AIRBORNE DNA AS BIOMARKERS OF AGING AND DISEASE

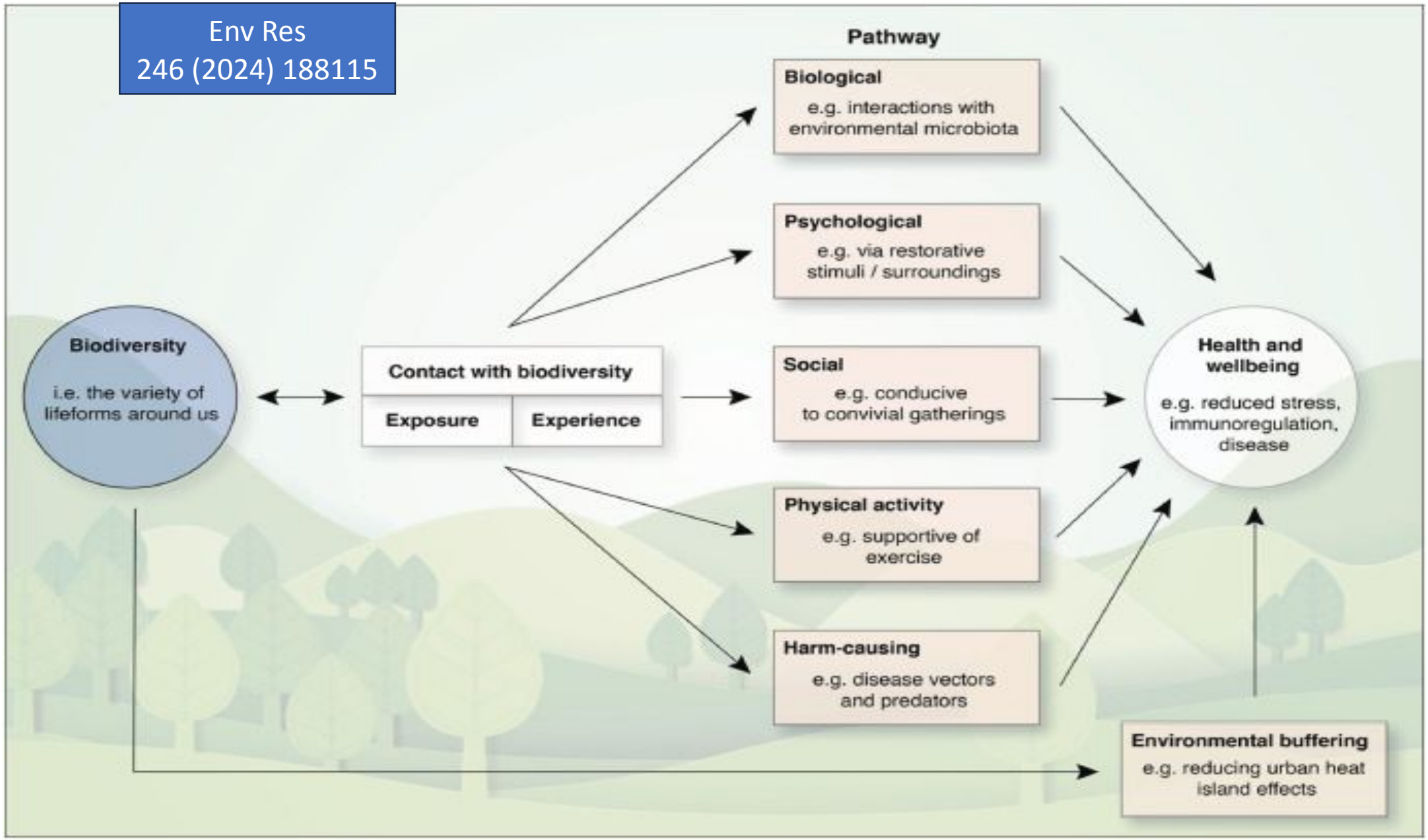
Robert B. Wallace, MD, MSc
Departments of Epidemiology and Internal Medicine
University of Iowa

No Conflicts of Interest to Declare

Outline of Talk

- Importance of biodiversity
- Difficulties of studying ecology and biodiversity in nature
- Environmental study of airborne DNA as one (tentative) solution
- Applications of airborne DNA collection directly related to population surveys, human health and aging
- Limitations of airborne DNA collection
- Some future directions

Env Res
246 (2024) 188115



DNA Pulled from Thin Air Identifies Nearby Animals

…and can be used to identify local biodiversity…

Stokstad, Science Magazine, 20July2021

Why DNA: Utility as a Molecular Biomarker

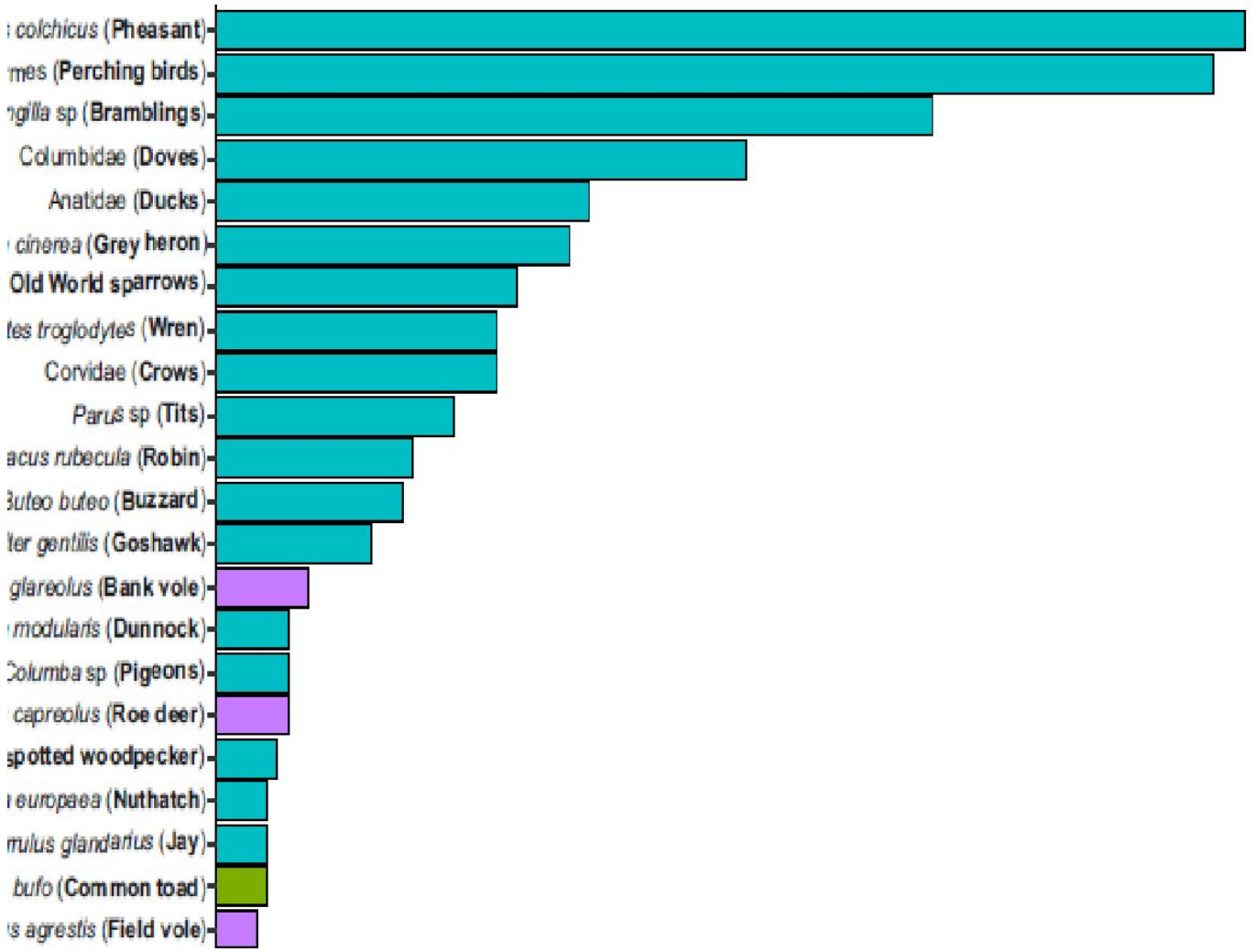
- Molecule that withstands degrading more than most
- Forms linkages with other chemical substances (e.g., adducts)
- Can be used to identify species (“barcoding”) and individuals because of molecule size and heterogeneity
- Central links to physiological function, health and disease

Swedish Nobel-winning scientist for extracting DNA from 40,000 y/o bones

Challenges Facing Direct Collection of Environmental DNA Through Fieldwork (Genes 2019;10;192)

- Natural history of eDNA not fully understood
- High costs of field sample data collection
- Volume of sample elements is large and diverse
- Data collection can be dangerous for the collectors
- Humans often don’t volunteer (blood, feces, other microbiota)
- Animal sampling can be environmentally destructive or lethal
- Sampling can be time-consuming, dangerous and stressful for scientists and technicians

Airborne Environmental DNA Captures Territorial Vertebrate Diversity in Nature: Denmark Mol Ecol Resour 2023;00:1020



Findings of a Systematic Review of Terms Related to Biodiversity

(Sci Total Env, March, 2024, 171692)

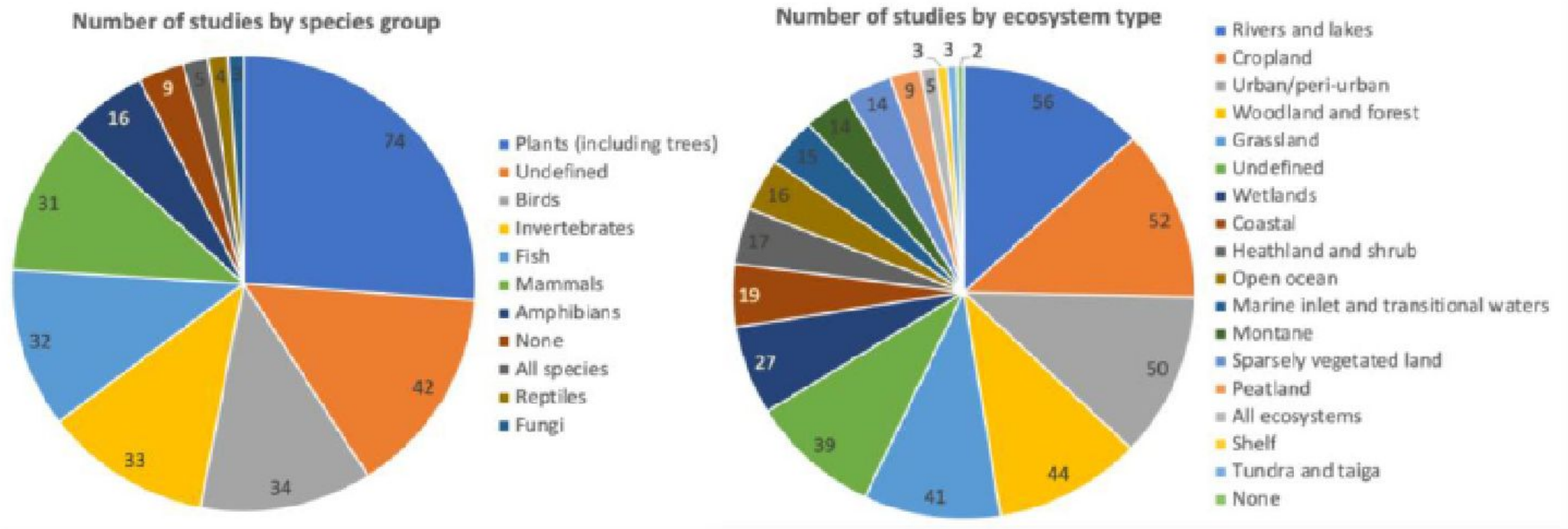
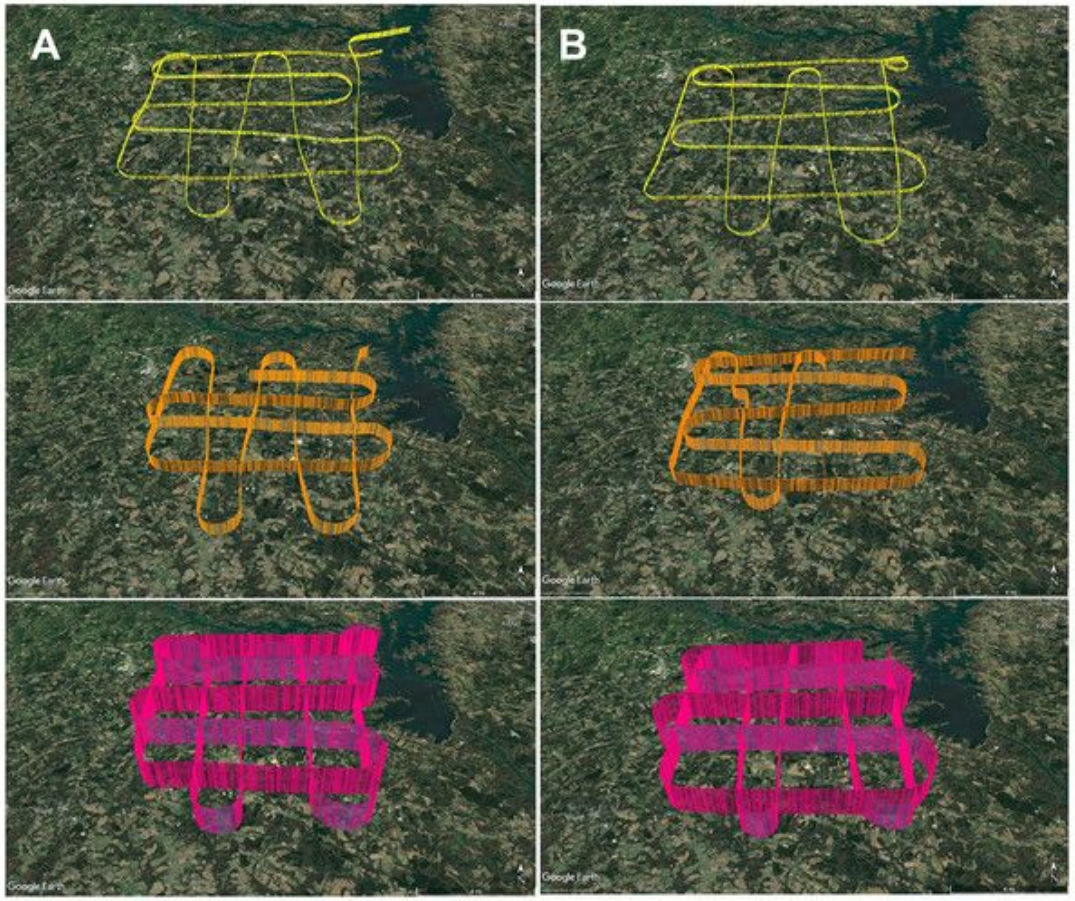


Figure 2. Number of studies by species group and ecosystem type

Applications and Technologies Related to Airborne DNA Collection

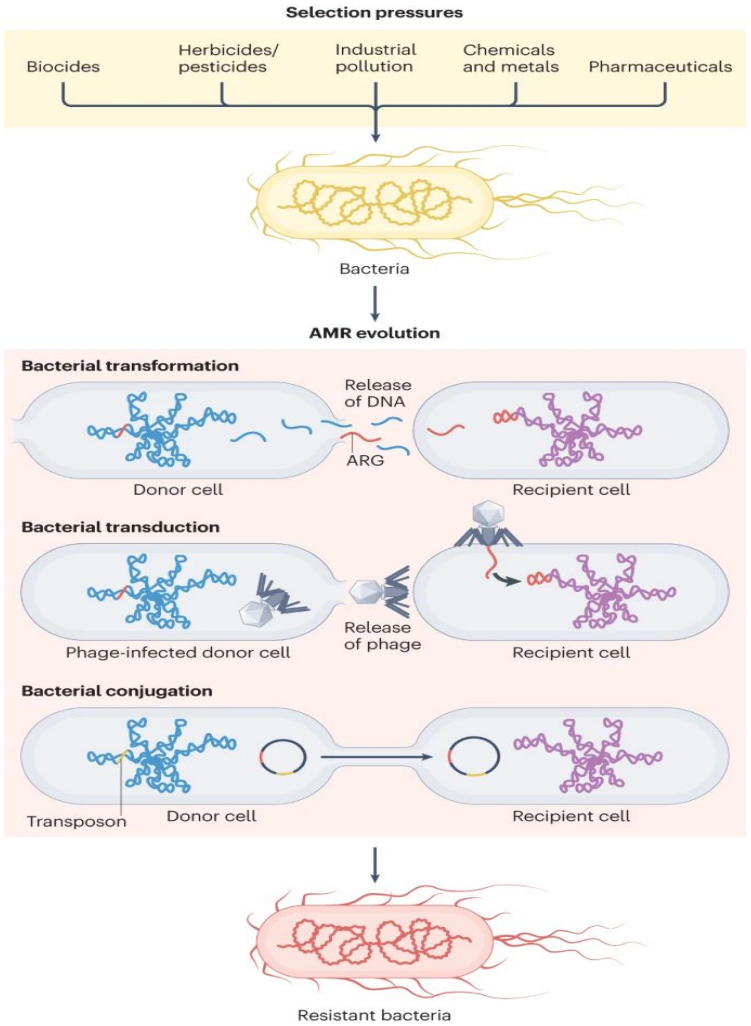
Aircraft Surveys for Air eDNA: Probing Biodiversity

(PeerJ doi: 10.7717/peerj.15171)



Environmental Genomic Surveillance for Antibiotic Resistance Genes

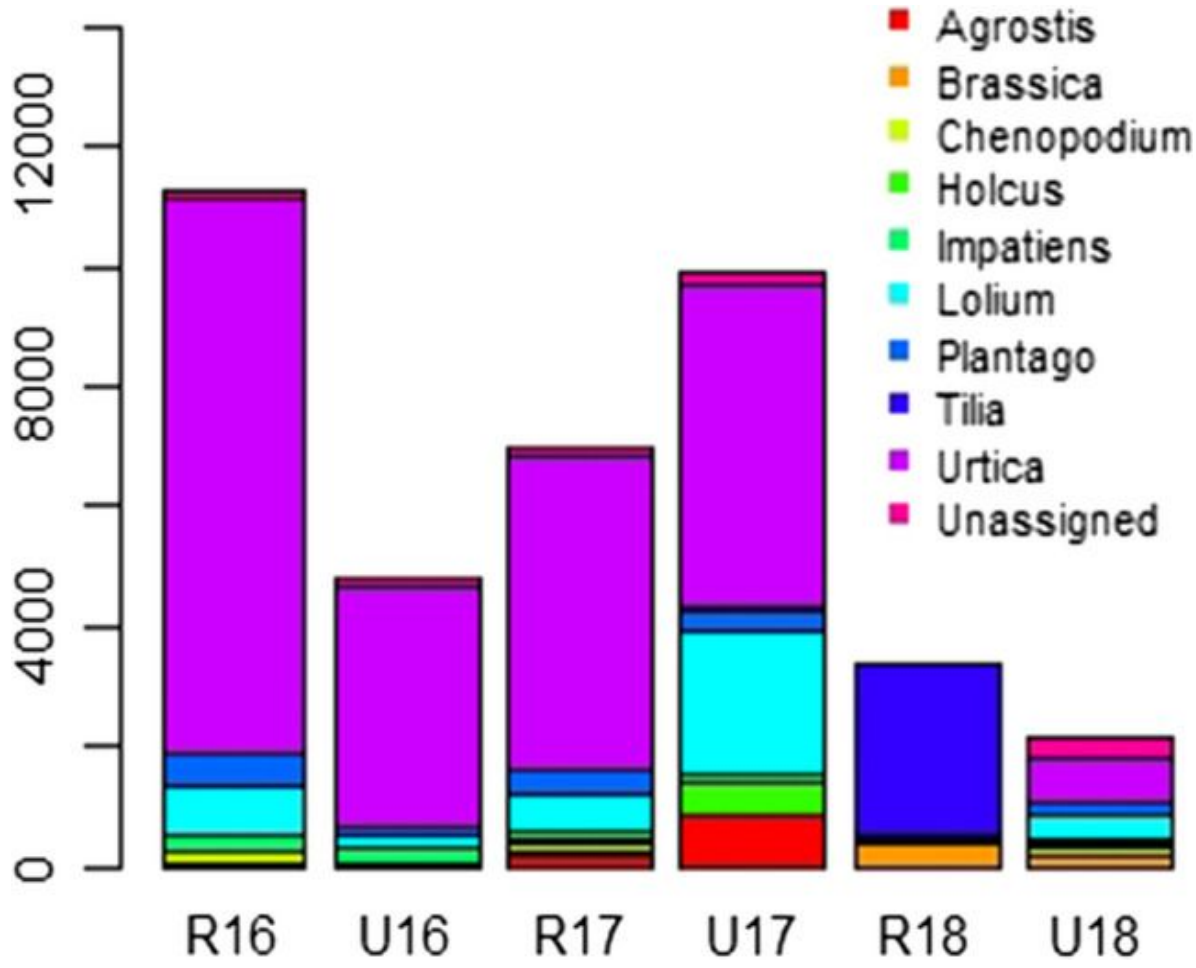
Nature Reviews Genetics 2024; 25:142-157



- Pollution *(biocides, pesticides, chemicals & metals, pharmaceuticals)* causes <u>bacterial evolution</u> of antibiotic resistance genes
- Bacterial change mechanisms:
  - -Transformation
  - -Transduction (phage release)
  - -Conjugation (“mating” with other bacteria)

Distribution of Summer Urban/Rural (UK) Plant Airborne DNA (pollen extract)

(Aerobiologia 2022;38:591-596)



BioWatch and Future Technological Resources for Airborne DNA NASEM Workshop PMID 29771479, 2018

- DNA capture and extraction systems
- “Field” mass spectrometry
- Point-of-need PCR
- Rapid, targeted next-generation sequencing
- Indoor surveillance modifications

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FARMING PRACTICES

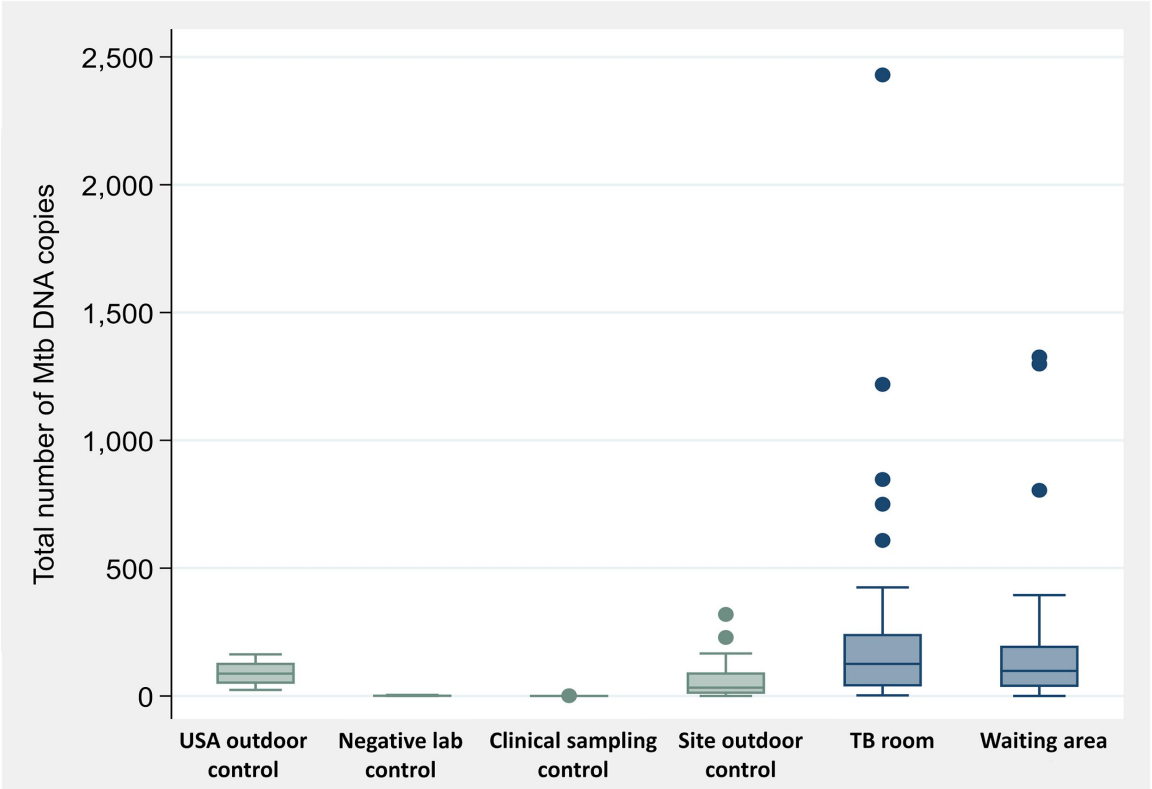
Joint environmental and social benefits from diversified agriculture

Laura Vang Rasmussen[1*†], Ingo Grass[2,3†], Zia Mehrabi[4,5,6], Olivia M. Smith[7,8], Rachel Bezner-Kerr[9], Jennifer Blesh[10], Lucas Alejandro Garibaldi[11,12], Marney E. Isaac[13], Christina M. Kennedy[14], Hannah Wittman[15,16], Péter Batáry[17], Damayanti Buchori[18], Rolando Cerda[19], Julián Chará[20], David W. Crowder[21], Kevin Darras[22], Kathryn DeMaster[23], Karina Garcia[24], Manuel Gómez[25], David Gonthier[24], Purnama Hidayat[26], Juliana Hipólito[27,28,29], Mark Hirons[30], Lesli Hoey[31], Dana James[15,16], Innocensia John[32], Andrew D. Jones[33], Daniel S. Karp[34], Yodit Kebede[35], Carmen Bezner Kerr[36], Susanna Klassen[15,16,37], Martyna Kotowska[38], Holger Kreft[39], Ramiro Llanque[40], Christian Levers[16,41,42], Diego J. Lizcano[43], Adrian Lu[23], Sidney Madsen[9], Rosebelly Nunes Marques[44], Pedro Buss Martins[44], America Melo[43], Hanson Nyantakyi-Frimpong[45], Elissa M. Olimpi[46], Jeb P. Owen[21], Heiber Pantevez[25], Matin Qaim[47], Sarah Redlich[48], Christoph Scherber[49,50], Amber R. Sciligo[51], Sieglinde Snapp[52], William E. Snyder[53], Ingolf Steffan-Dewenter[48], Anne Elise Stratton[10,54], Joseph M. Taylor[53], Teja Tscharntke[55], Vivian Valencia[56,57], Cassandra Vogel[48,58], Claire Kremen[59]

Agricultural simplification continues to expand at the expense of more diverse forms of agriculture. This simplification, for example, in the form of intensively managed monocultures, poses a risk to keeping the world within safe and just Earth system boundaries. Here, we estimated how agricultural diversification simultaneously affects social and environmental outcomes. Drawing from 24 studies in 11 countries across 2655 farms, we show how five diversification strategies focusing on livestock, crops, soils,

Air Filter Sampling for Tuberculosis DNA in Clinical Areas

(Infect Control Hosp Epidemiology 2023; 44:744-749)



N	6	33	20	19	48	26
Median copies (IQR)	87 (48- 130)	0.0 (0.0 – 0.0)	0.8 (0.4 - 2)	33 (8 - 93)	125 (37 – 243)	98 (35 – 197)

Diseases Causes by Mold and Fungal Spores

(Source: Microsoft Co-Pilot AI-aided; Downloaded 17Mar24)

- Allergic and invasive aspergillosis
- Aspergillomas
- Allergic rhinitis (hay fever)
- Hypersensitivity pneumonitis
- Superinfection in persons with immunosuppressive conditions
- Atopic dermatitis (?)
- Candidiasis (*C. auris*)

Household “Microbiome:” Five Cities in Northern Europe https://ubmed.com/m/37523308

- Household characteristics

-Season sampled/ weather averages

-No./demographics of occupants

-Cats/dogs in house/bedrooms

-Kitchen fan use

-Types of heating/ventilation/air cond. systems

-Cleaning chemicals and systems

-Mold visibility/odor

-Water damage

- More DNA/RNA species identified:

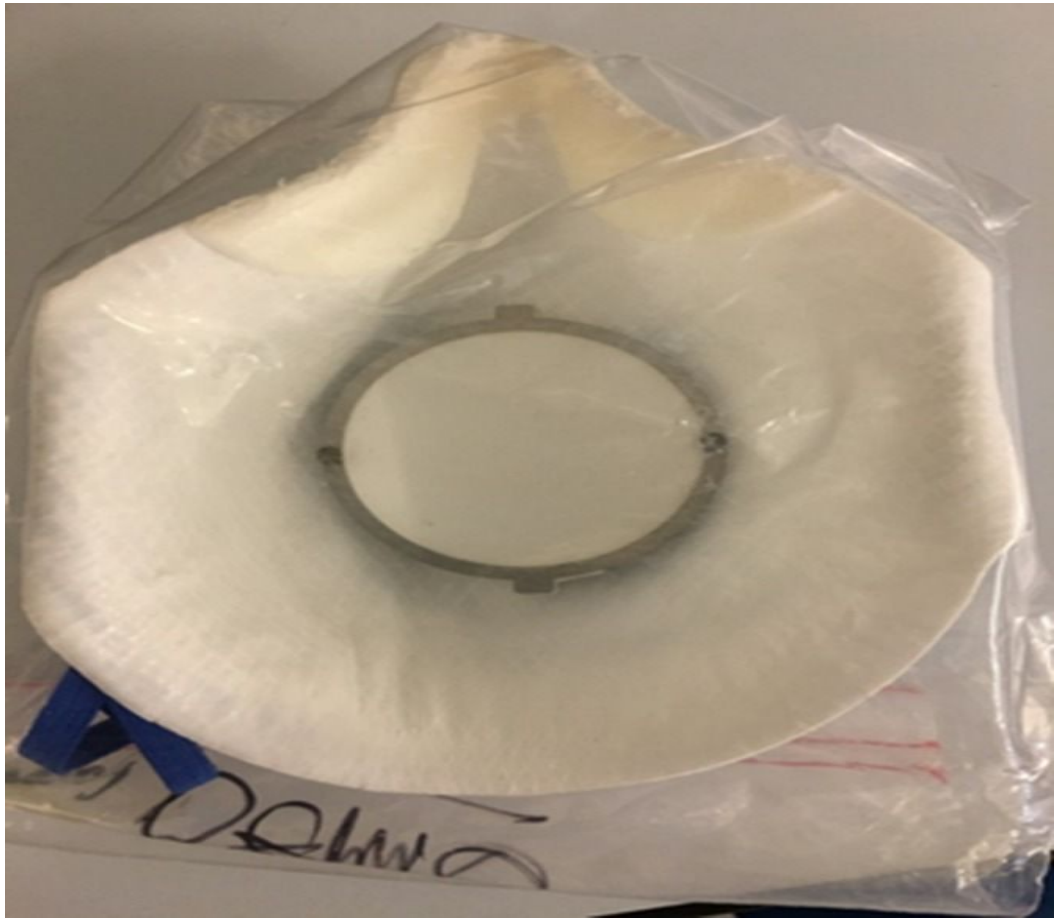
-More occupants

-More pets

-Younger vs. older people

-More evidence of mold…

In Patients with COPD and in Healthy Controls, Antibiotic Resistance Genes can be Identified. (BMJ Open Respir Res 5(1):e000321)

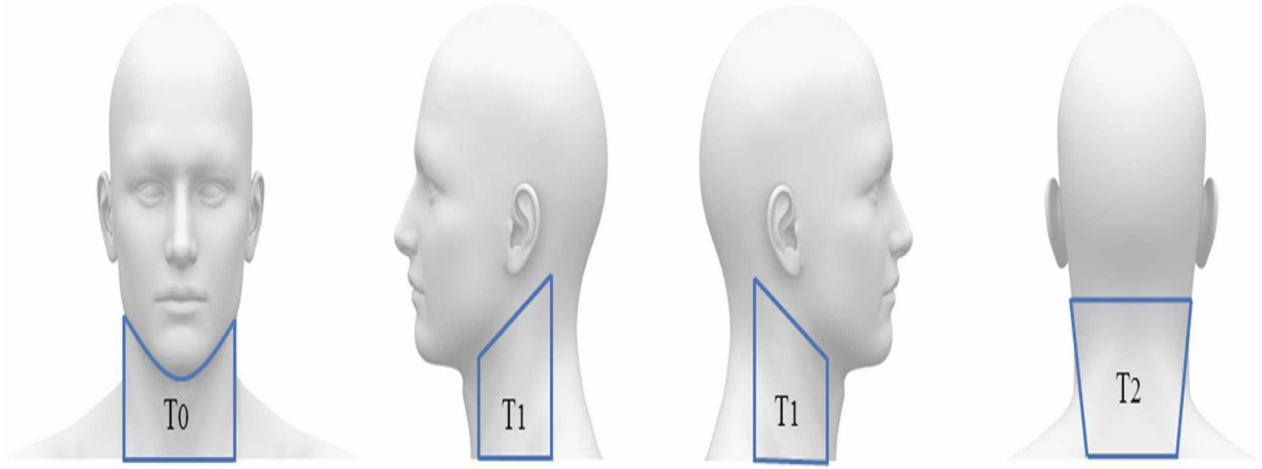


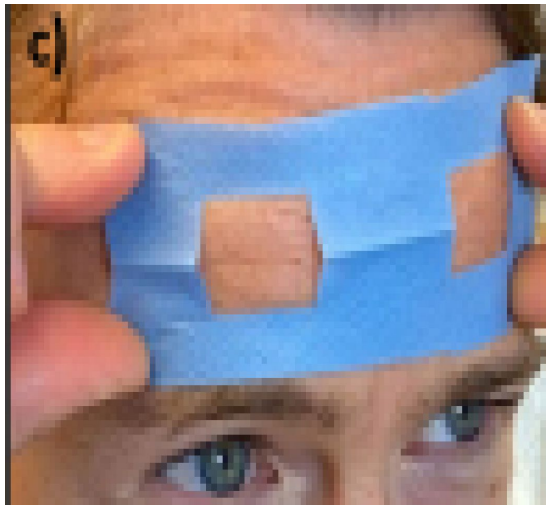
"Special" facemask fitted with synthetic fibers; single-use

Non-Self and Self-DNA from:

Skin Swabs Forensic Sci Int: Genetics 57 (2022) 102661

Non Skin (Sebum) Swabs Forensic Sci Int: Genetics 56 (2022) 102626





frontiers in Cell and Developmental Biology

REVIEW
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Horizontal Gene Transfer: From Evolutionary Flexibility to Disease Progression

Melissa Emamalipour[1], Khaled Seidi[2], Sepideh Zununi Vahed[3], Ali Jahanban-Esfahlan[4], Mehdi Jaymand[5], Hasan Majdi[6], Zohreh Amoozgar[7], L. T. Chitkushev[8,9], Tahereh Javaheri[9], Rana Jahanban-Esfahlan[10]* and Peyman Zare[11,12]**

OPEN ACCESS

Issues and Limitations of Collecting Airborne DNA (and other Environmental Sources, e.g., Water, Sewage)

- Over-abundance of DNA of less understood sources
- Costs are still a real issue; sample collection and transport
- Sample collection devices still being improved
- Doesn’t avoid complex laboratory methods
- Measurement and analysis problems
- Attendant ethical issues (e.g. human genome “by-catch”)

nature ecology & evolution

Article

https://doi.org/10.1038/s41559-023-02056-2

Inadvertent human genomic bycatch and intentional capture raise beneficial applications and ethical concerns with environmental DNA

Received: 21 April 2022

Accepted: 29 March 2023

Liam Whitmore[1,2,6], Mark McCauley[1,3,6], Jessica A. Farrell[1,4,6], Maximilian R. Stammnitz[5], Samantha A. Koda[1], Narges Mashkour[1], Victoria Summers[1], Todd Osborne[1], Jenny Whilde[1] & David J. Duffy[1,4]

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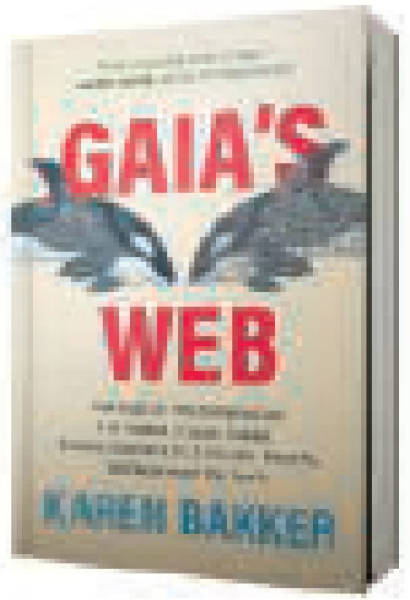
ECOLOGY

Digitizing nature

Digital tools are transforming conservation work but must be carefully deployed, argues an environmental scholar



Gaia's Web
Karen Bakker
MIT Press. 2024. 288 pp.

In Summary: Some Potential Benefits for Older People Using Emerging Airborne DNA Technology

- Non-invasive DNA collection, including microbiota (personal and environmental)
- Rapid detection of DNA-based threats:
  - Genes for antibiotic resistance
  - Real time detection of microbial threats (e.g., Listeria spp, molds/fungi, COVID-19)
  - Tuberculosis/ Other pathogens
- Forensic evidence for elder mistreatment
- Searches for lost/missing older persons (e.g, dementia)
- Endless research applications (mtDNA, epigenetics, aging clocks, RNA, etc.)

Thanks

Robert-wallace@uiowa.edu