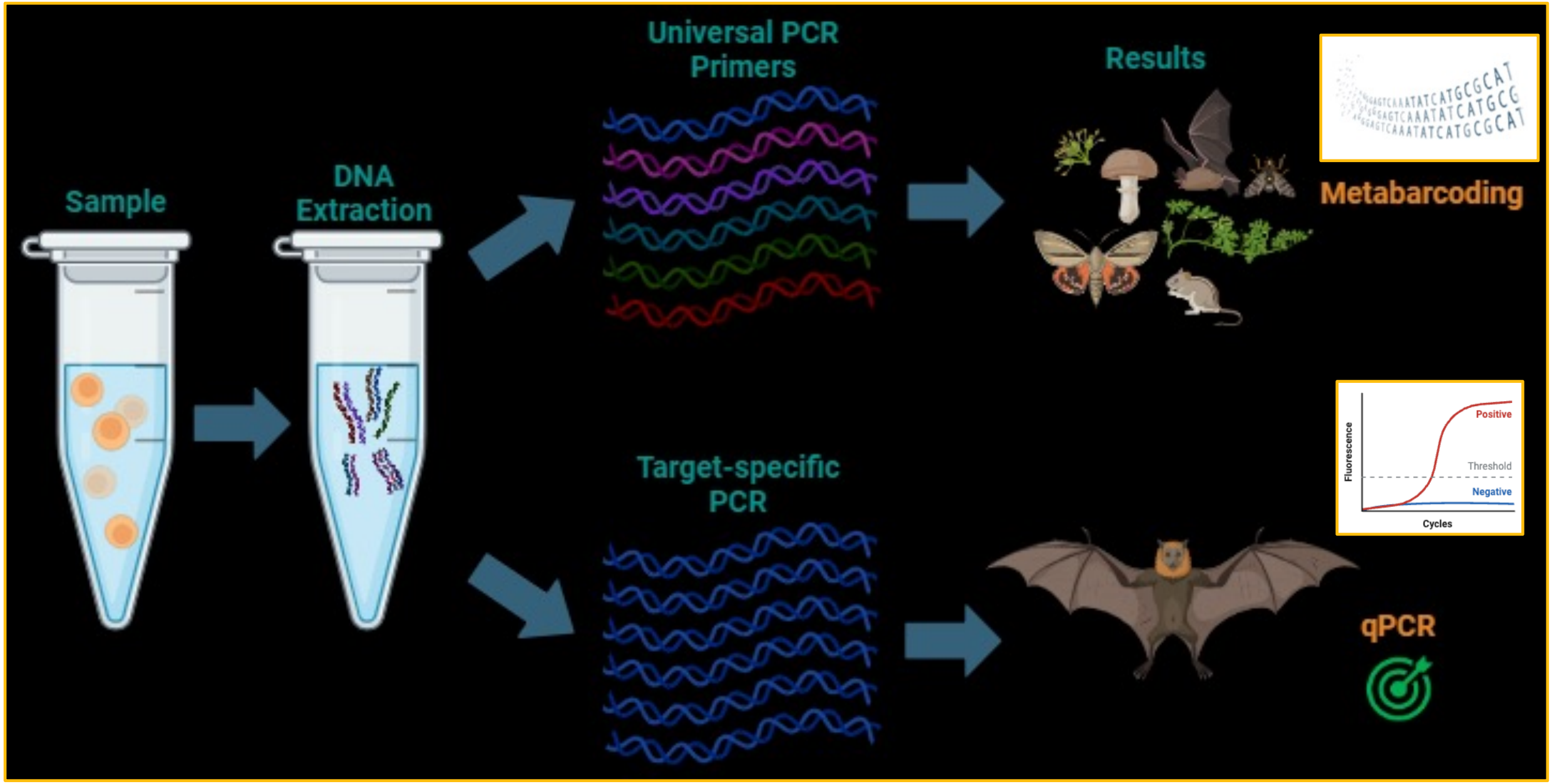
Species From Feces: Order-Wide Identification of Chiroptera From Guano and Other Non-Invasive Genetic Samples

Faith M. Walker[1,2*], Charles H. D. Williamson[2], Daniel E. Sanchez[1,2], Colin J. Sobek[1,2], Carol L. Chambers[1]




92%

Common eDNA detection methods



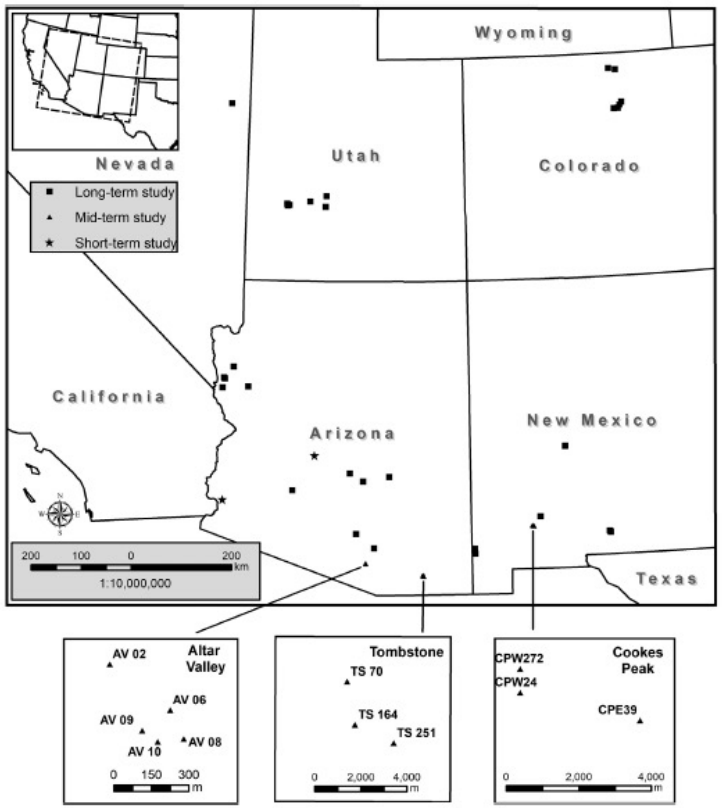
PLOS ONE

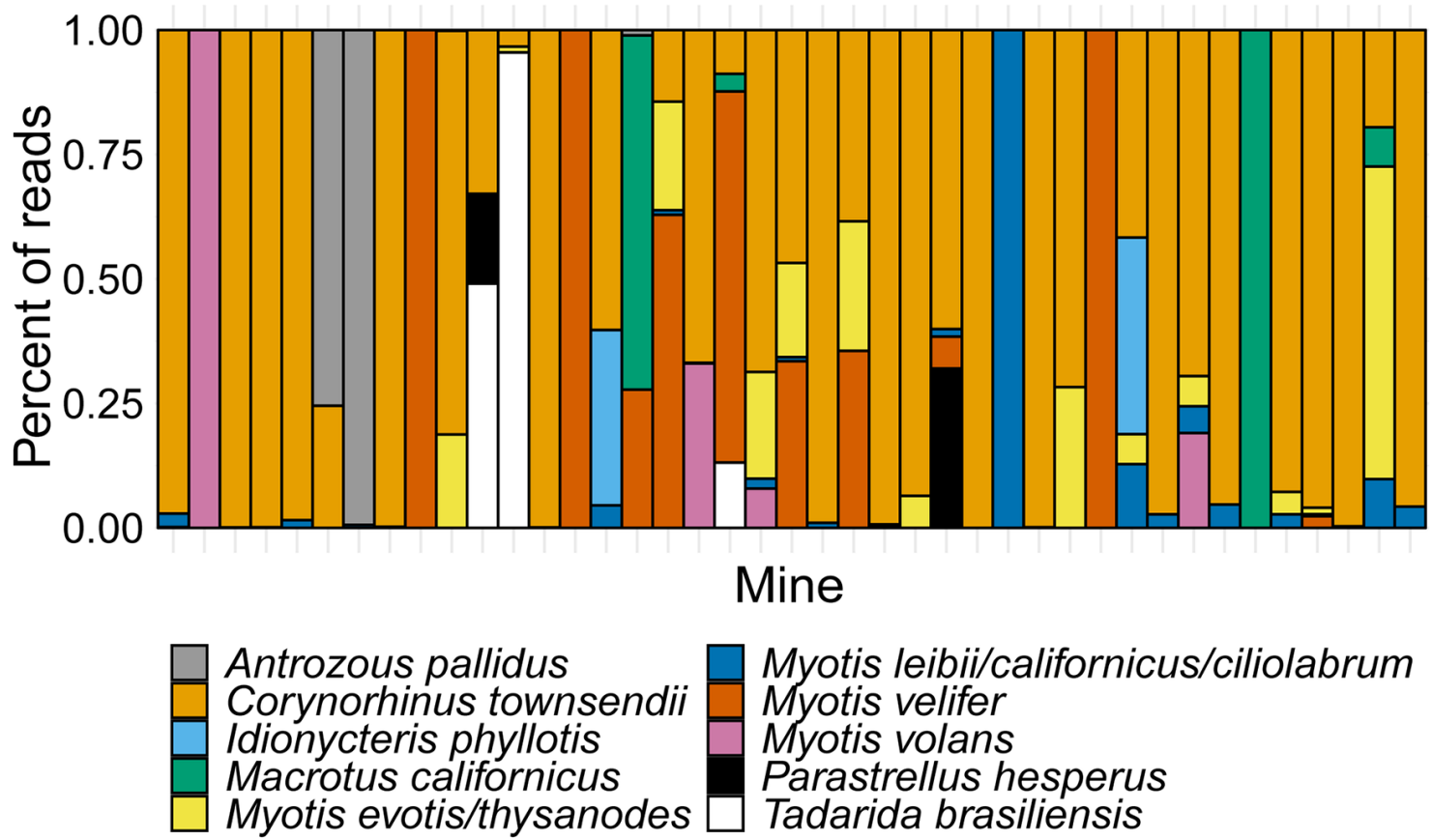
RESEARCH ARTICLE

A fecal sequel: Testing the limits of a genetic assay for bat species identification

Faith M. Walker[1,2]*, Abby Tobin[1], Nancy B. Simmons[3], Colin J. Sobek[1,2], Daniel E. Sanchez[1,2], Carol L. Chambers[1], Viacheslav Y. Fofanov[4]

Published: November 14, 2019

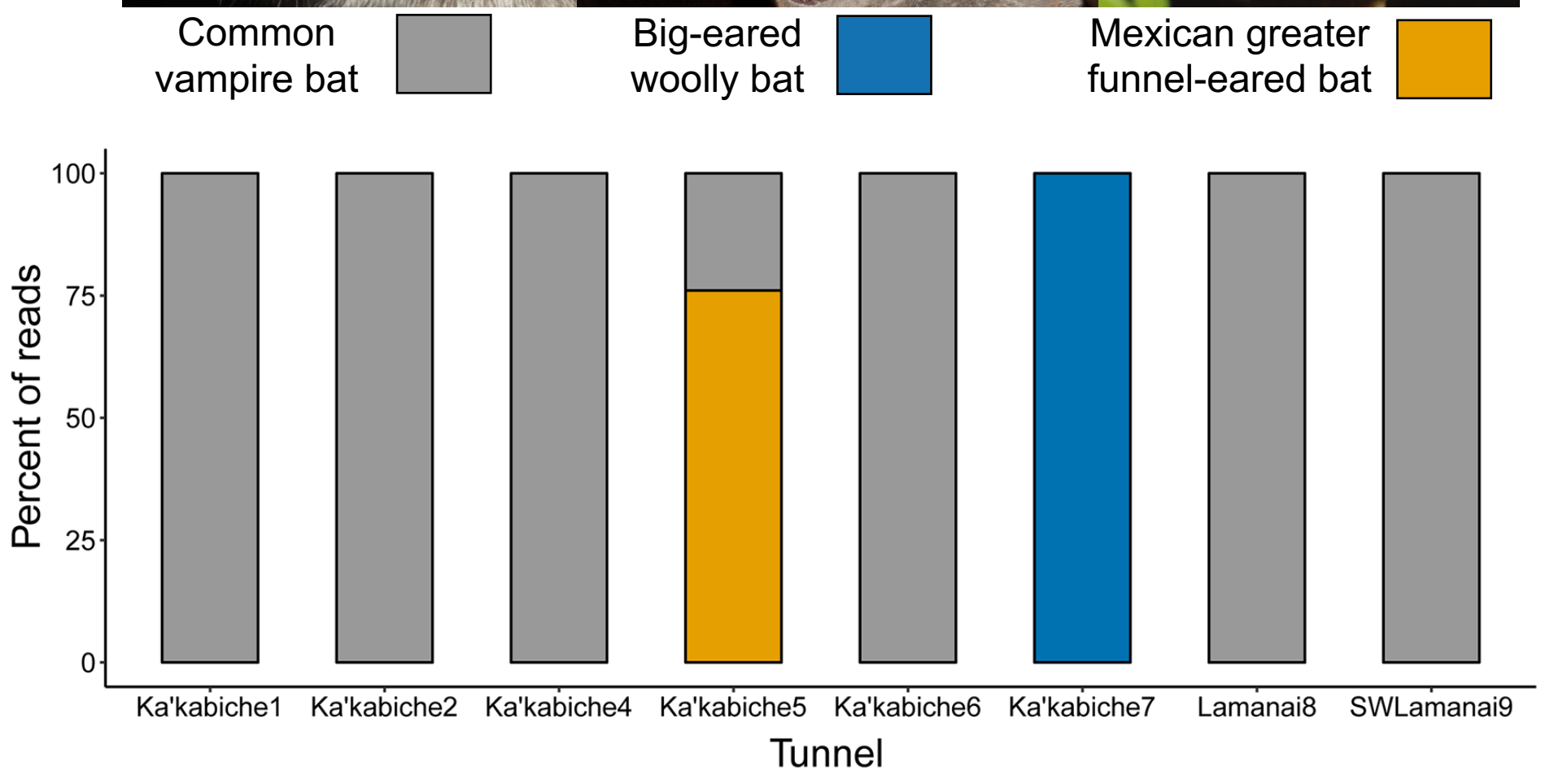

Wyoming
Nevada
Utah
Colorado
Long-term study
Mid-term study
Short-term study
California
Arizona
New Mexico
Texas
200 100 0 200
km
1:10,000,000
AV 02
Altar Valley
AV 06
AV 09
AV 08
AV 10
0 150 300
m
Tombstone
TS 70
TS 164
TS 251
0 2,000 4,000
m
CPW272
CPW24
Cookes Peak
CPE39
0 2,000 4,000
m


1.00
0.75
0.50
0.25
0.00
Percent of reads
Mine
Antrozous pallidus
Corynorhinus townsendii
Idionycteris phyllotis
Macrotus californicus
Myotis evotis/thysanodes
Myotis leibii/californicus/ciliolabrum
Myotis velifer
Myotis volans
Parastrellus hesperus
Tadarida brasiliensis

First eDNA detection of bats from sediment (soil, sand, and rocks)

Inconspicuous eDNA sources?

Walker et al. (2019)



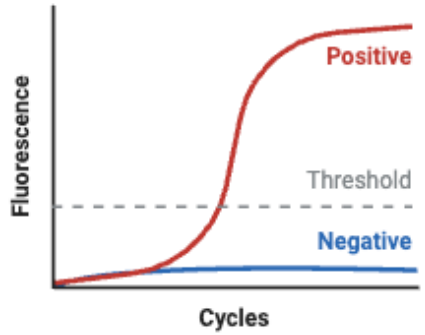
First eDNA detections of bats from water, soil, and air

Molecular genetic analysis of air, water, and soil to detect big brown bats in North America

Natasha R. Serrao [a,b], Julie K. Weckworth [a,b,*], Kevin S. McKelvey [a], Joseph C. Dysthe [a], Michael K. Schwartz [a]

[a] National Genomics Center for Wildlife and Fish Conservation, Rocky Mountain Research Station, United States Forest Service, Missoula, MT, United States of America
[b] Wildlife Biology Program, Department of Ecosystem and Conservation Sciences, W. A. Franke College of Forestry and Conservation, University of Montana, Missoula, MT, United States of America

Biological Conservation 261 (2021) 109252

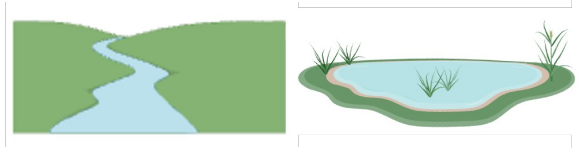


Known occupation

	✓	1/4 samples: 1 site	Natural site
	✓	1/5 samples: 1 site	Natural site
	✓	6/7 samples: 1 site	Captive colony

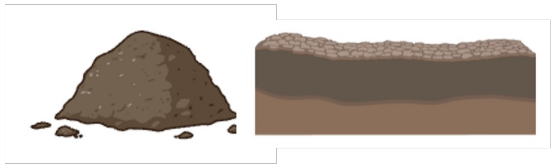
Eptesicus fuscus

Inconspicuous sources of bat eDNA



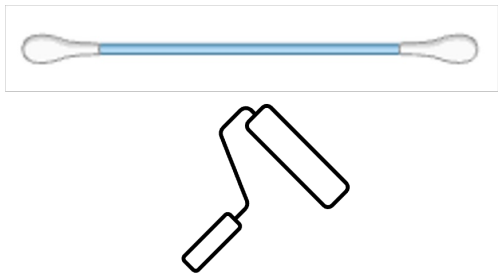
WATER

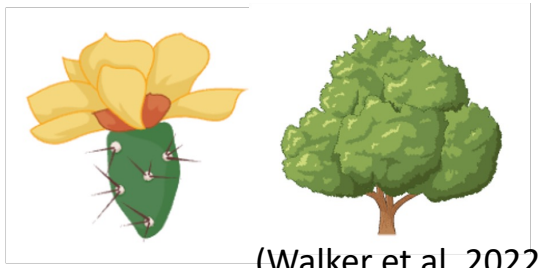
(Serrao et al. 2021; Marshall et al. 2022)



SOIL/SEDIMENT

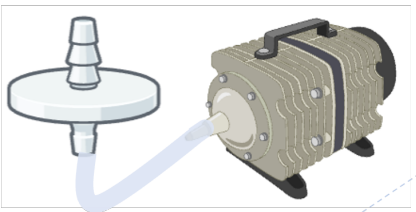
(Walker et al. 2019; Serrao et al. 2021; Allen et al. 2023)





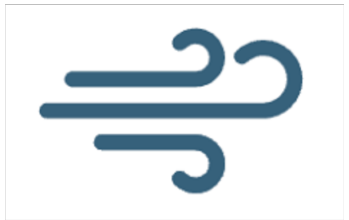
RESOURCES/HABITAT

(Walker et al. 2022; Allen et al. 2023)



Active

Passive?...
Stay tuned



AIR

(Garrett et al. 2022; Garrett et al. 2023)

NAU NORTHERN ARIZONA UNIVERSITY

School of Forestry

RESOURCES/HABITAT

Can we detect nectar-feeding bats from agave flowers?

Open Access Article

Endangered Nectar-Feeding Bat Detected by Environmental DNA on Flowers

by Faith M. Walker [1,2,*], Daniel E. Sanchez [1,2], Emma M. Froehlich [1,2], Emma L. Federman [1,2], Jacque A. Lyman [1,2], Meagan Owens [1,2] and Kristen Lear [3,4]

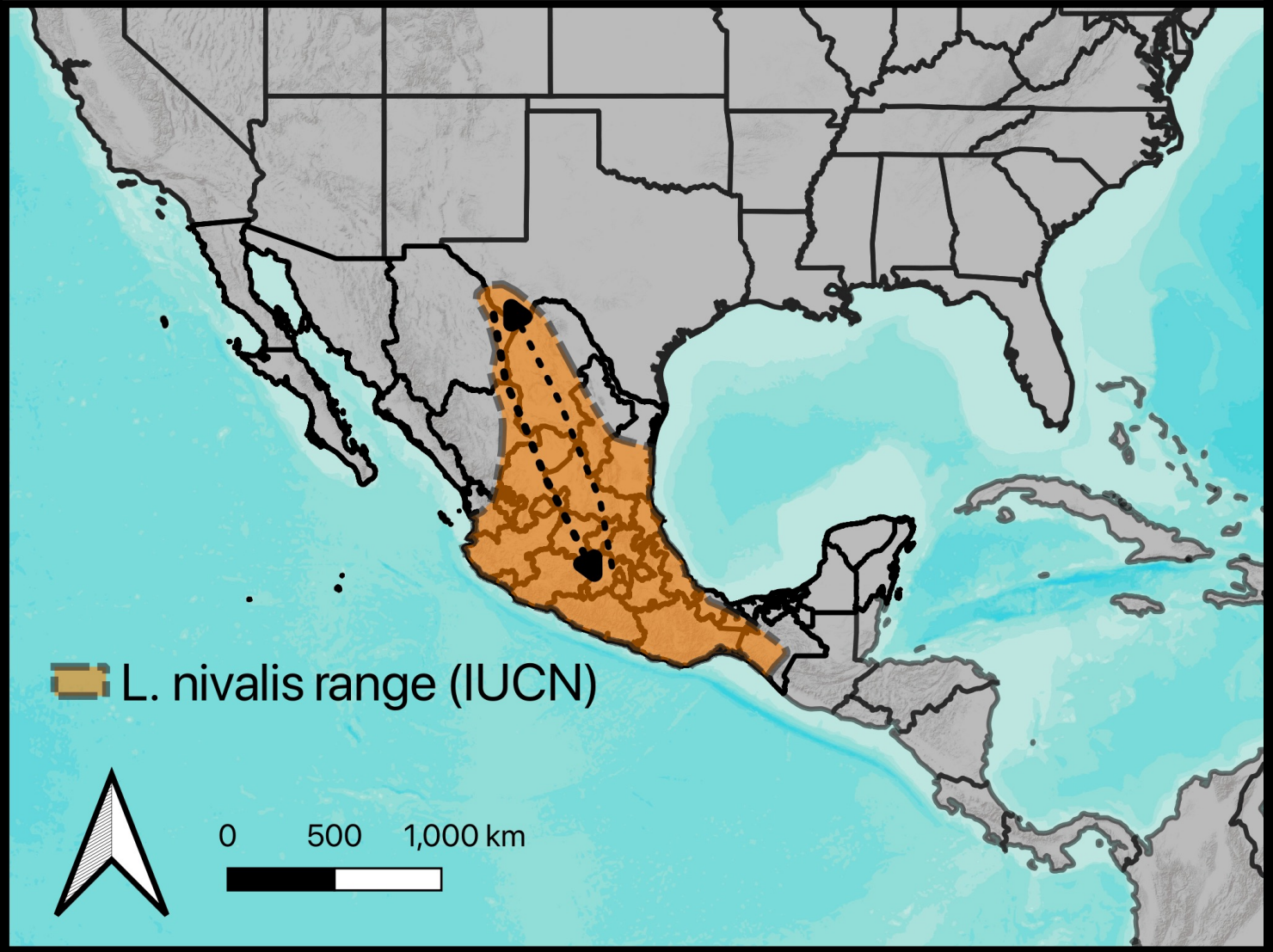
animals

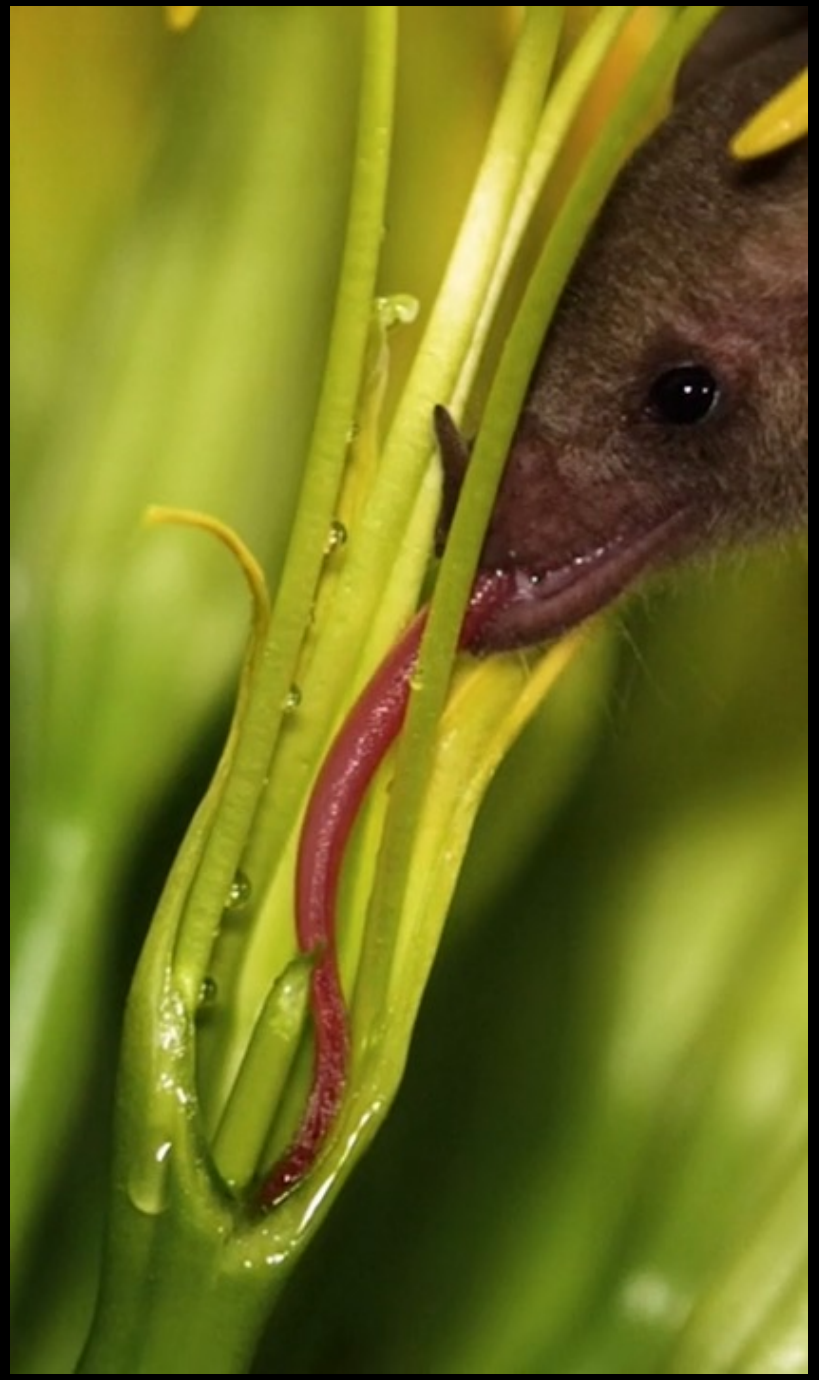
Kristen Lear

BAT CONSERVATION INTERNATIONAL

Mexican long-nosed bat (*Leptonycteris nivalis*)

- Unknown migration corridors





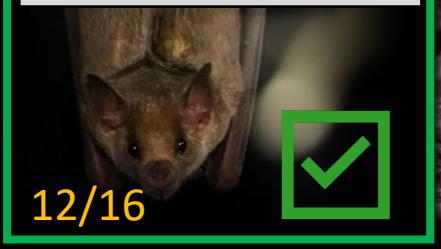
Swabs

eDNA: Metabarcoding

Capturing a desert community from 2 agave plants

Mammals

Mexican long-nosed bat



12/16

Gray fox

Ringtail

Deer

6 taxa

Arthropods

4 bee species

Western flower thrip

Crab spider

Leaf-footed bug

62 taxa
3 classes
15 orders

Plants

Agave

Scarlet bouvardia

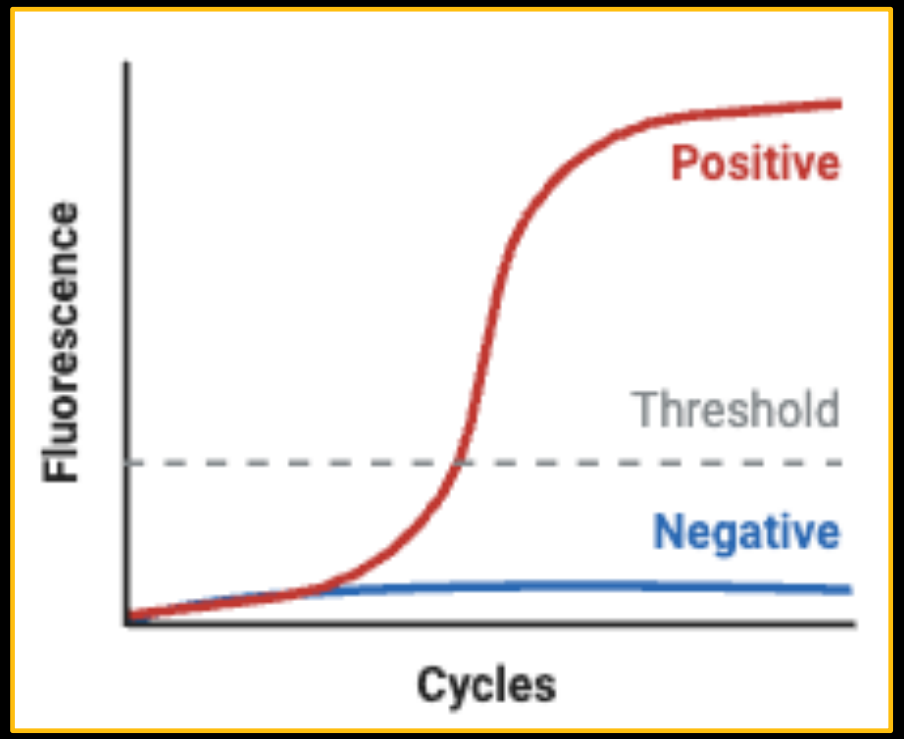
Evening primrose

Alkali sacaton

23 taxa
12 families

eDNA: qPCR 🎯

Agave a promising eDNA source of nectar feeding bats

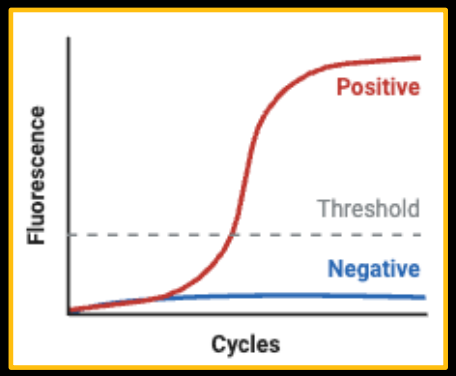


13/16 samples

qPCR: Cheaper, faster, likely more sensitive

Also developed new qPCR assays for other nectar feeding bats

eDNA: qPCR



Lesser long-nosed bats at a hummingbird feeder in Arizona. Photo: Ted Fleming

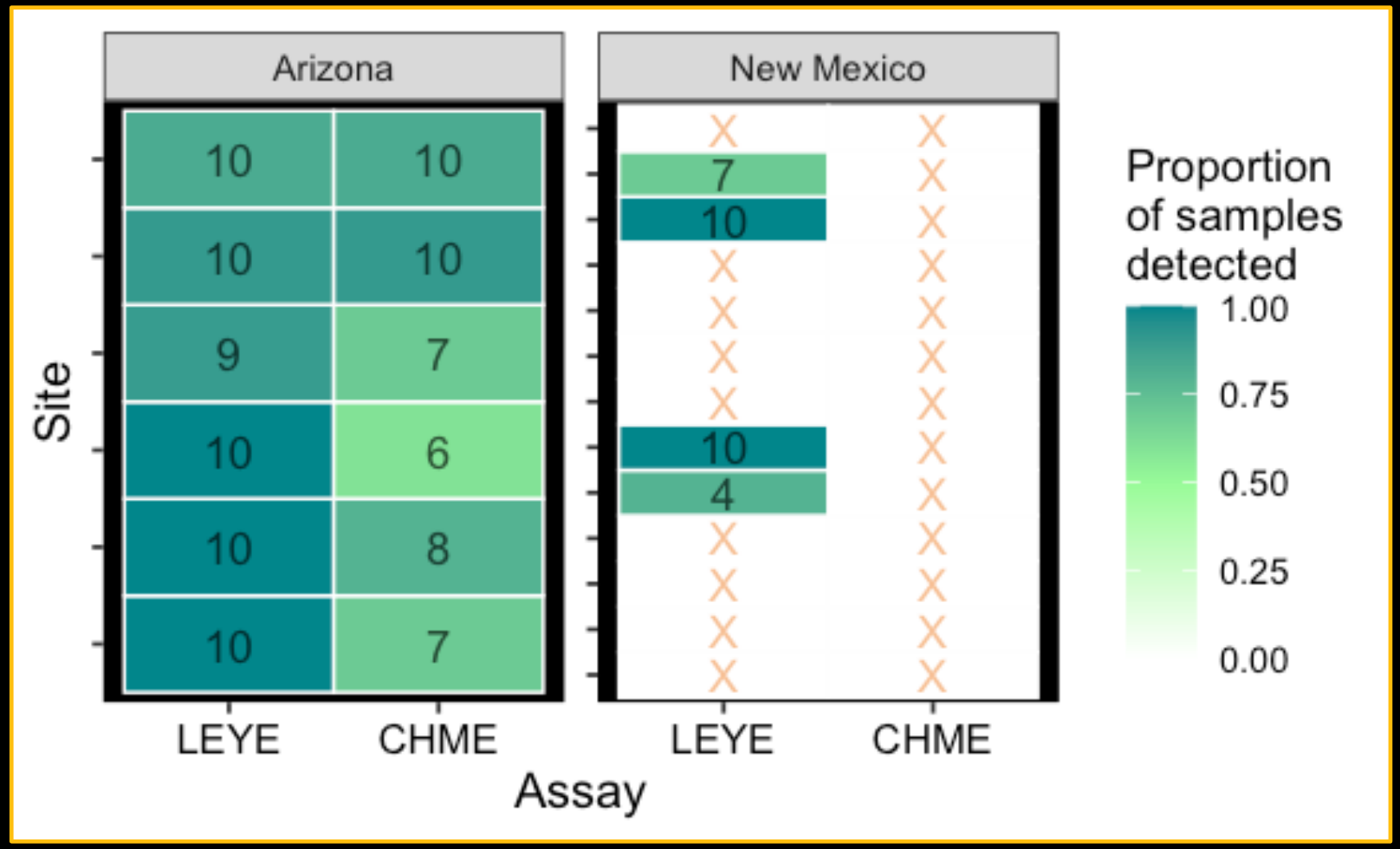
Anna Riley

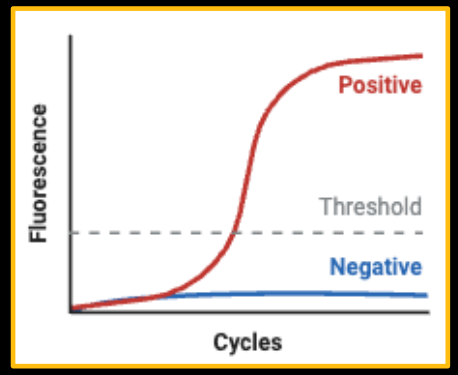
Mexican long-tongued bat
(*Choeronycteris Mexicana:* CHME)

Lesser long-nosed bat
(*Leptonycteris yerbabuenae:* LEYE)

eDNA: qPCR 🎯

Opportunities for citizen science

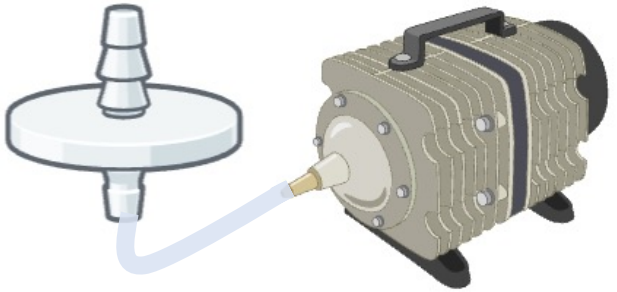


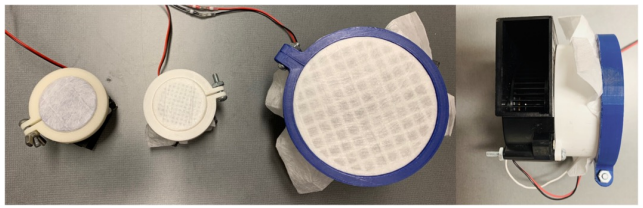


Lesser long-nosed bats at a hummingbird feeder in Arizona. Photo: Ted Fleming

Out of thin air: surveying tropical bat roosts through air sampling of eDNA

Nina R. Garrett[1], Jonathan Watkins[2], Charles M. Francis[3], Nancy B. Simmons[4], Natalia Ivanova[5], Amanda Naaum[5], Andrew Briscoe[6], Rosie Drinkwater[7] and Elizabeth L. Clare[1]





PeerJ

Published 26 April 2023

Can we detect bat eDNA passively?

- **No pump/vacuum**

Can we detect from the open air?

Cheesecloths? (see Frere et al. 2023)

Dr. Carol Chambers

Dr. José Gabriel Martinez-Fonseca

Air samplers: Cheesecloth

Open air: netting sites

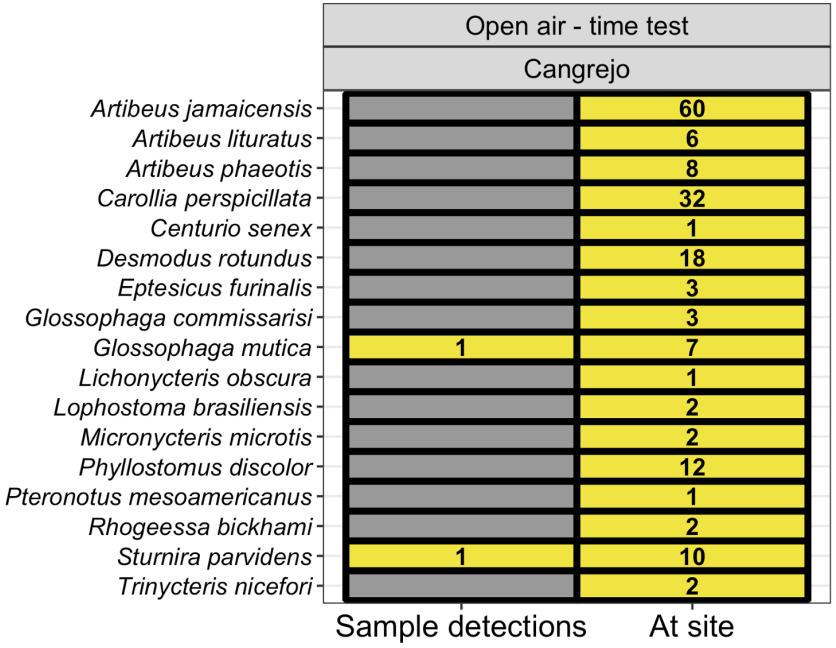
Enclosure: cave roost

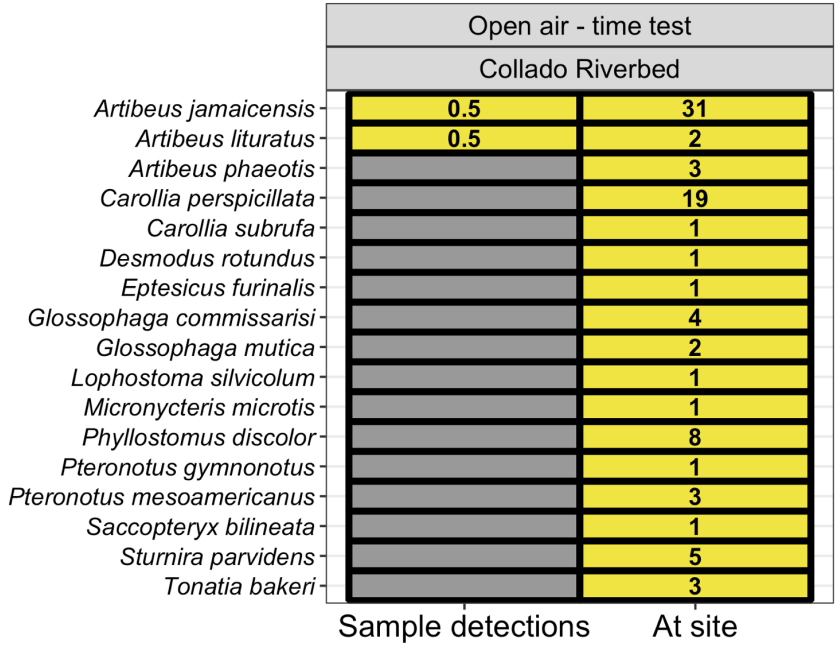
Detection method: Metabarcoding

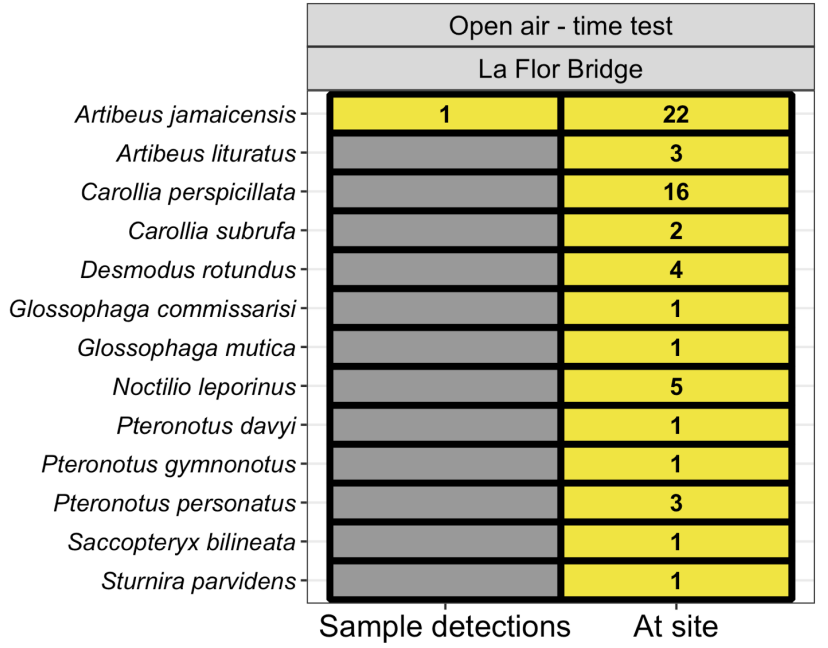
Open air eDNA detections

Air samplers: Cheesecloth

Detection method: Metabarcoding



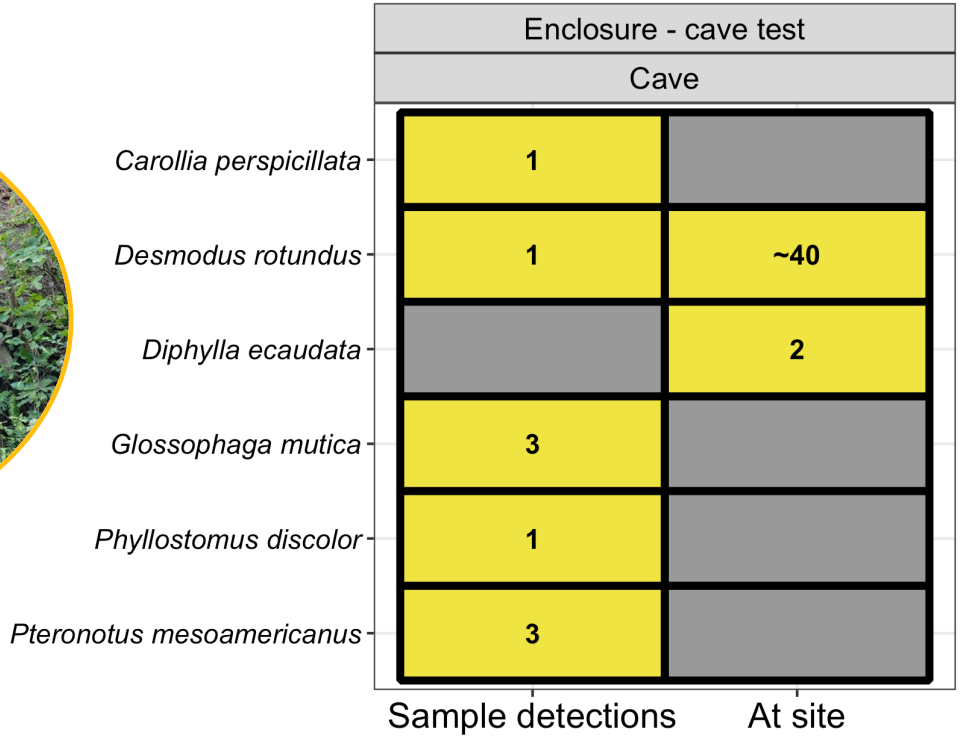




eDNA detections in a cave roost

Air samplers: Cheesecloth

Detection method: Metabarcoding



NAU NORTHERN ARIZONA UNIVERSITY

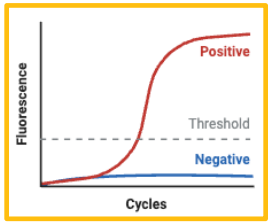
School of Forestry

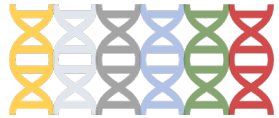
Environmental DNA (eDNA) applications for detecting bat species

- **Bat eDNA can be detected from numerous environmental sources**
  - **Conspicuous**
    - Guano
  - **Inconspicuous**
    - Water
    - Soil/sediment
    - Resources/habitat
    - Air

SPECIES FROM FECES

Daniel.Sanchez@nau.edu





SPECIES FROM FECES