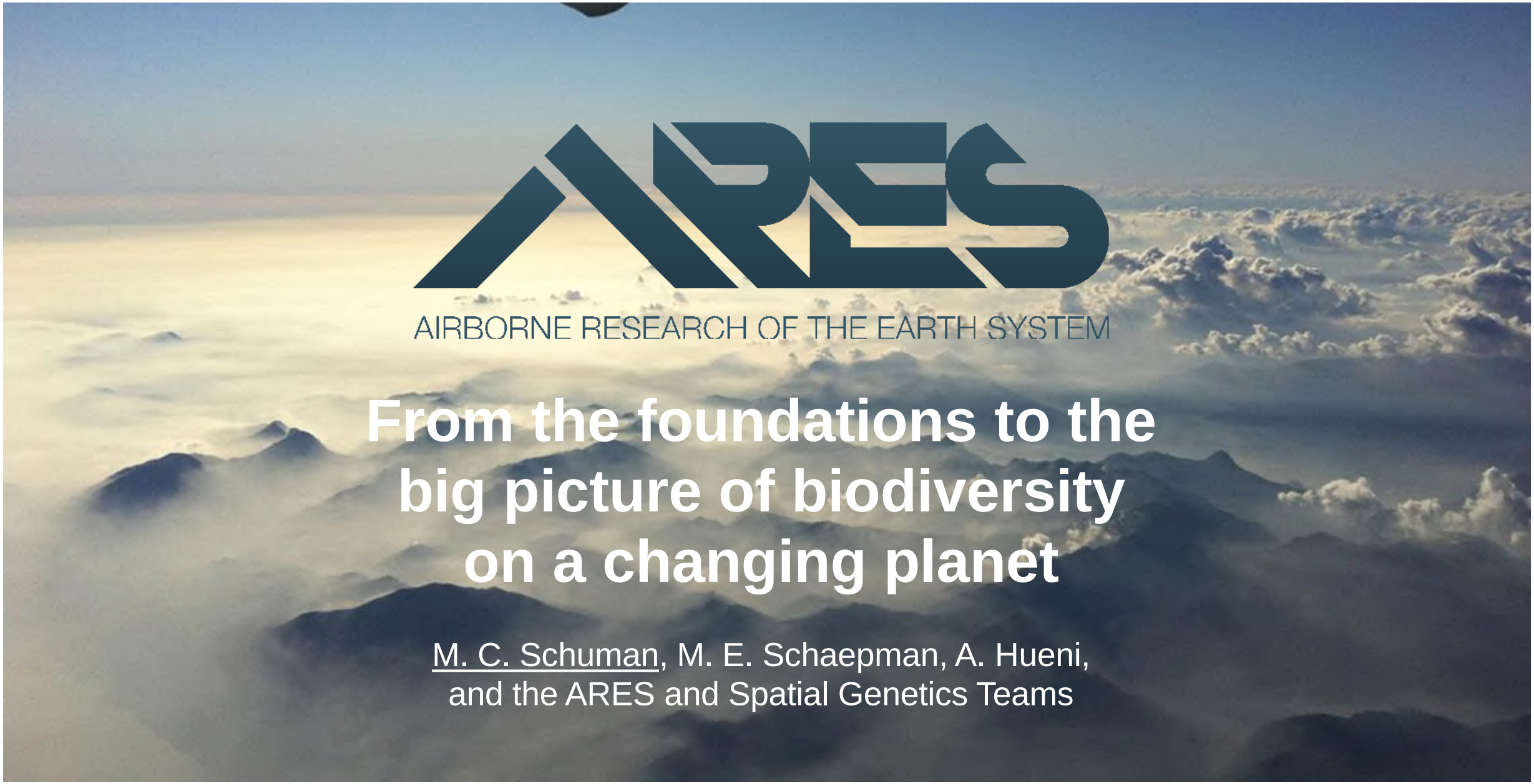
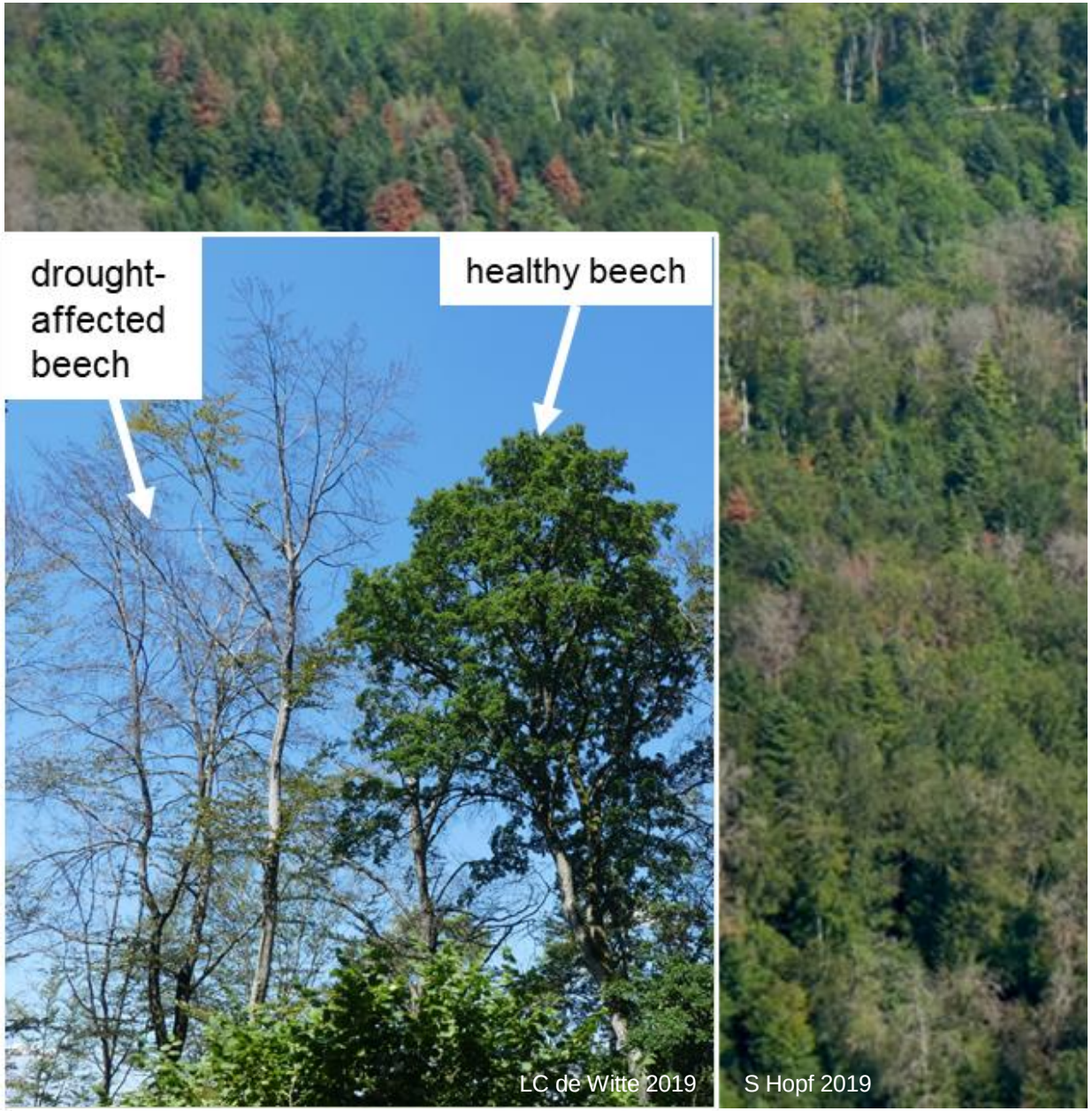


From the foundations to the big picture of biodiversity on a changing planet

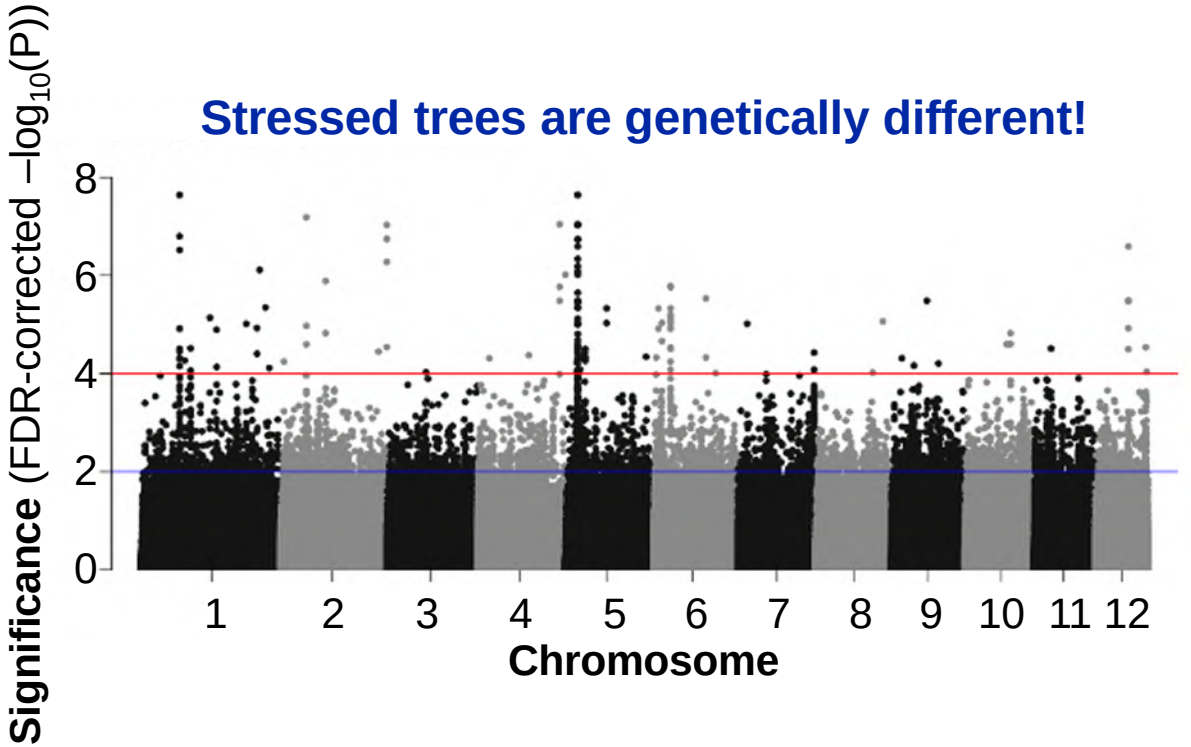
M. C. Schuman, M. E. Schaepman, A. Hueni,
and the ARES and Spatial Genetics Teams


S Hopf 2019

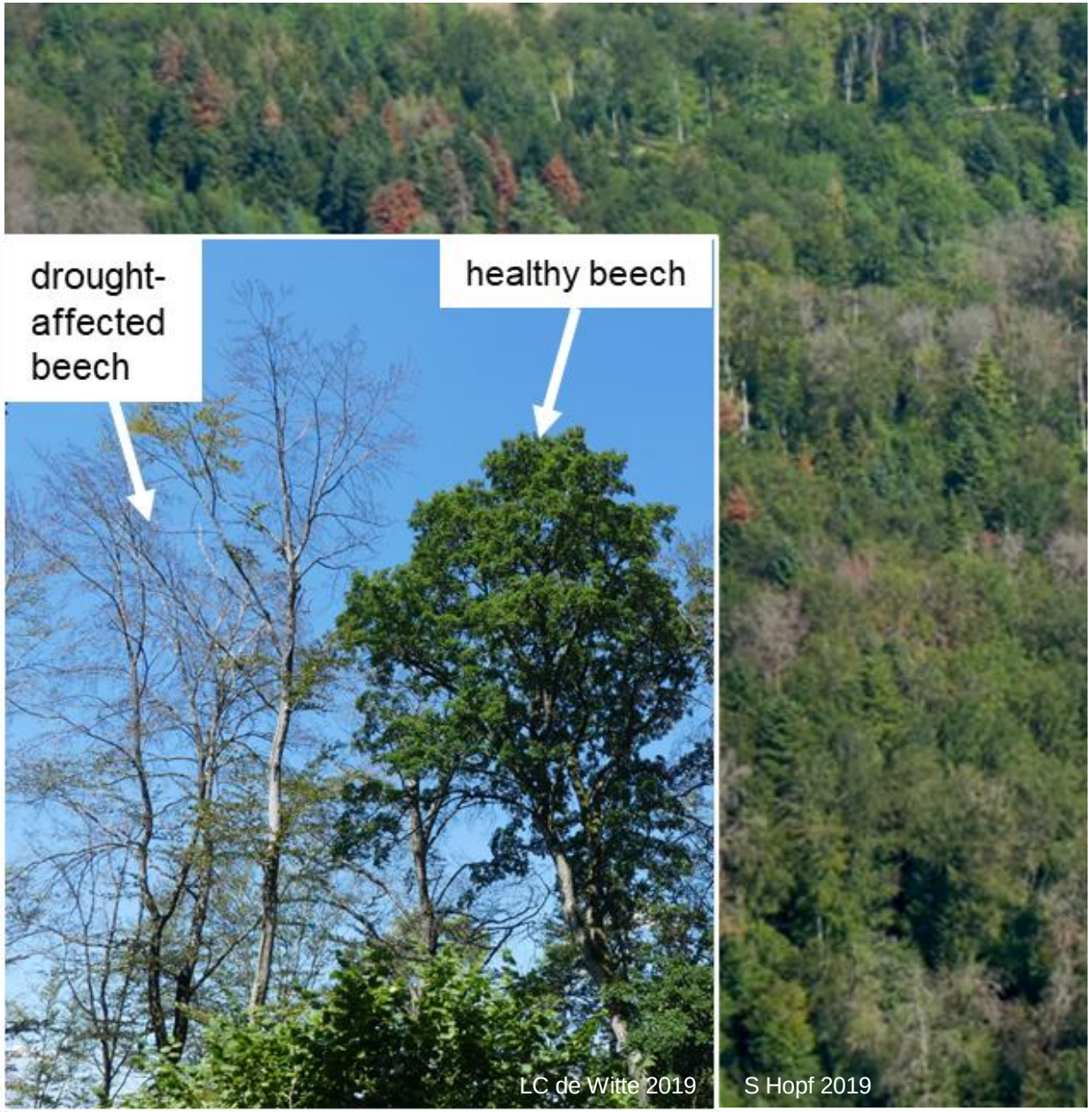

drought-affected beech
healthy beech
LC de Witte 2019
S Hopf 2019



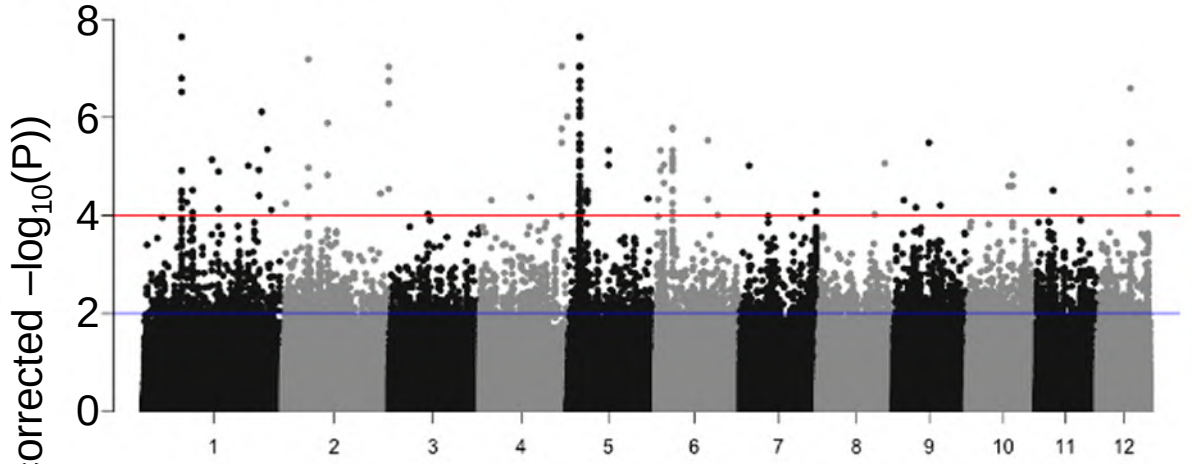
Stressed trees are genetically different!



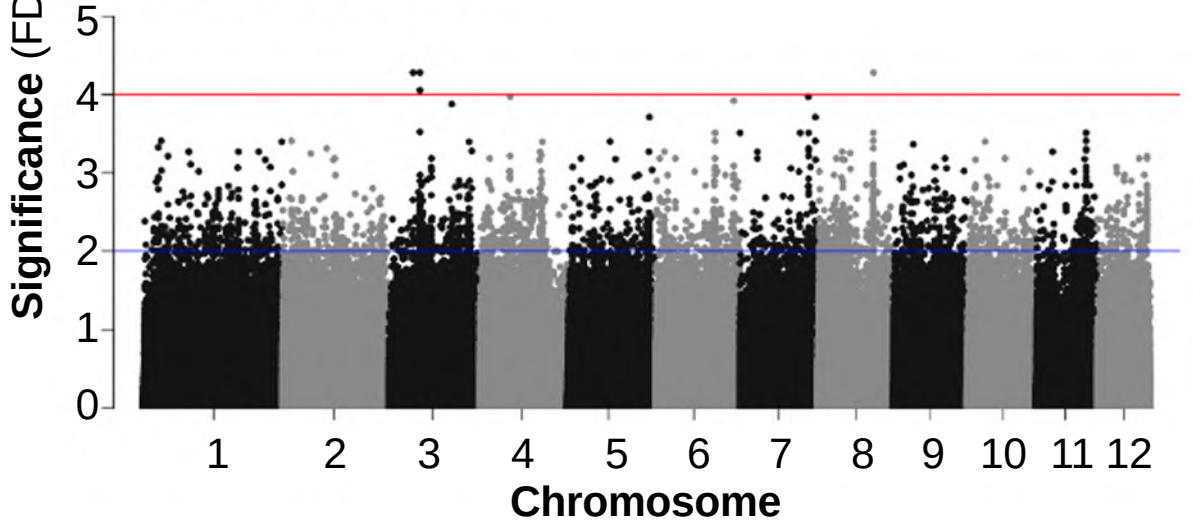
Li C et al. in prep.



Stressed trees are genetically different! (population 1)

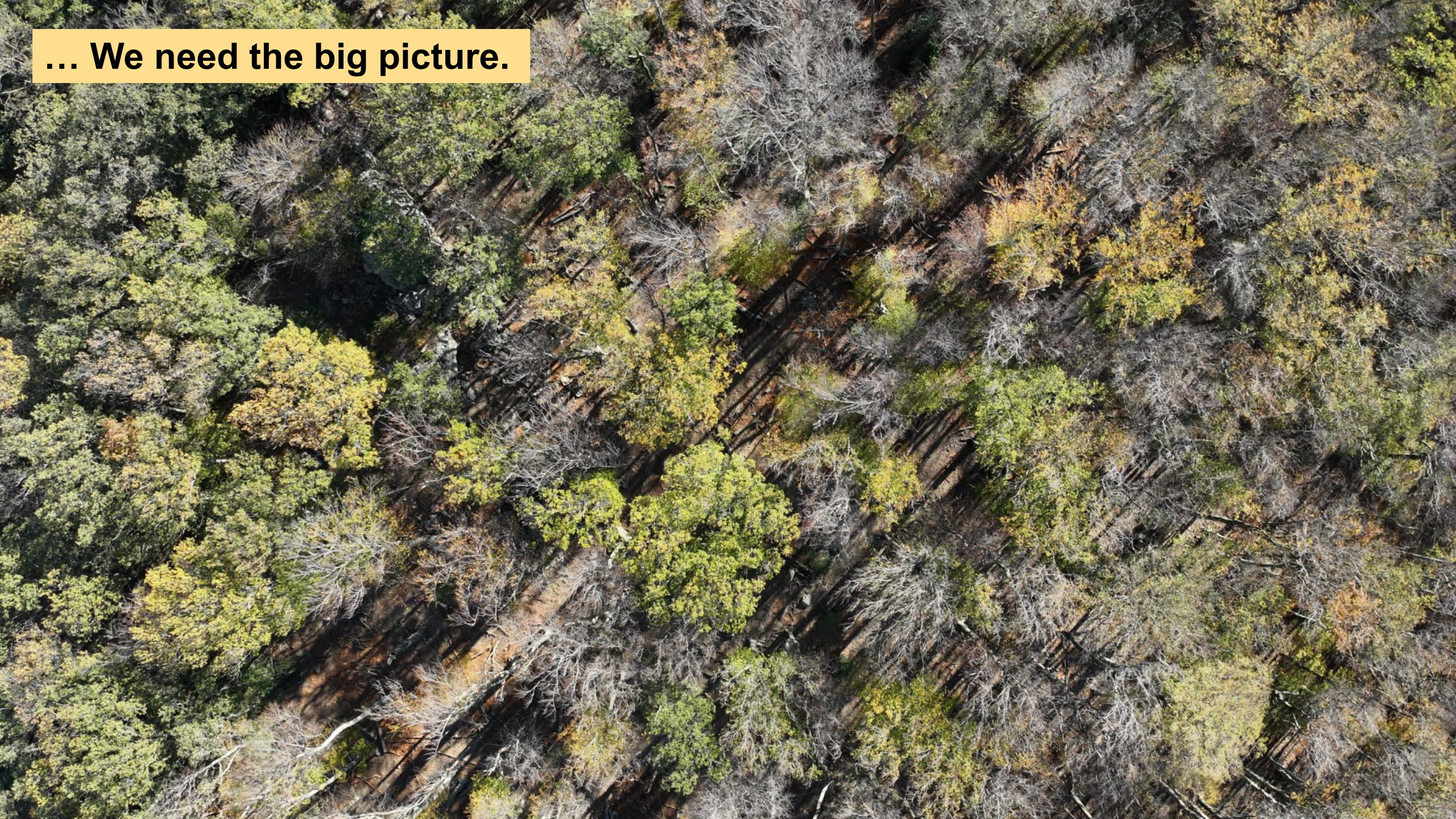


Stressed trees aren't very different! (population 2)



Li C et al. in prep.

Instead of one-at-a-time…


… We need the big picture.

Example: Global forest monitoring

Rondônia, Brasil, Landsat 5, 08 July 1989 (left) and Sentinel-2, 29 June 2022 (right), 30 m
See also Global Forest Watch initiative, https://www.globalforestwatch.org/

From monitoring forests, to monitoring genetic potential?

INTERNATIONAL SPACE SCIENCE INSTITUTE

GENES FROM SPACE

Michael: Marc Latzel, CC BY-SA 4.0, via Wikimedia Commons

Using information about forest habitats to monitor endangered populations beneath the canopy


Google Earth Pro


Sentinel-2

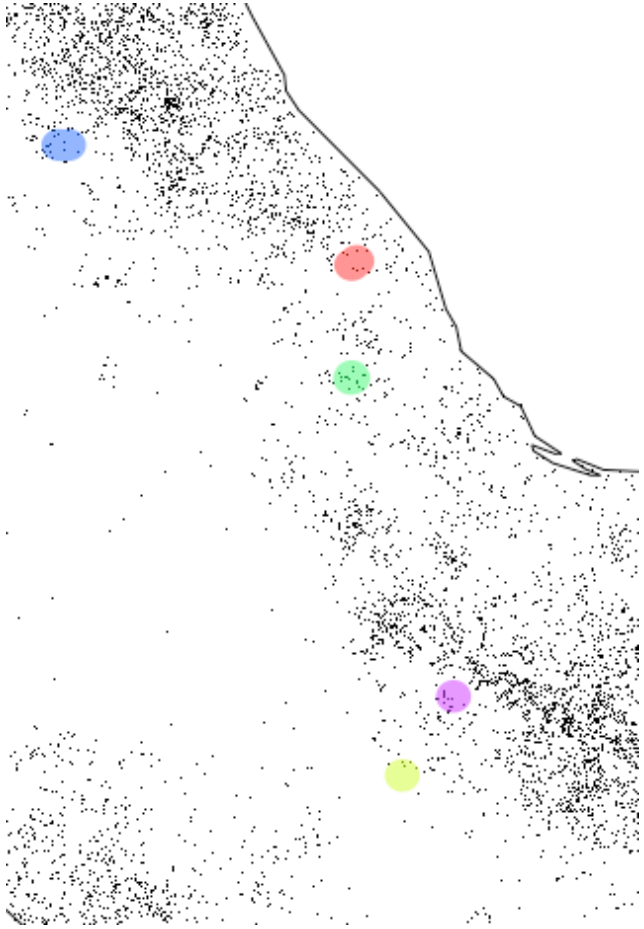
Global Forest Watch

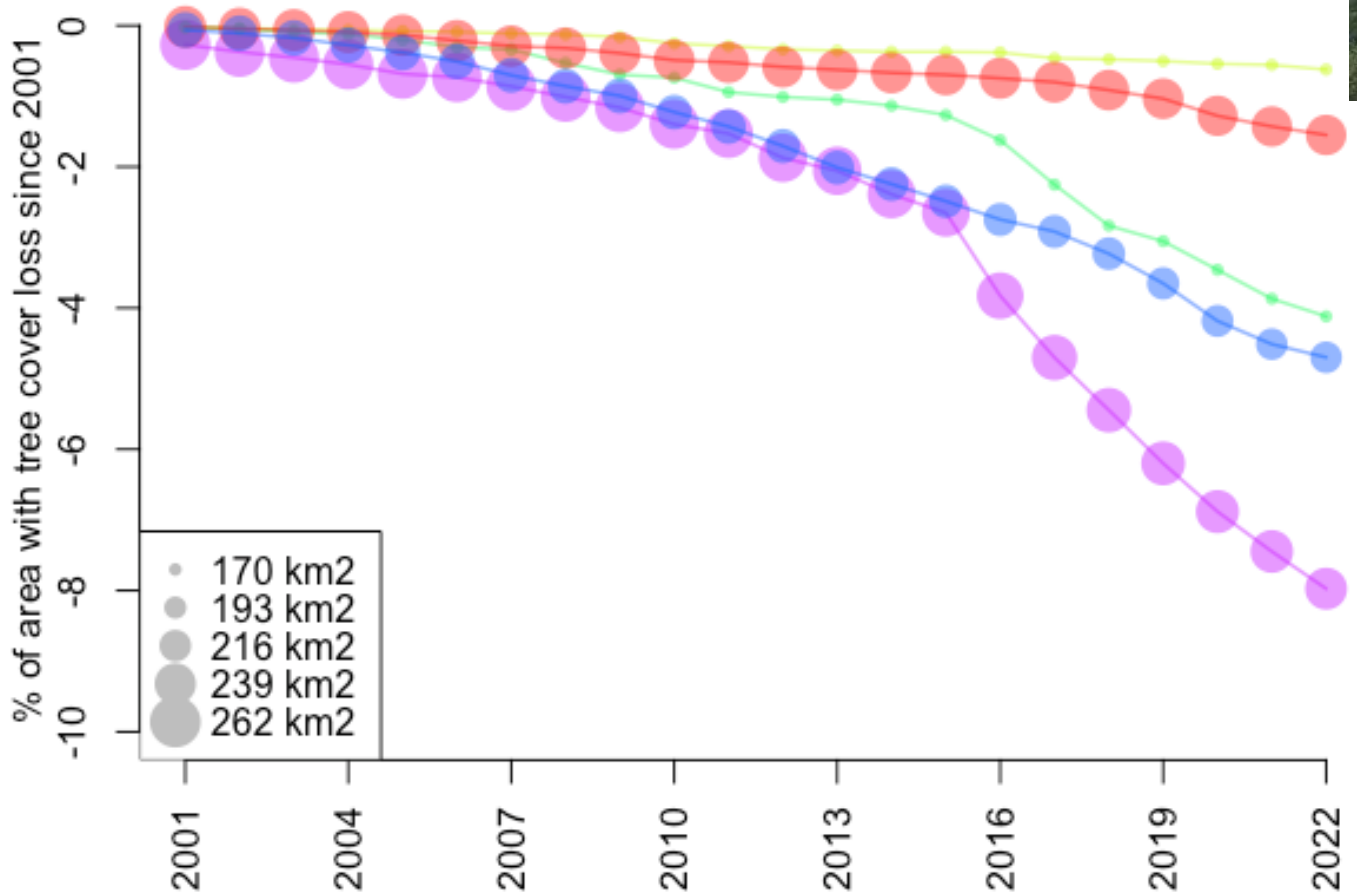
Land use change 2001-2022
- Tree cover
- Tree cover loss
- Tree cover gain
- No tree cover

wild avocado - *Persea cinerascens*

Schuman MC, Roeoesli C *et al*. (preprint) Genes from Space…
doi: 10.32942/X2RS58

Using information about forest habitats to monitor endangered populations beneath the canopy



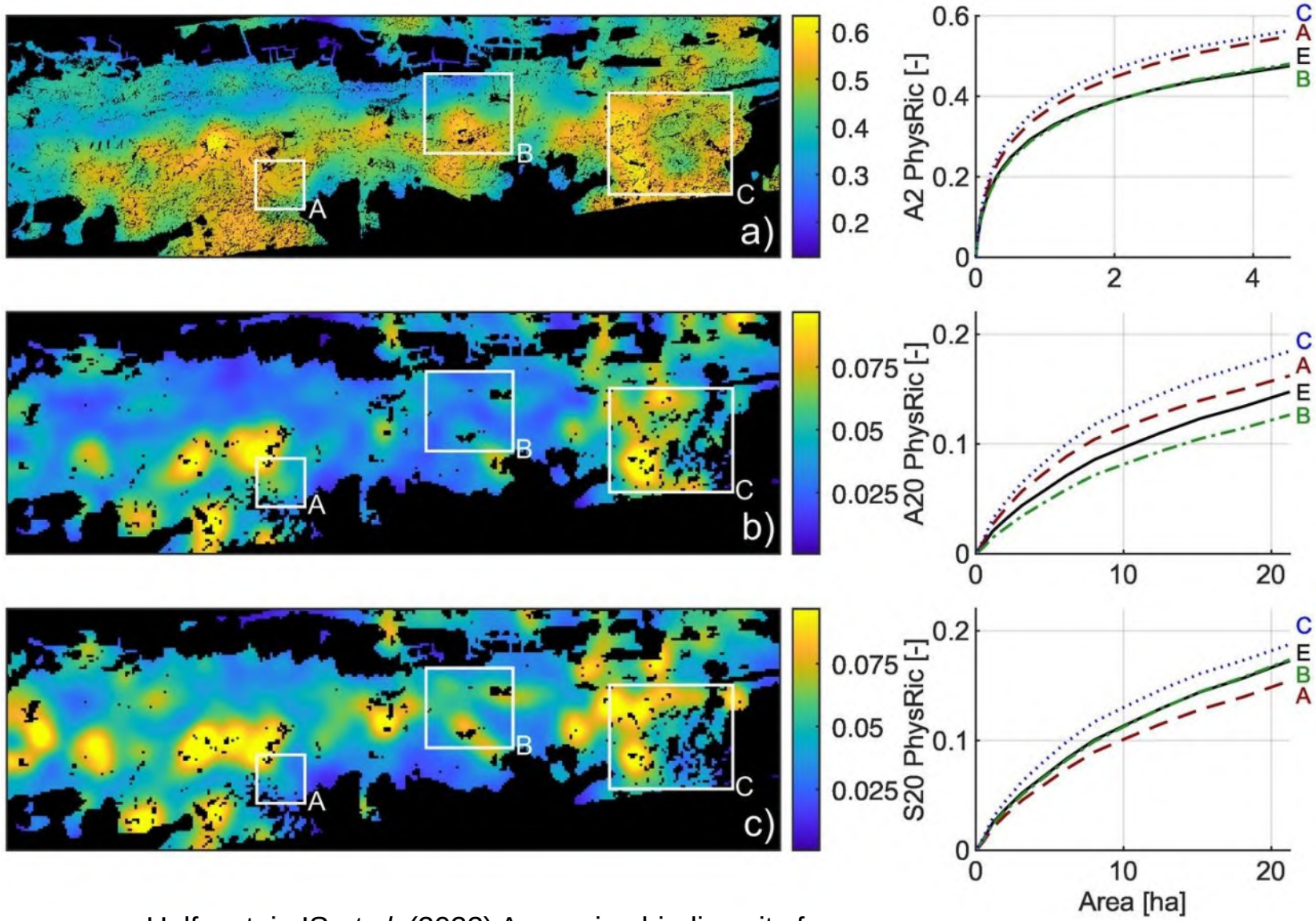


Schuman MC, Roeoesli C *et al*. (preprint) Genes from Space…
doi: 10.32942/X2RS58

Assessing the state of forest habitats by remotely sensing canopy diversity

Functional diversity of a forest canopy measured by spectral indices of chlorophyll, carotenoid, and water content at…

2 m
From imaging spectroscopy data

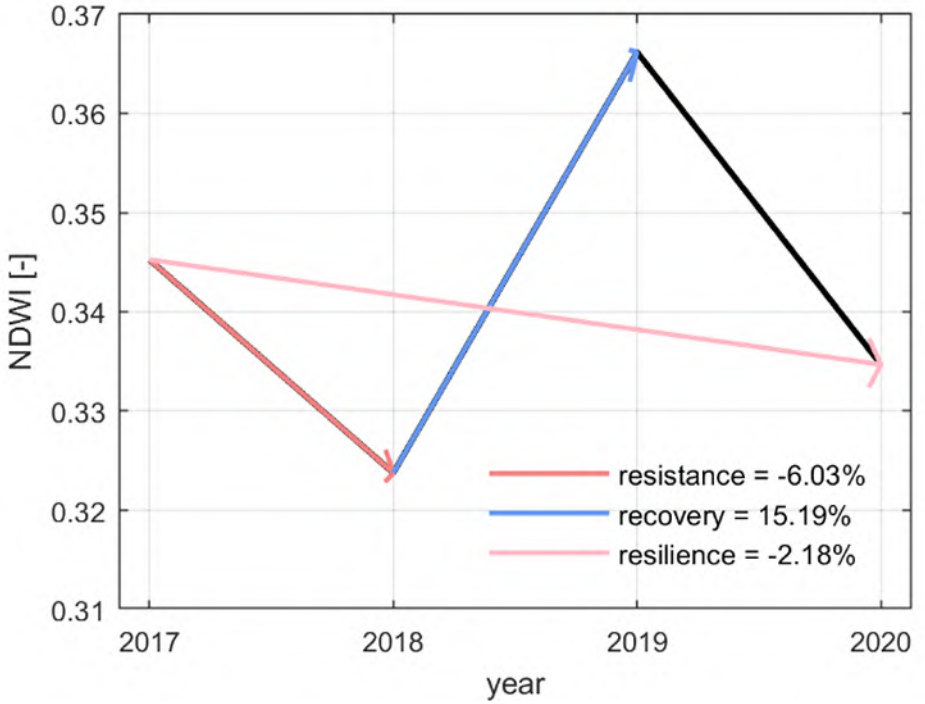


20 m
From imaging spectroscopy data

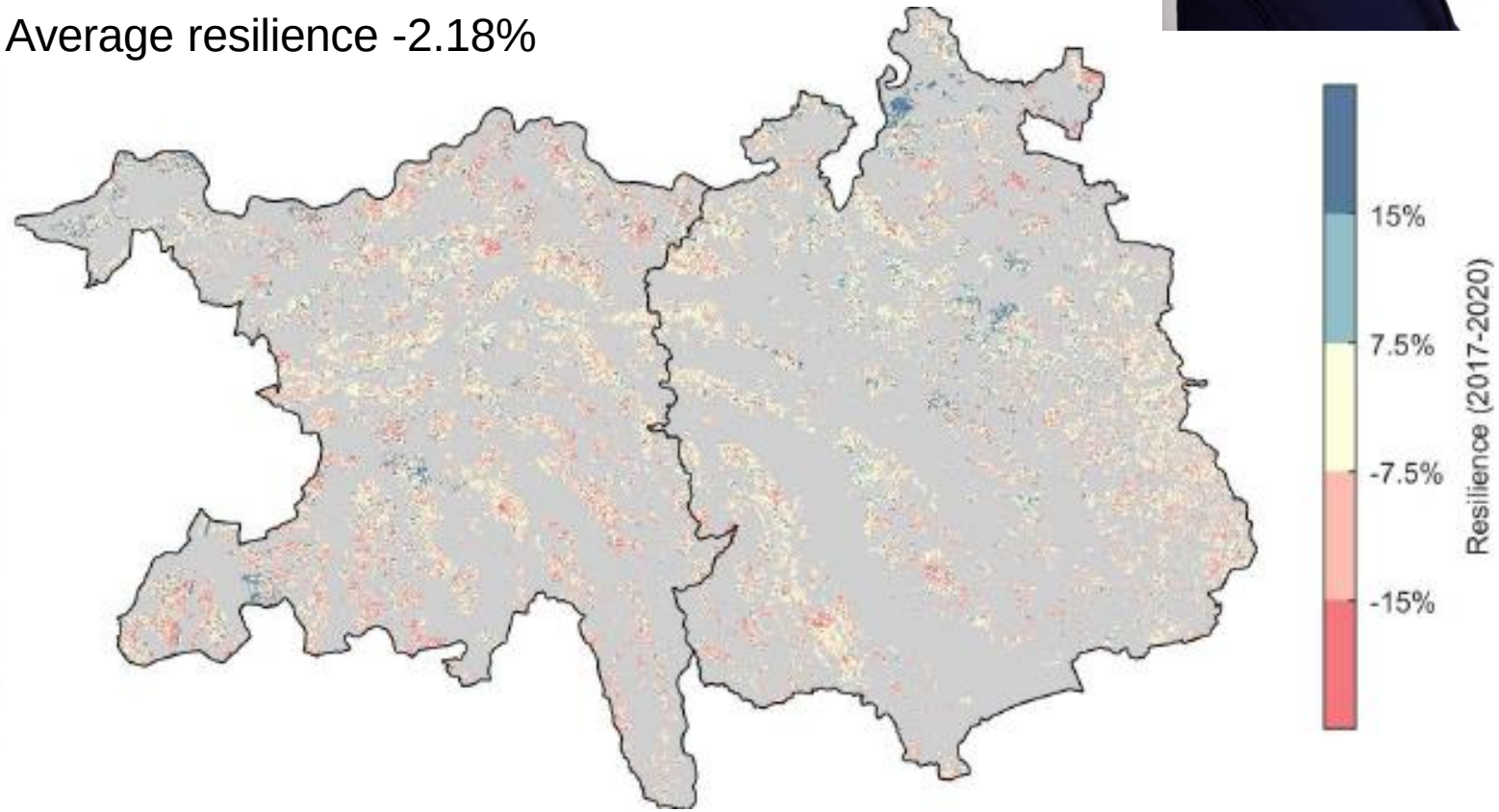
20 m
From multispectral satellite data (Sentinel-2)

Helfenstein IS *et al*. (2022) Assessing biodiversity from space…
doi: 10.1016/j.rse.2022.113024

Remotely sensed canopy diversity is related to drought response

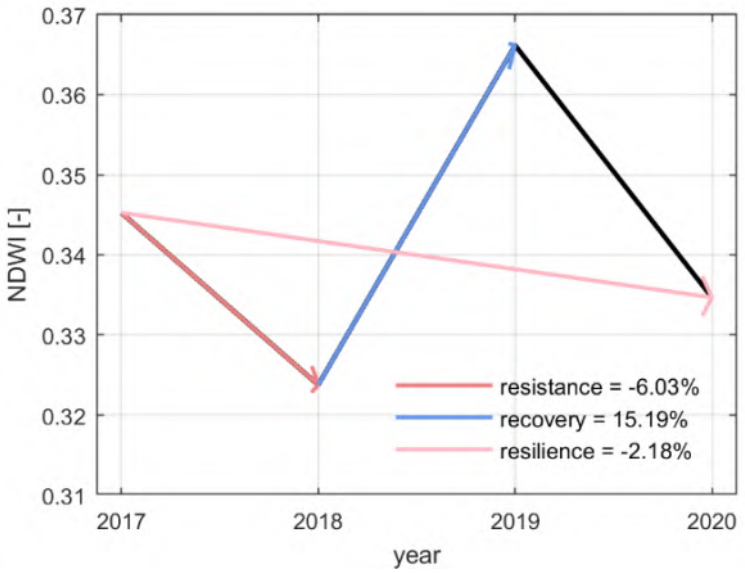


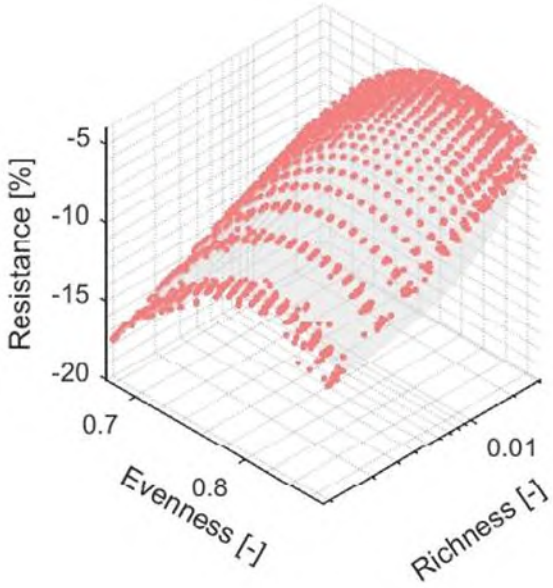
Average resilience -2.18%

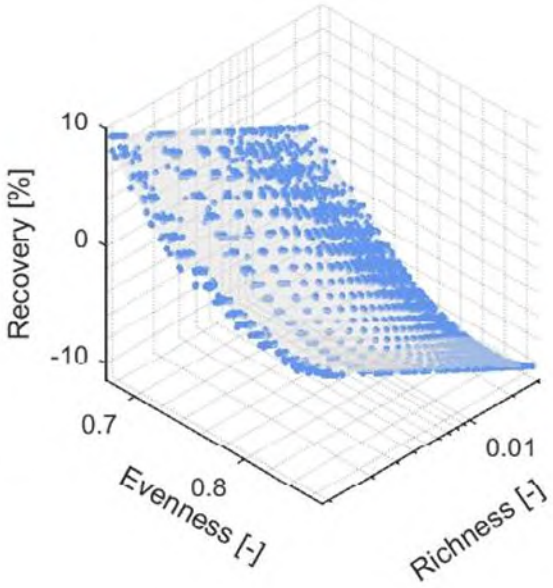


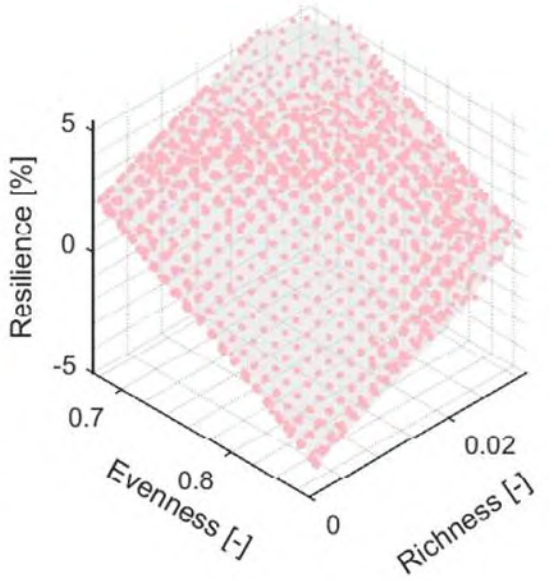
Helfenstein IS *et al*. (preprint) Satellite observations reveal a positive relationship…
doi: 10.32942/X24619

Remotely sensed canopy diversity is related to drought response



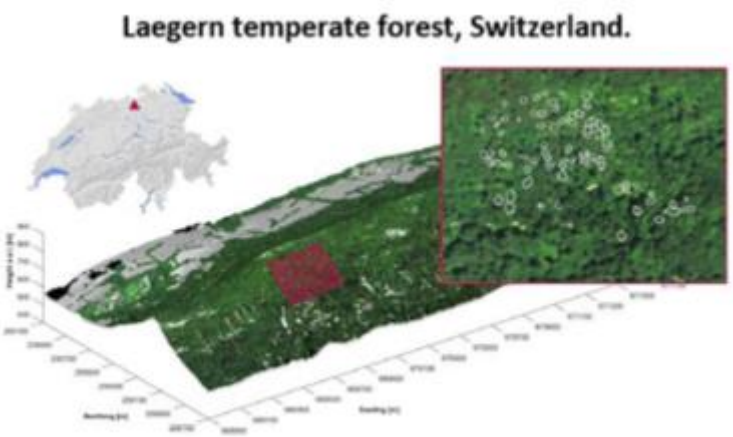






Helfenstein IS *et al*. (preprint) Satellite observations reveal a positive relationship…
doi: 10.32942/X24619

Remotely sensed canopy diversity is related to genetic potential



Pearson correlation between

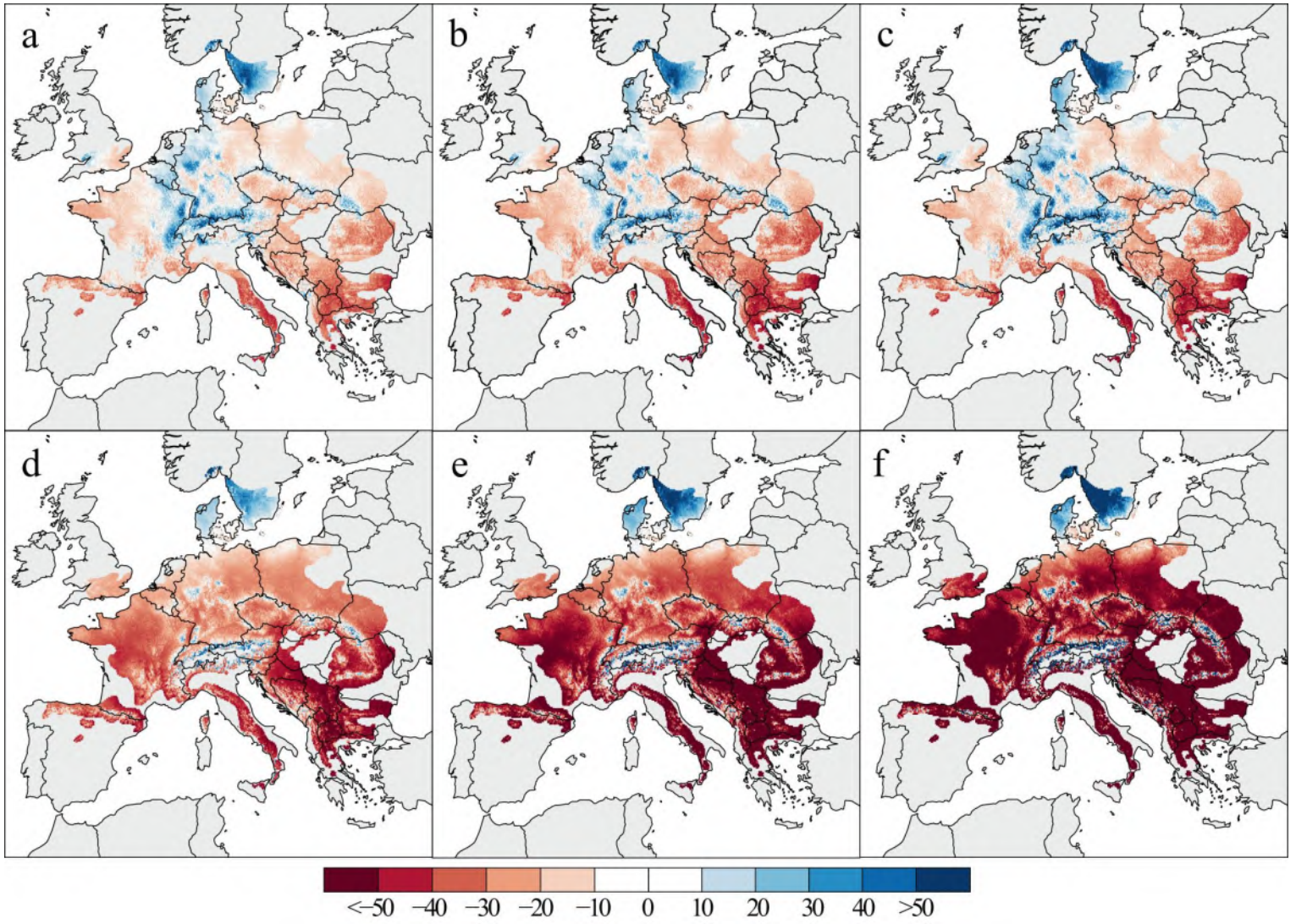
Spectral-Genetic Similarity = partial Mantel correlation coefficient between genetic (Nei's) distance and spectral (Euclidean) distance of trees

and

values of environmental variables

Czyż EA *et al*. (2023) Genetic constraints on temporal variation of airborne reflectance...
doi: 10.1016/j.rse.2022.113338

Future of beech forests relies on response diversity based in genetic diversity



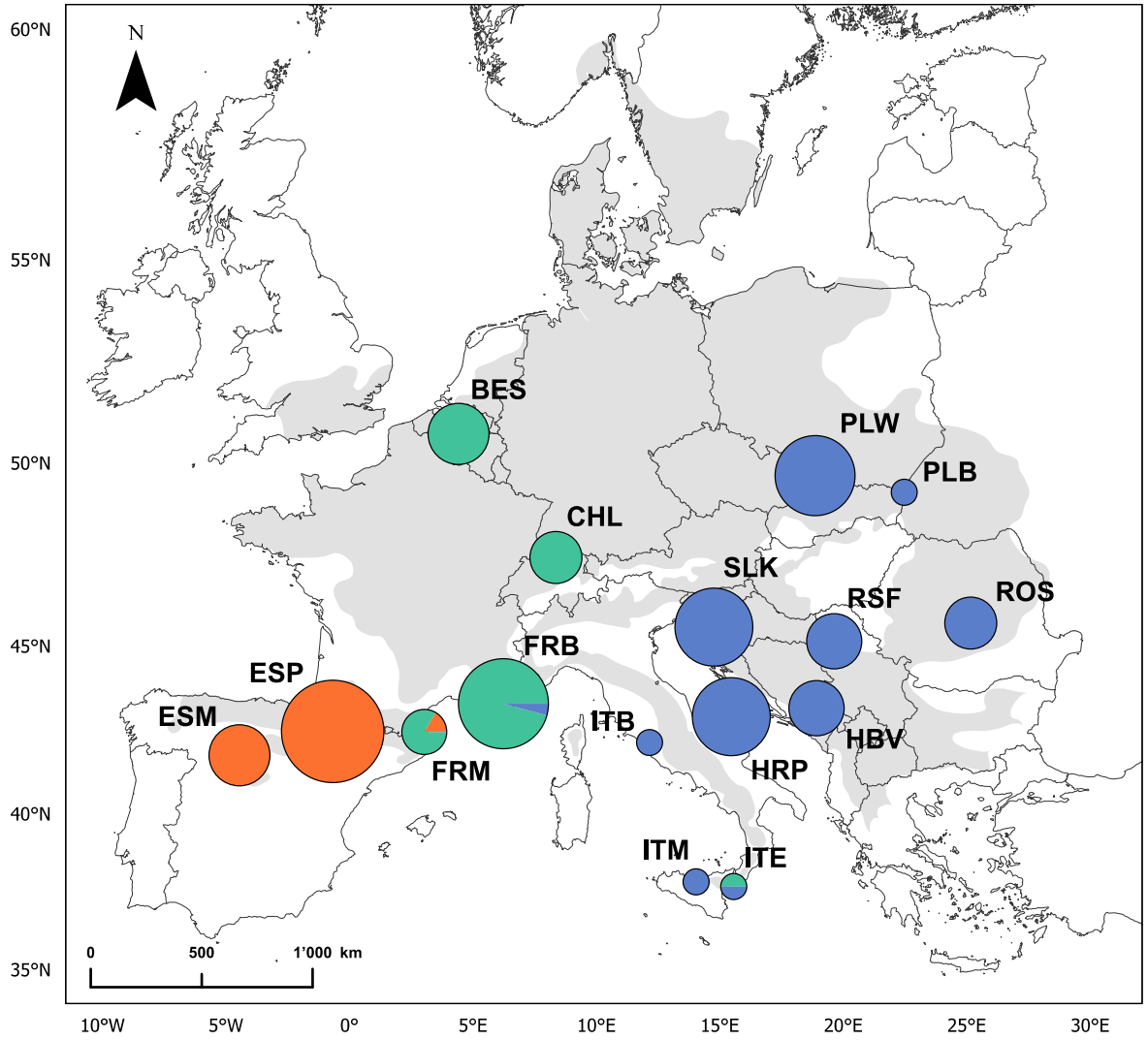
Modelled future percentage change in basal area increment (BAI) compared to 1986 – 2016 under SSP1-2.6, top, or SSP5-8.5, bottom

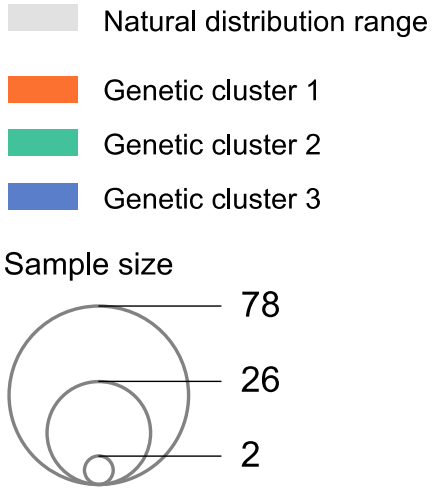
Photo by **Free_Nature_Stock** from **Freerange Stock**

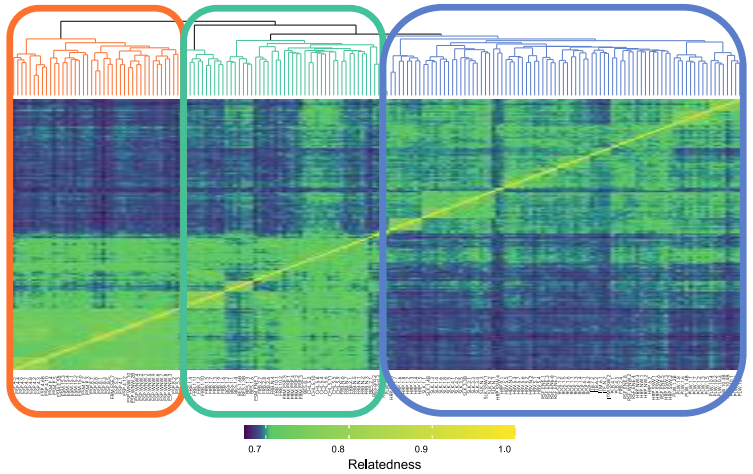
Martinez del Castillo E *et al*. (2022) Climate-change-driven growth decline…
doi: 10.1038/s42003-022-03107-3

Beech common garden at UZH for testing diversity – response relationships

Beech saplings in the experiment are from three genetic groups





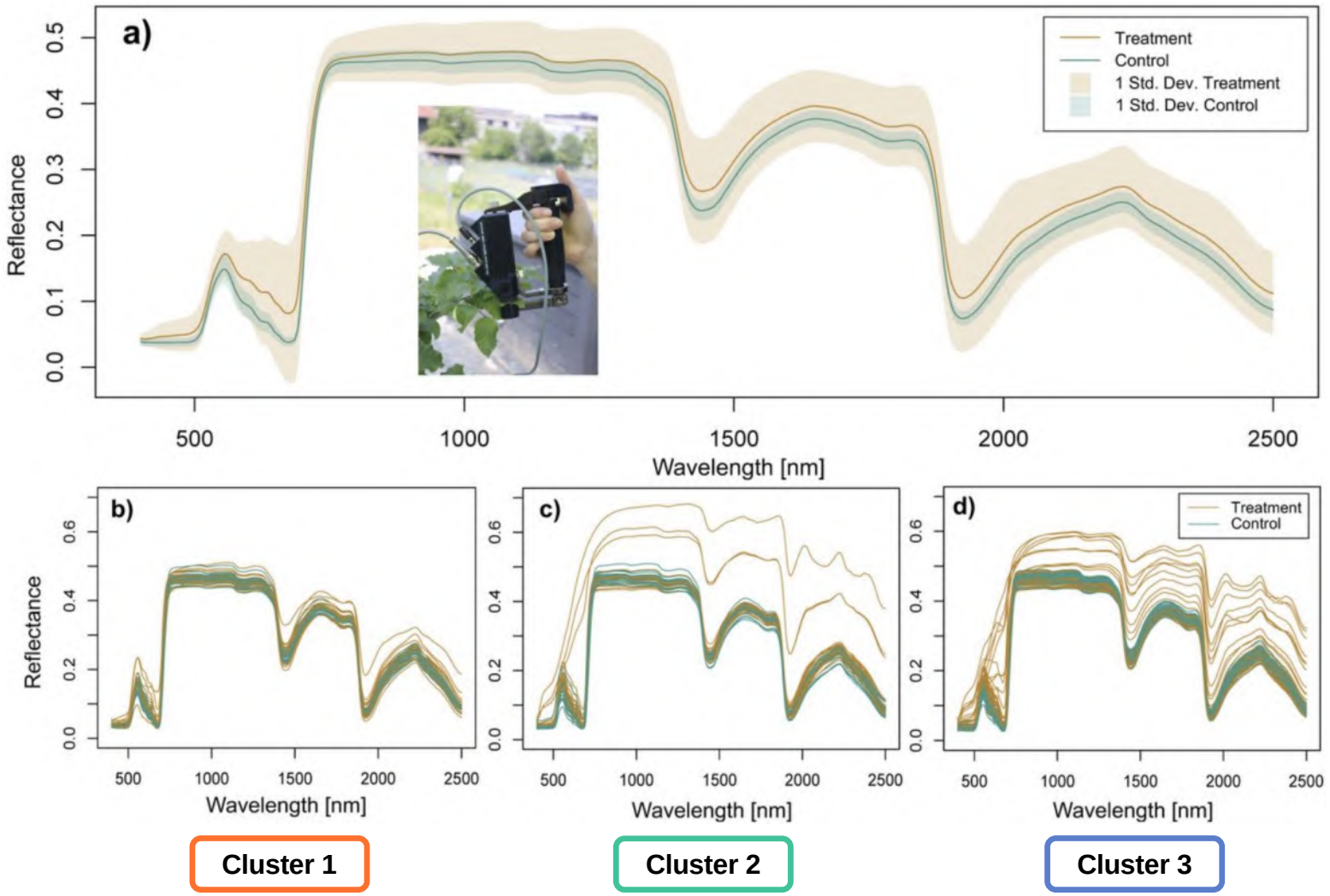


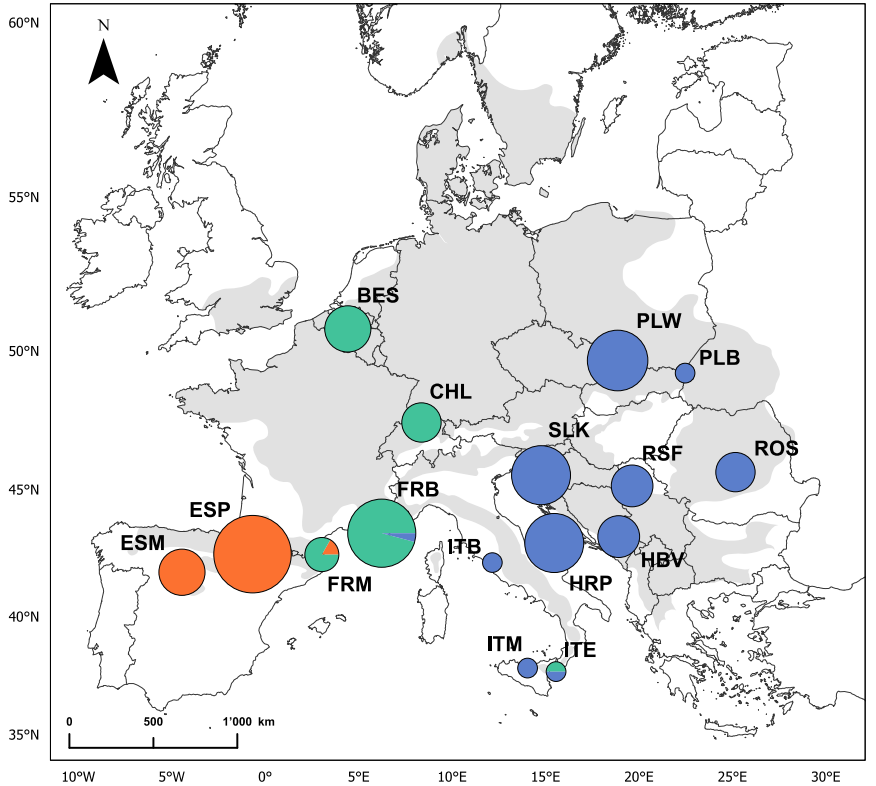
Based on reference-free kmer approach (Voichek Y and Weigel D, doi: 10.1038/s41588-020-0612-7)

Kurath D *et al*. (preprint) Leaf spectroscopy reveals drought response variation... doi: 10.1101/2024.07.23.604726

Drought responses of beech seedlings as measured by their leaf spectra

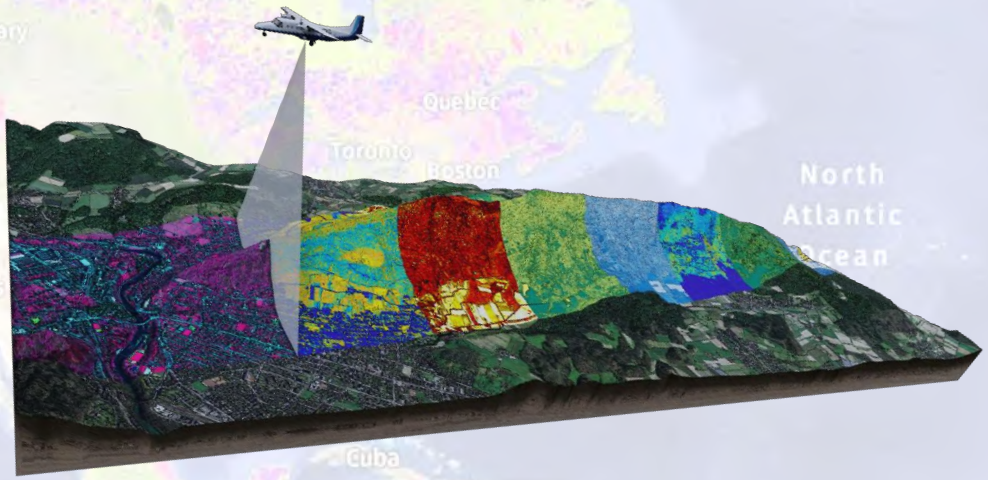
20 measurements per leaf
(black and white backgrounds),
2 leaves per seedling





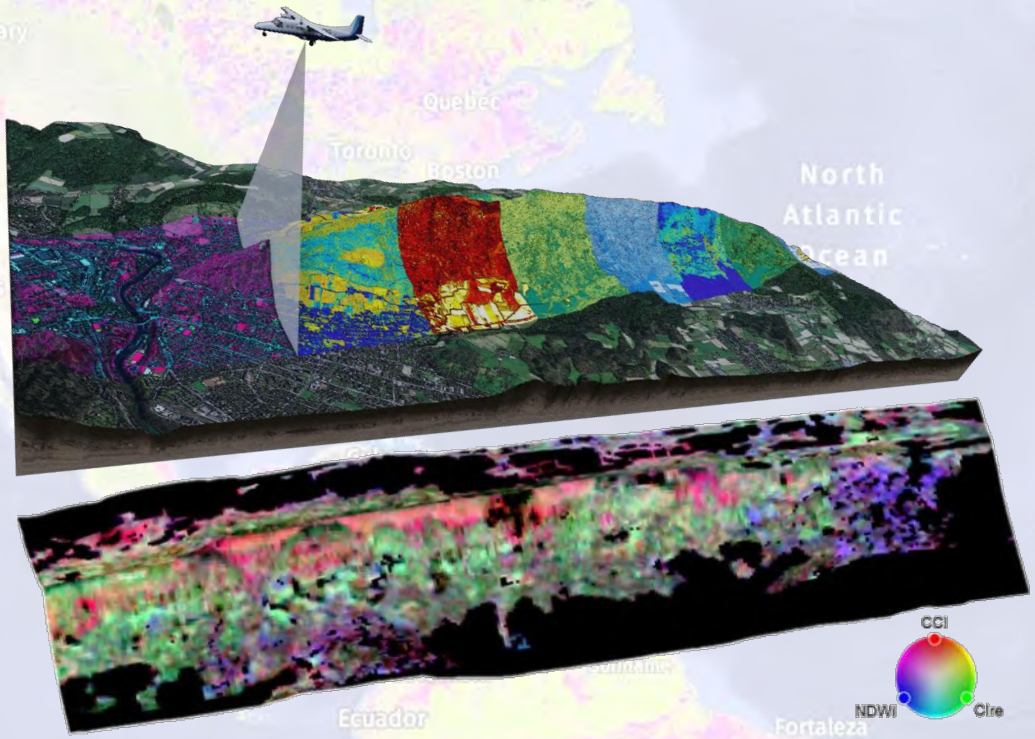
Kurath D *et al*. (preprint) Leaf spectroscopy reveals drought response variation...
doi: 10.1101/2024.07.23.604726

From the foundations to the big picture of biodiversity on a changing planet



Background: Global Forest Watch, airplane: F. Morsdorf

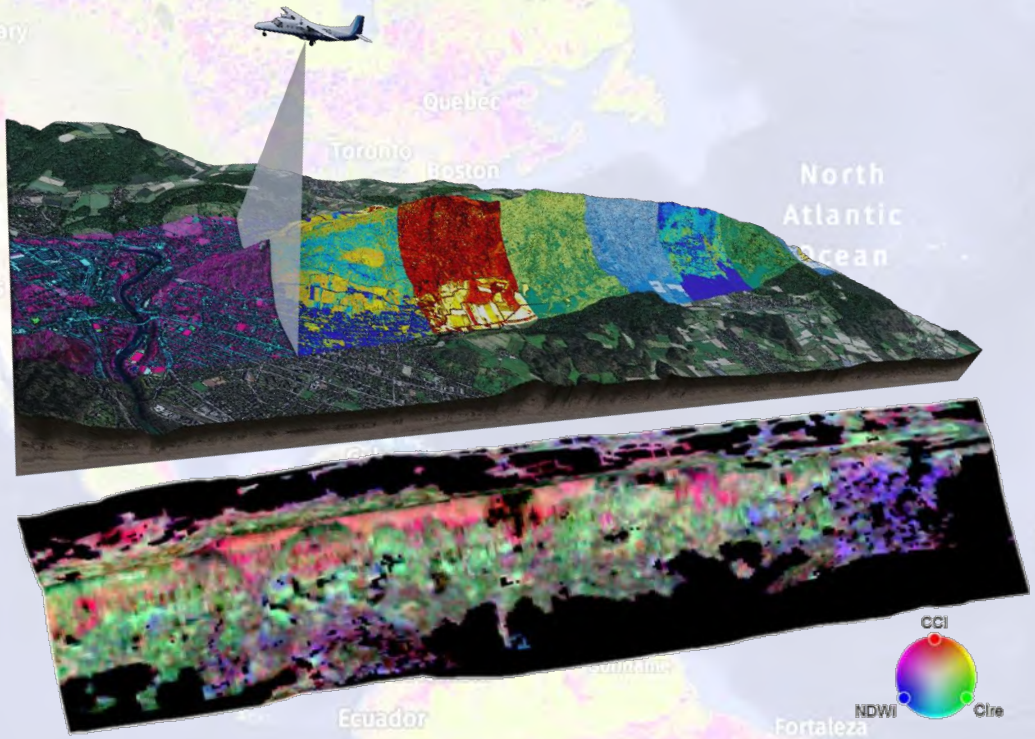
From the foundations to the big picture of biodiversity on a changing planet

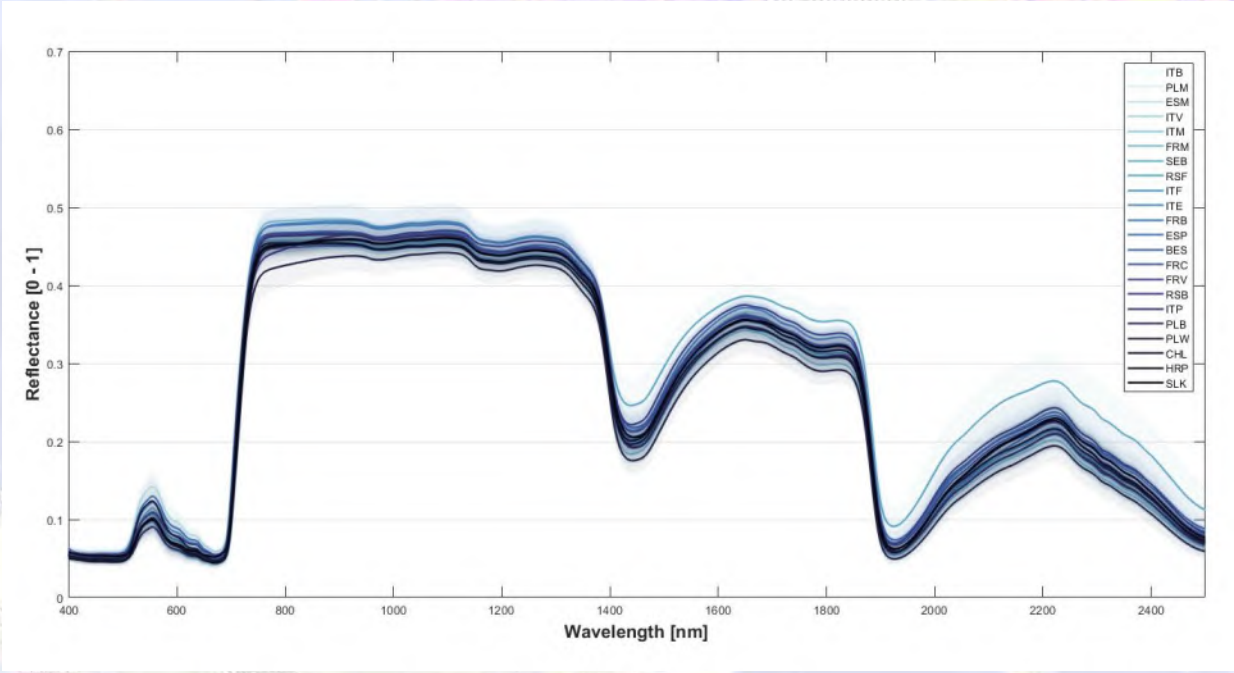


Background: Global Forest Watch, airplane: F. Morsdorf

Trait landscape modified from Helfenstein *et al*. (2022) Assessing biodiversity from space… doi: 10.1016/j.rse.2022.113024

From the foundations to the big picture of biodiversity on a changing planet





Background: Global Forest Watch, airplane: F. Morsdorf, spectra: E. Czyż

Trait landscape modified from Helfenstein *et al*. (2022) Assessing biodiversity from space… doi: 10.1016/j.rse.2022.113024

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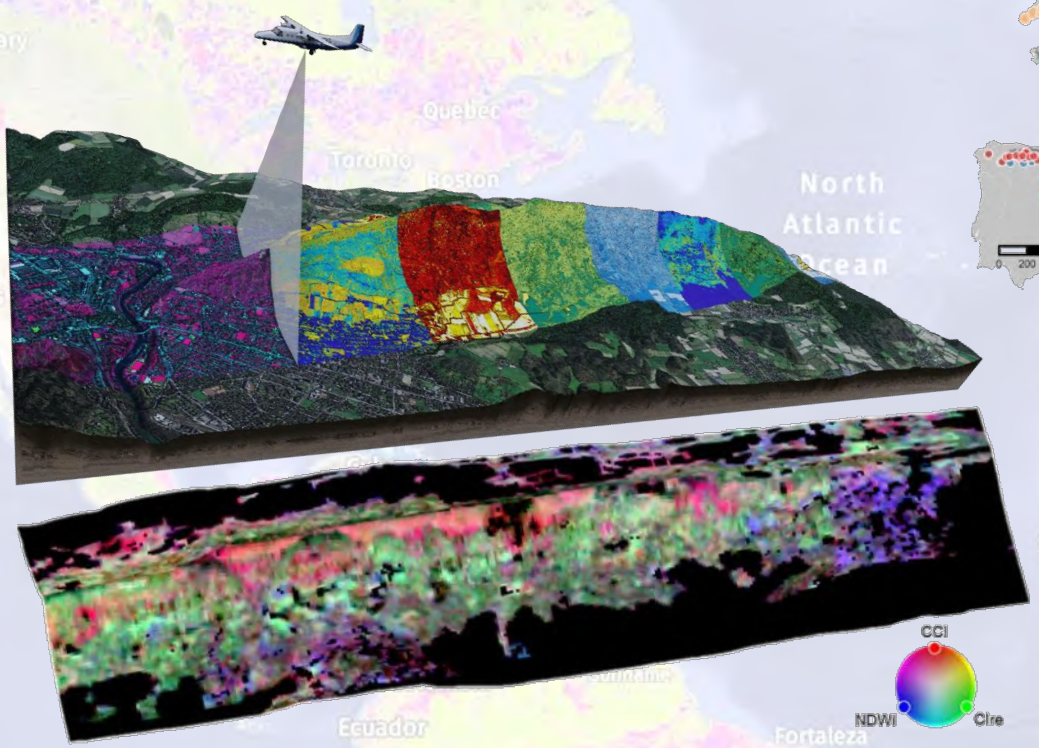
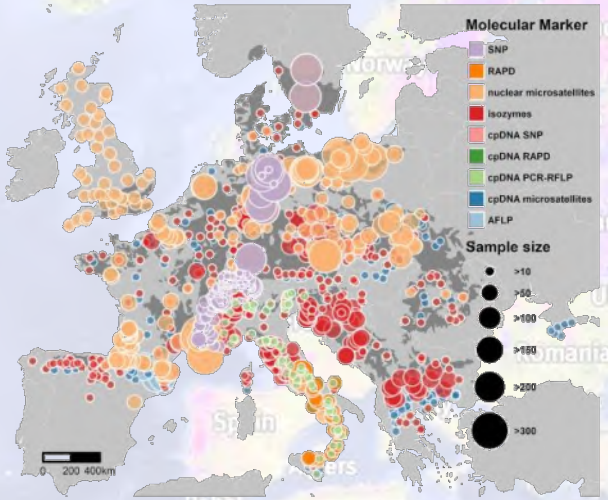
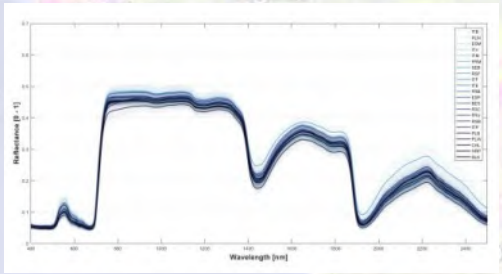
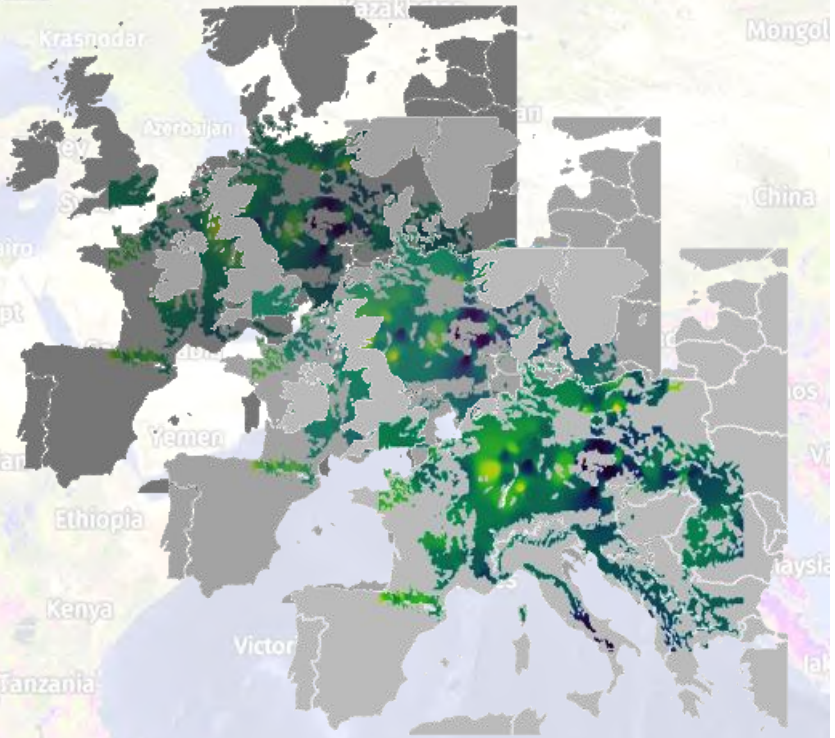




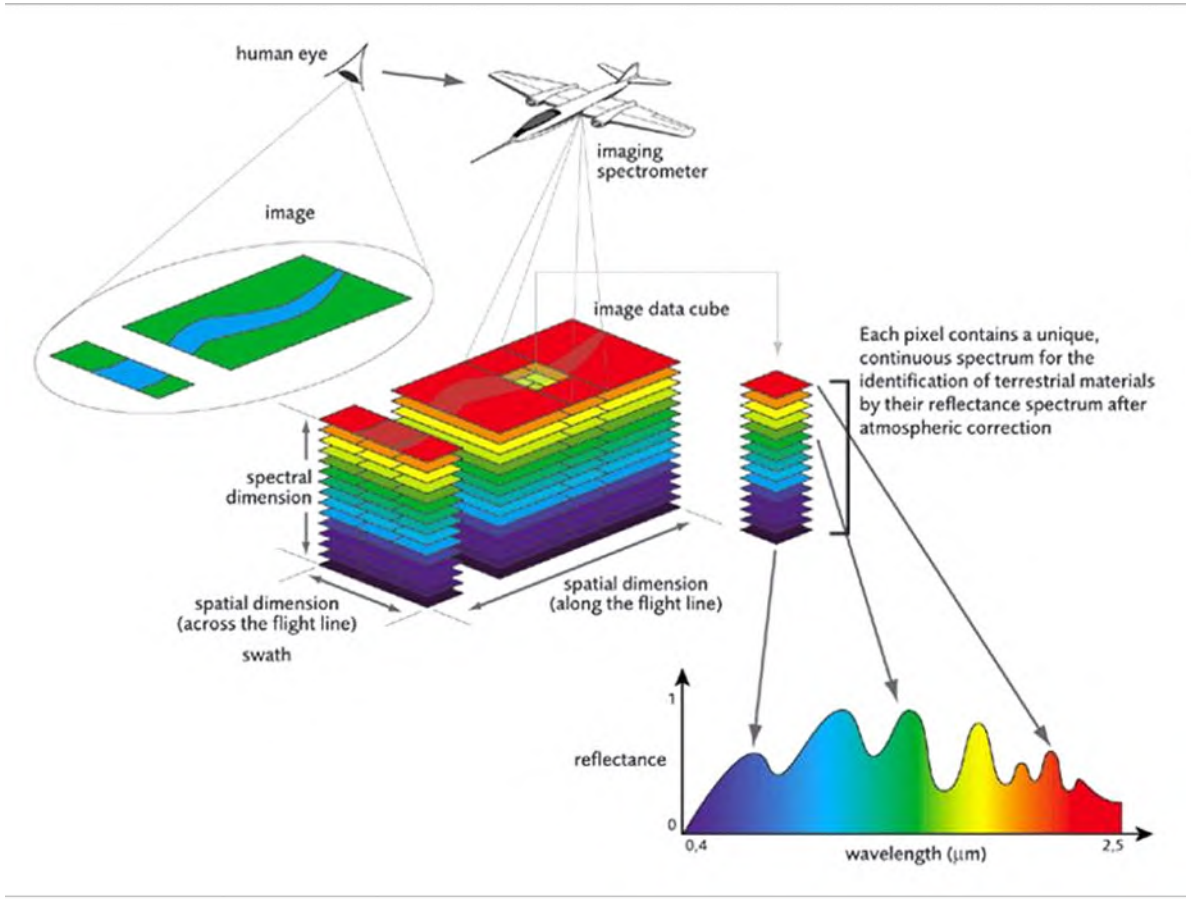


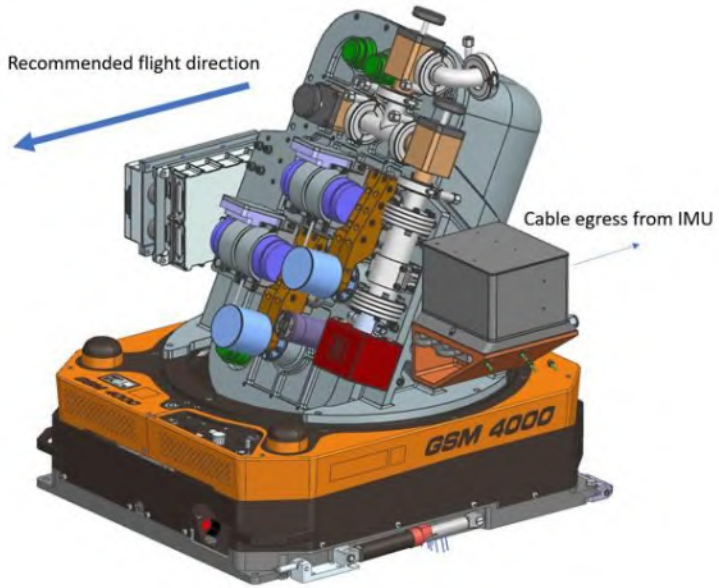


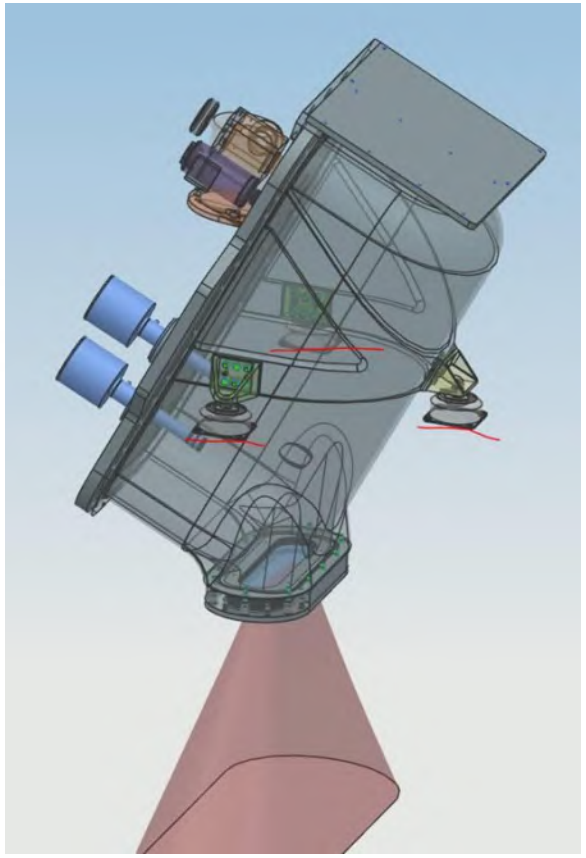
Background: Global Forest Watch (https://www.globalforestwatch.org/map/), airplane: F. Morsdorf, , spectra: E. Czyż
Trait landscape modified from Helfenstein *et al*. (2022) Assessing biodiversity from space… doi: 10.1016/j.rse.2022.113024
Maps modified from Stefanini *et al*. (2023) A novel synthesis of two decades… doi: 10.1007/s11295-022-01577-4

ARES – Airborne Research Facility for the Earth System

AIRBORNE RESEARCH OF THE EARTH SYSTEM

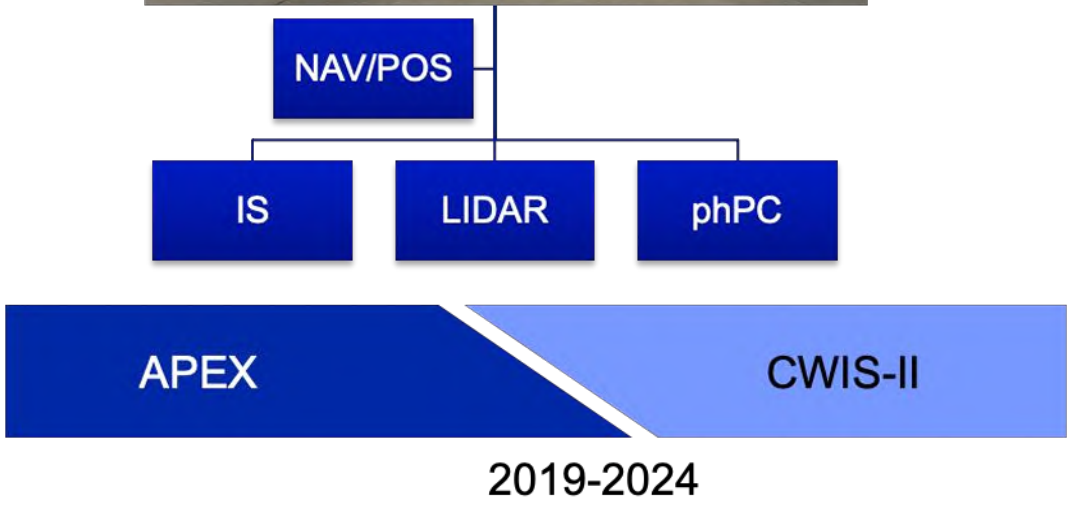


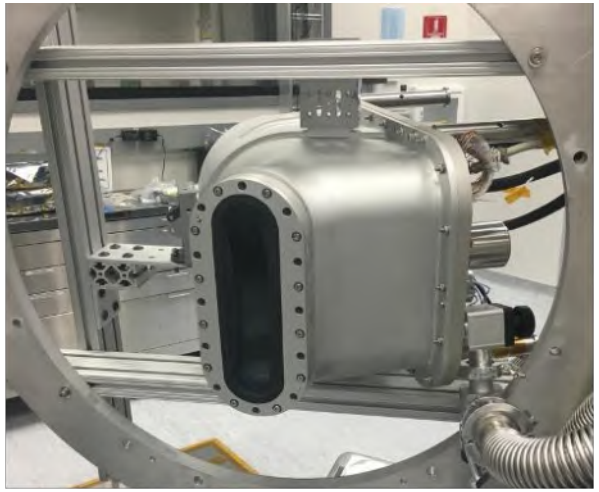




Source: A. Hueni

ARES – Airborne Research Facility for the Earth System



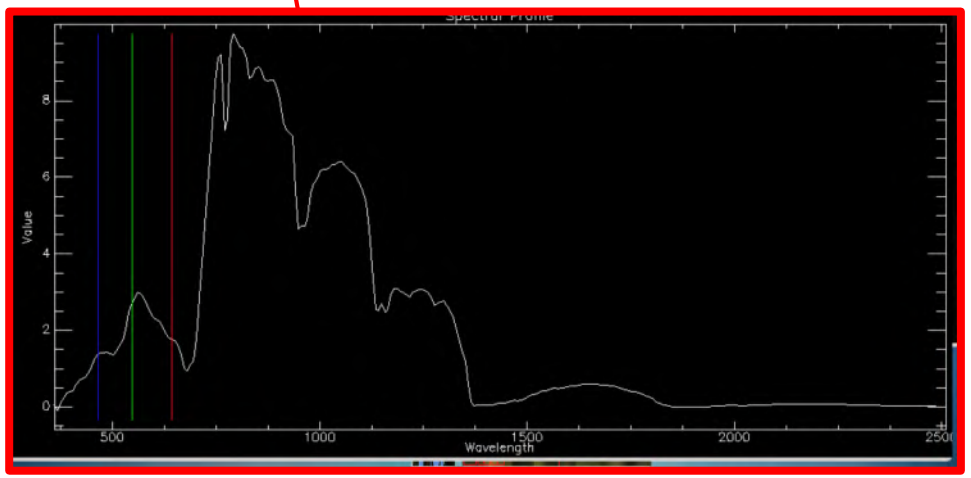


New Imaging Spectrometer CWIS-II to replace APEX is built in cooperation by NASA/JPL and UZH.

Test of imaging spectrometer CWIS-II (AVIRIS-4) at NASA-JPL

Source: A. Hueni

Test of imaging spectrometer CWIS-II (AVIRIS-4) at NASA-JPL



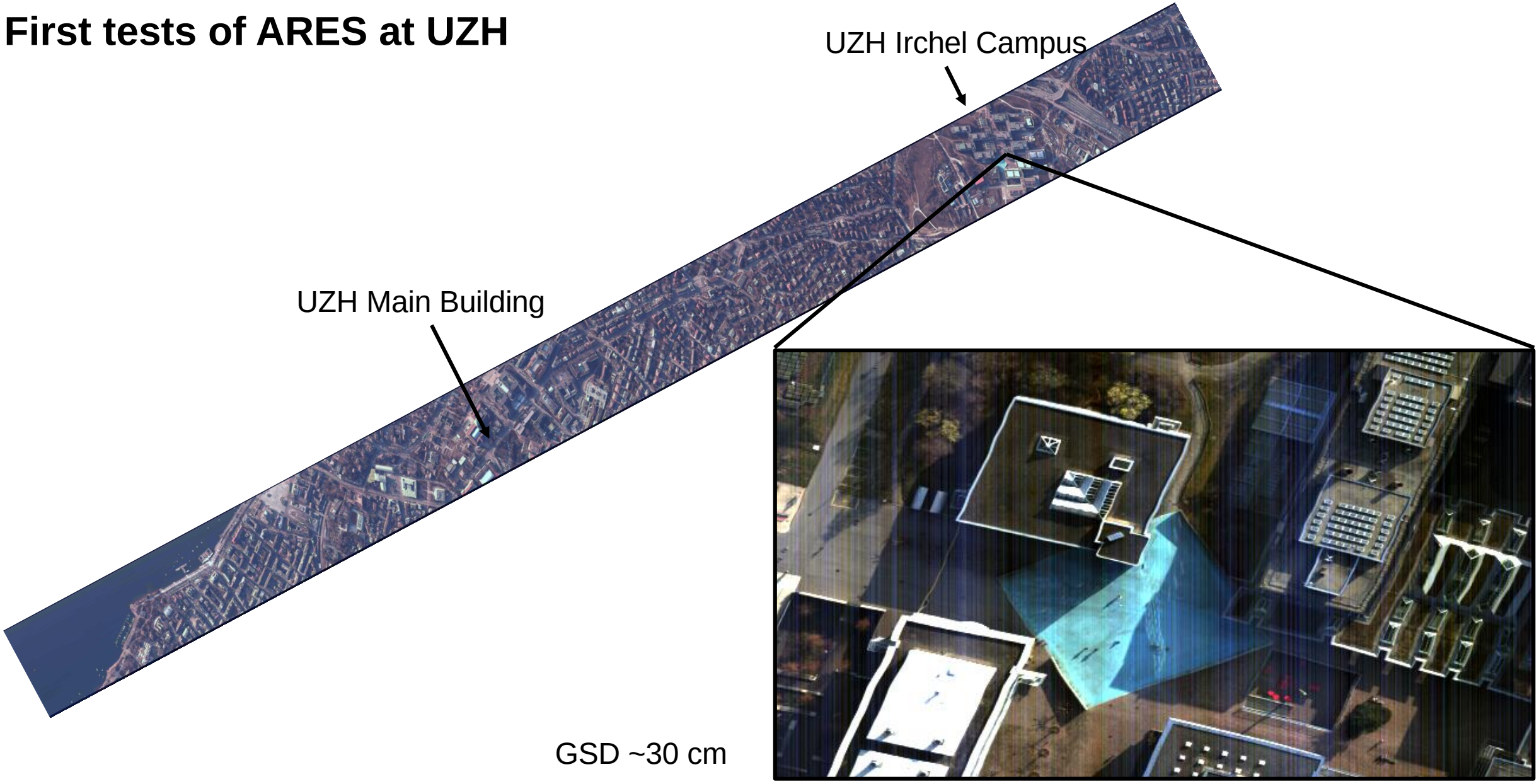
Solar-illuminated spectrum extract from the research group picture

Source: A. Hueni

First tests of ARES at UZH (spring 2024)

Source: A. Hueni

First tests of ARES at UZH

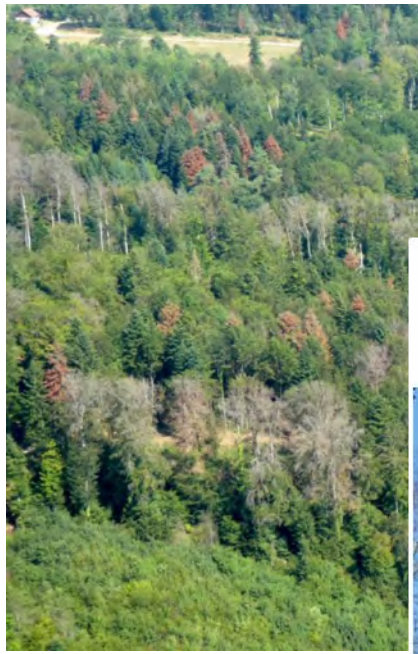


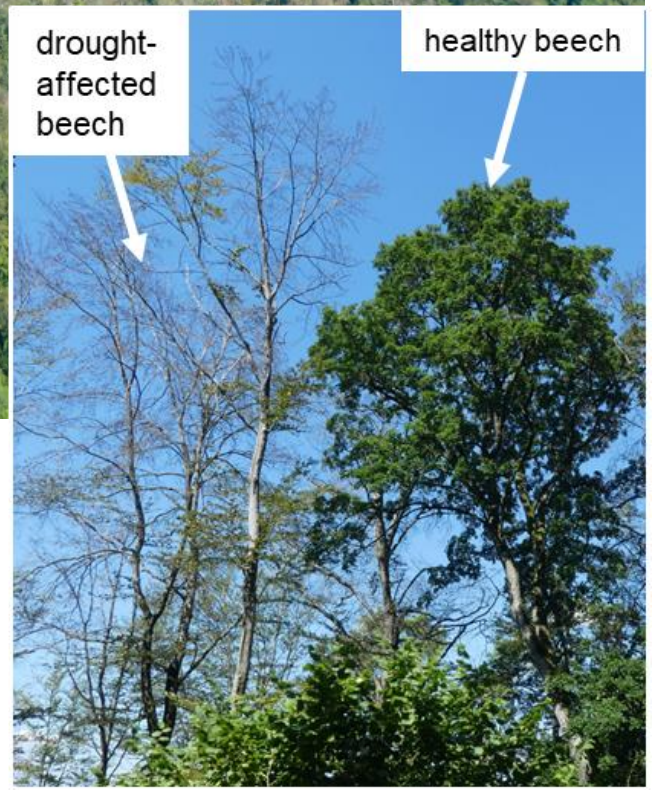
GSD ~30 cm

Source: A. Hueni

ARES: Getting the big picture without losing the important details

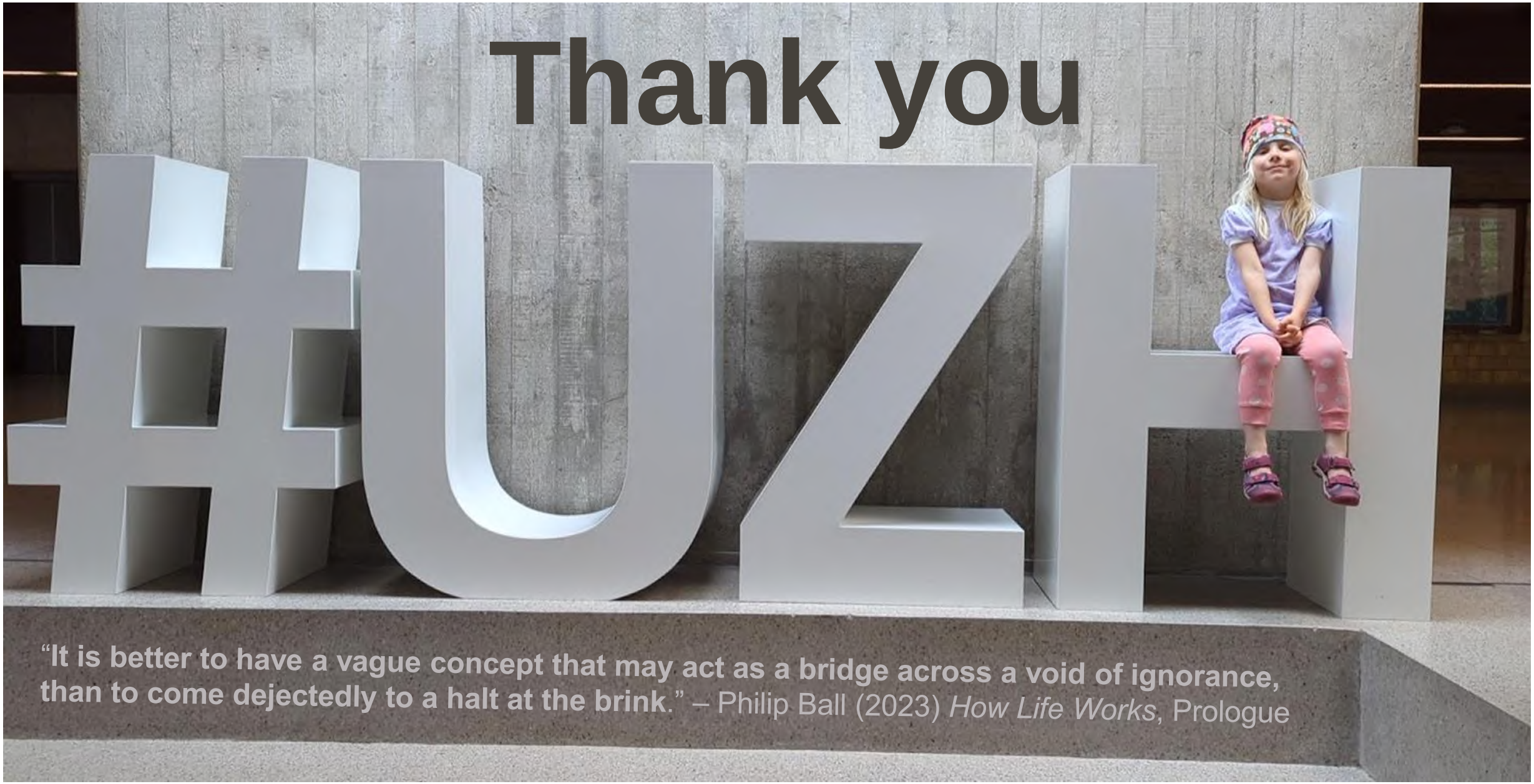
K. Mason, AVIRIS-NG reprocessed to high-res (RGB projection)





S. Hopf, Ajoie JU (top)
L. C. de Witte, neighboring trees (right)
July 2019

Thank you



"It is better to have a vague concept that may act as a bridge across a void of ignorance, than to come dejectedly to a halt at the brink." – Philip Ball (2023) *How Life Works*, Prologue