

# Humans on Planet Earth (HOPE)

## Long-term impacts on biosphere dynamics

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# Some Basic Definitions

**Patterns** – what we can **observe today** in ecological surveys, **reconstruct for the past** using historical or palaeoecological data, or **predict for the future** using appropriate models

**Processes** – the underlying **mechanisms** that generate patterns, e.g. dispersal, establishment, assembly rules, competition.  
**Unobservable** – only inferred

**Biosphere dynamics** – ecological and evolutionary **changes** that occur as biological systems **respond** to and contribute to environmental change, e.g. population growth rates, shifts in geographical range, compositional change, speciation, extinction.

**Ecosystem or ecological properties** – composition, abundance, species richness, diversity, evenness, turnover, species co-occurrences, etc.

# Key and Much-Debated Questions in Earth System Science

What was the **impact of prehistoric people** on Earth's biosphere and climate systems?

Did Neolithic people initiate an **'early Anthropocene'** through forest clearance, agriculture, and burning?

There is a wealth of data from palaeoecological studies collected over 75 years showing human impact on vegetation composition and extent, soil erosion, water and nutrient budgets, and landscape resilience in many parts of the world. Therefore there has been (and continues to be) **human impact on biosphere patterns** from the poles to the tropics.

**But did prehistoric humans modify the biosphere to such an extent that the fundamental ecological processes shaping communities were changed as a result?**

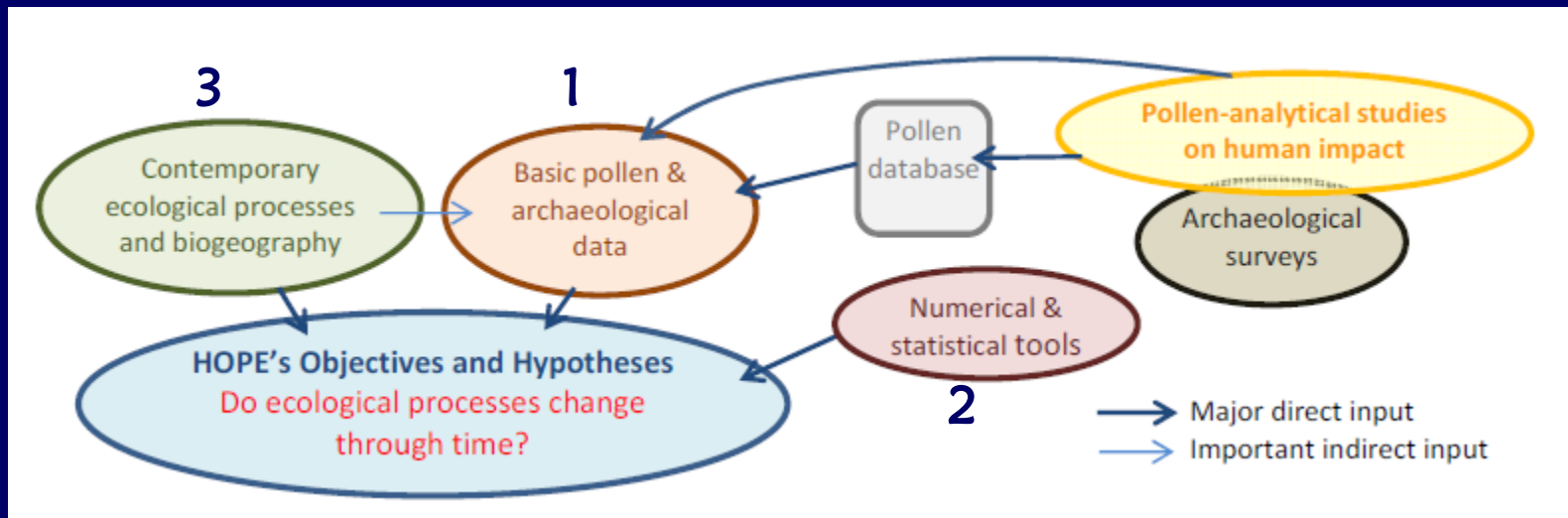
# HOPE's Challenge is to Test Two Major Hypotheses

1. Ecological processes changed through time (last 6000 years) due to human activity
2. Inter-relationships (correlations) between these processes changed through time – in other words the ecological processes of Earth today are different from the processes of the Earth 6000 years ago

Fundamental questions in Earth system science

# How Will HOPE Test These Hypotheses?

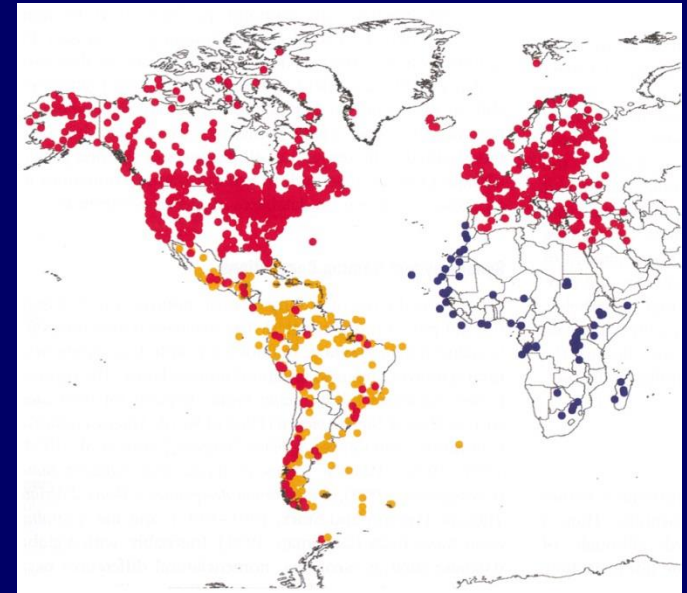
Three major inputs or tools



1) fossil data; 2) analytical methods; 3) ecological processes

# 1. Fossil data

Basic pollen-analytical data with associated radiocarbon dates from lake sediments and peats from 2000+ sites across Europe, North America, South America, south-west Asia, and Africa. Source of information about past vegetation and human impact



Grimm et al. 2013

Data are in international open-access databases (Neotoma, etc.)

## 2. Analytical methods

**Numerical and statistical methods** to summarise major patterns in each pollen sequence and estimate 25 quantitative characteristics of the sequence, e.g. richness, diversity, evenness, beta-diversity (differentiation), rates of compositional change and turnover – ‘**past ecosystem properties**’.

Statistical techniques such as reduced-rank multivariate regression, generalised linear and additive mixed regression, and computer-intensive permutation tests will be used to test the **basic hypotheses**.

# 3. Ecological processes

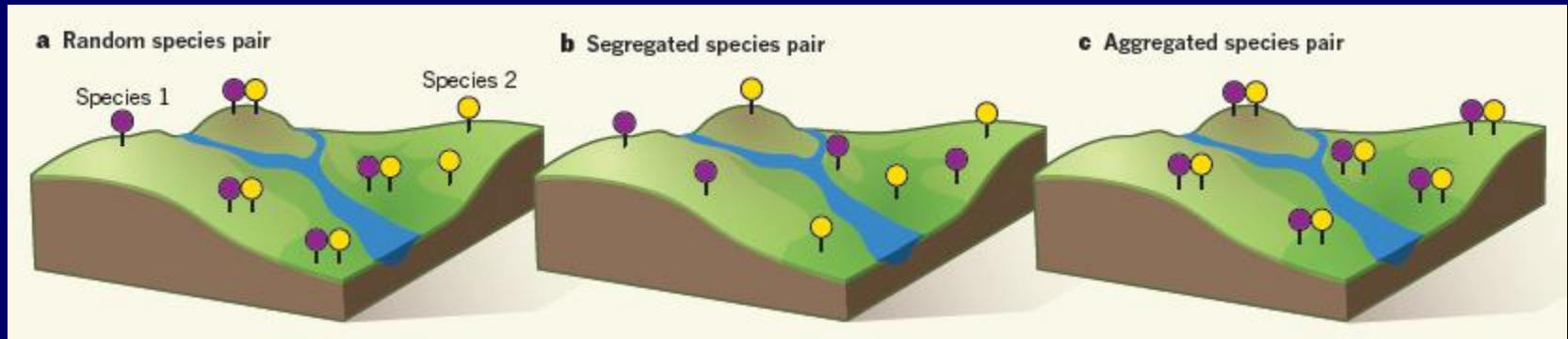
- **Extrinsic** environmental factors, e.g. climate change, human impact
- **Intrinsic** interactions, e.g. competition
- **Neutral** processes, e.g. historical legacies, random events

Probably operate simultaneously to varying degrees to generate ecosystem properties that we can quantify from pollen data.

Challenge is to infer underlying **unobservable processes** from the **observable patterns and estimated properties**



**Species co-occurrences** – do pairs of species occur randomly or non-randomly? *If* non-randomly, do they occur less frequently together than expected by chance (=segregated) or more frequently (=aggregated)?



Dietl 2015

**Segregated** pairs  $\approx$  dispersal-limitation due to habitat fragmentation and a high-mosaic landscape

**Aggregated** pairs  $\approx$  long-established assemblages and low-mosaic landscapes

Ecological understanding of ecosystem properties **essential**

# Hypothesis Testing

**Hypothesis 1** – ecological processes changed through time

Change-point analysis of observed changes in ecosystem properties compared with a random model to test whether changes are aggregated, segregated, or random and linked to human disturbance events

**Hypothesis 2** – correlations between 25 processes over time

Multivariate Procrustes analysis and associated permutation tests

Tests will be within and between continents (e.g. Europe vs N America), within and between biomes (e.g. boreal forest vs. Mediterranean), etc.

**Different spatial scales** and ‘experimental’ designs imposed by nature will provide >60 tests of hypothesis 1 and >100 of hypothesis 2.

Powerful use of JR Platt’s (1964) ‘strong inference’ approach as well as T Chamberlin’s ‘method of multiple working hypotheses’.

# HOPE Team

## Early-career

2 PhDs – 1 starting 2018 + 1 (funded by BIO & UiB) starting 2019

3 Post-docs – 1 starting 2018 + Vivian Felde from 2019 +  
1 (funded by BIO & UiB) starting in 2020



Vivian

## Mid-career

1 Researcher starting 2020 + 20% Alistair Seddon & Richard Telford +  
10% John-Arvid Grytnes

2 Technicians at 20% - Linn Krüger &  
Arild Breistøl + 1 Assistant 20%



Alistair



Richard



John-Arvid



Linn



Arild



Cathy Jenks

## Very late-career

2 Emeriti – 30% Hilary Birks + 50% myself



Hilary

## International consortium

Eric Grimm (Minneapolis)



Jack Williams (Madison)



Henry Hooghiemstra (Amsterdam)



Thomas Giesecke (Göttingen)



Willy Tinner (Bern)



Cajo ter Braak (Wageningen)



# Challenges and Roles in HOPE

1. Developing new statistical methods and appropriate permutation tests (Cajo ter Braak, John-Arvid Grytnes)
2. Data acquisition (Eric Grimm, Jack Williams, Thomas Giesecke, Henry Hooghiemstra, Linn Krüger, post-doc)
3. Data storage, coding, results, with 100% transparency of HOPE's analyses (Vivian Felde, Arild Breistøl, post-doc)
4. Data-quality control (Richard Telford, Eric Grimm, Thomas Giesecke, John Birks, Hilary Birks, post-doc)
5. Management of HOPE (John Birks, Alistair Seddon, John-Arvid Grytnes)
6. Administration of HOPE (Cathy Jenks, John Birks, BIO)

# Concerns for HOPE

Ability to house the HOPE Bergen team together, which is key to a successful project, rather than being scattered around that can easily lead to an unsuccessful project

# Why is HOPE Important to Earth System Science?

Earth system science, geological science, palaeoecology (and all historical sciences) rely on Hutton's (1795) principle of **uniformitarianism – the present is the key to the past.**

Physical and biological laws apply to all of geological time as well as the present

This is the underlying logic and conceptual methodology by which the past can be reconstructed (and the future predicted).

**Basic research approach and philosophy of Earth science.**



Recent papers (Lyons et al. 2015; Dietl 2015) suggest that biological assemblages after 6000 years ago were formed in a **fundamentally different way** from earlier assemblages unaffected by human activity.

They propose that *uniformitarianism should be discarded*, that using past *natural experiments* to predict future changes is *flawed*, and that *out is the use of uniformitarianism as a guiding principle* in Earth science.

There is therefore an urgent need to assess critically and robustly the view that uniformitarianism should be discarded. Without it, much of Earth science, restoration ecology, and conservation strategies for the future that are based on past ecosystems, grind to a stop. HOPE is thus **important** to Earth system science and ecological science.



# Personal Reflections

1. HOPE is my 60<sup>th</sup> research grant and **my very last!** First grant in 1975 provided a computer card punch, a teleprinter, and a monitor – a lot has happened in the intervening 42 years!
2. HOPE is wonderfully **multidisciplinary** – pollen analysis, palaeoecology, Quaternary science, ecology, numerical and statistical analyses, applied statistics, computing, archaeology, taxonomy, biogeography, and Earth sciences. Just what I like – story of my 50+ years of research.
3. HOPE is scientifically the **Mount Everest** of my career.

# What Tools Does HOPE Have?



... and a team of first-rate early-, mid-, and (very) late-career scientists!

# Acknowledgements

Eystein Jansen

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Alistair Seddon

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Hilary Birks

Kathy Willis

Rick Battarbee

Cathy Jenks