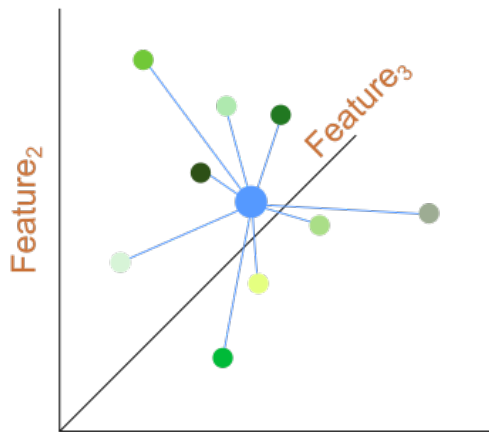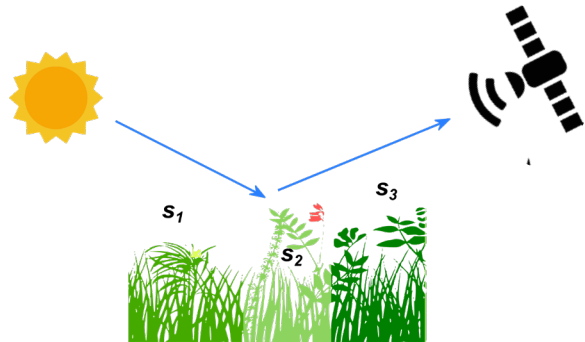# The death of the Spectral Variation Hypothesis applied to satellite data and the rise of its useful 'Zombies'

Christian Rossi, Swiss National Park, University of Zurich
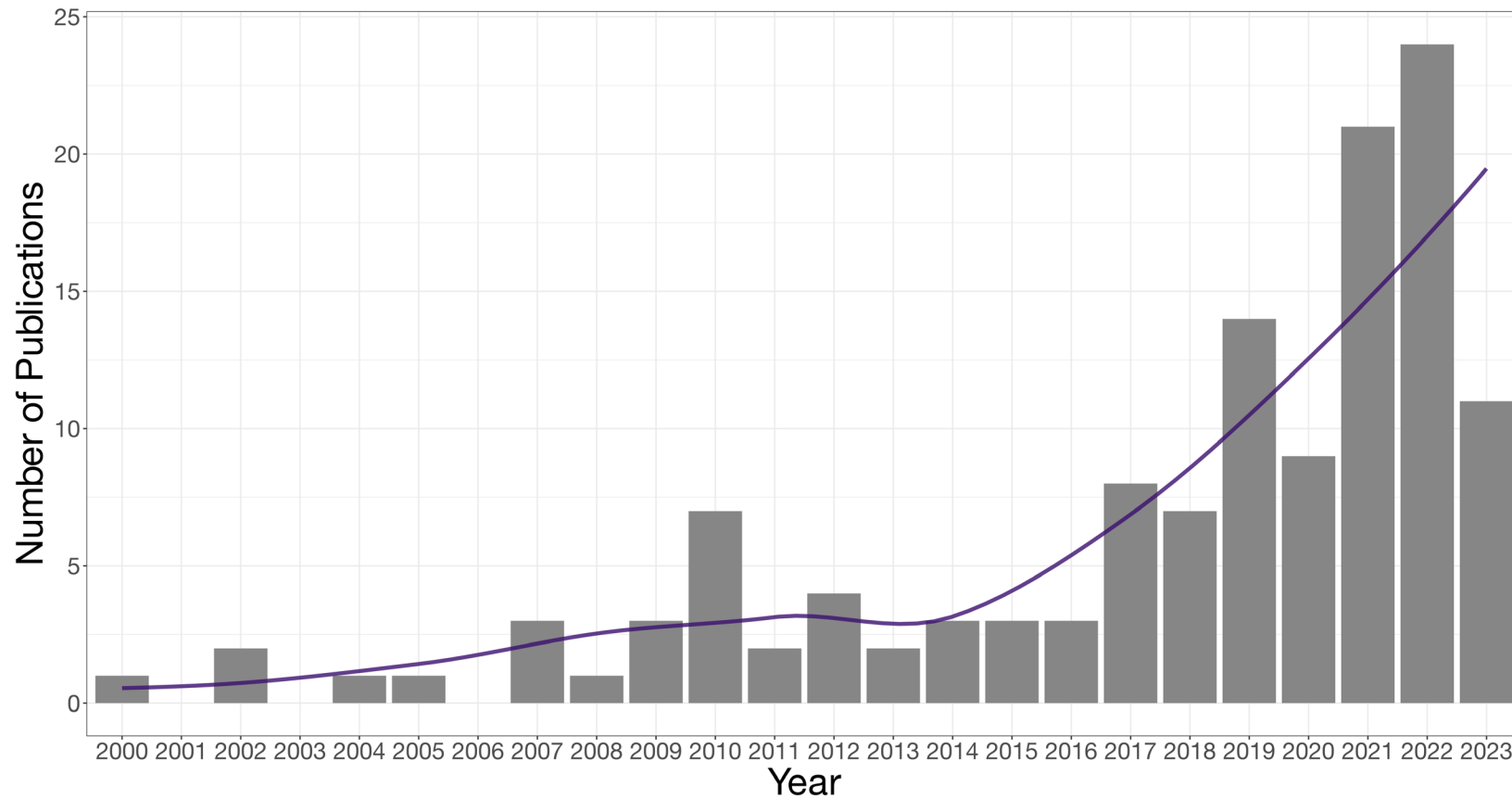
Biospace25, Frascati, 11.02.2025

1

parc nazinual svizzer

Universität Zürich UZH

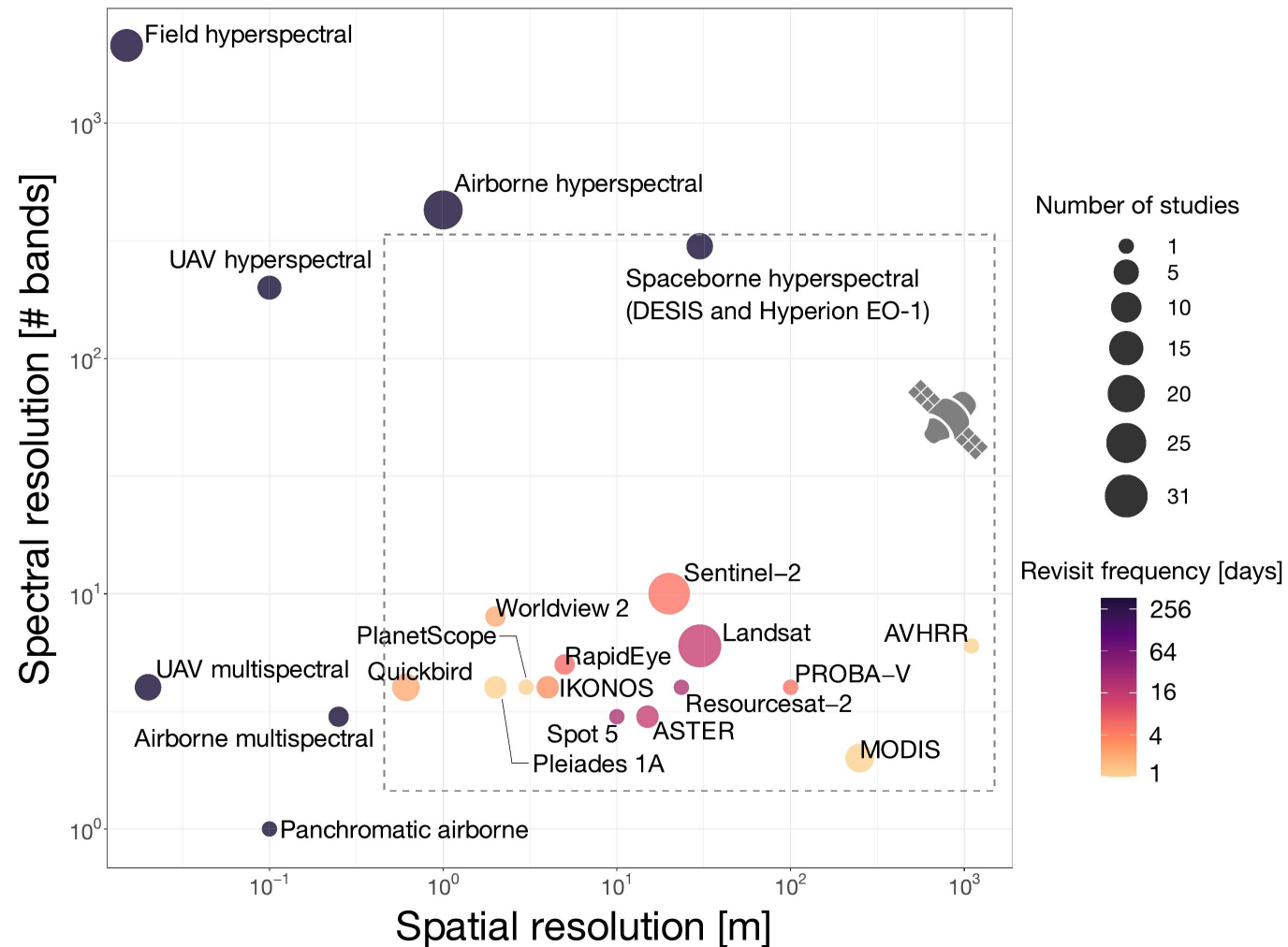# Spectral Variation Hypothesis

Species Richness will be positively related to any objective **measure of the variation** *in the* **spectral characteristics** *of a* **remotely sensed image***.*

Palmer et al., 2000

The enthusiasm for the SVH fueled by its simplicity

And increasing availability of free and open satellite data

Recent studies have raised significant issues

Relationship at leaf level do not easily translate to landscape-level assessments

Ecosystem and site specificity

Contrasting results in terms of spectral metrics to use and plant diversity that can be estimated

Is spectral pixel-to-pixel variation a reliable indicator of grassland biodiversity? A systematic assessment of the spectral variation hypothesis using spatial simulation experiments

Antonia Ludwig [a,b,c,*], Daniel Doktor [a,b,d], Hannes Feilhauer [a,b,c,d]

RESEARCH ARTICLE

Global Ecology and Biogeography — A Journal of Macroecology — WILEY

Making remote sense of biodiversity: What grassland characteristics make spectral diversity a good proxy for taxonomic diversity?

Elisa Van Cleemput [1,2,3] | Peter Adler [4] | Katharine Nash Suding [1,2]

The relationship between spectral and plant diversity: Disentangling the influence of metrics and habitat types at the landscape scale

Michela Perrone [a,*], Mirko Di Febbraro [b], Luisa Conti [a], Jan Divíšek [c,d], Milan Chytrý [c], Petr Keil [a], Maria Laura Carranza [b,e], Duccio Rocchini [a,f], Michele Torresani [g], Vítězslav Moudrý [a], Petra Šímová [a], Dominika Prajzlerová [a], Jana Müllerová [h], Jan Wild [a,i], Marco Malavasi [j]
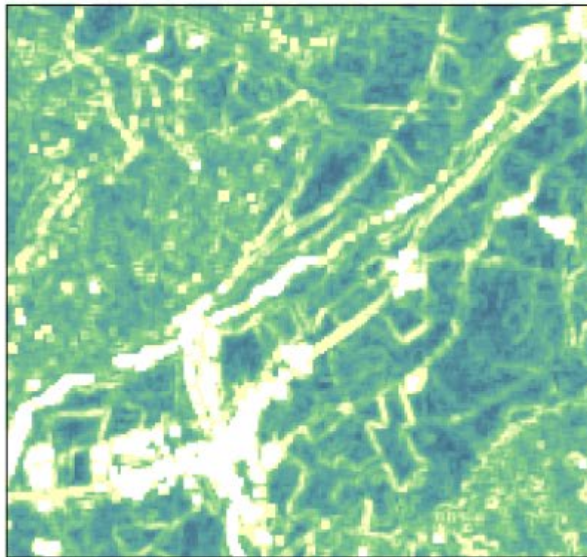
parc nazIunal svizzer

Universität Zürich UZH

Weak performance of the SVH using standard approaches

a) Sentinel-2 image 10 m 12.07.2021

b) 3 × 3 pixel moving window approach

c) 50 m × 50 m fixed window approach

0   500   1,000 Meters

Spectral diversity

Low   High

Rossi et al (2024). *Environmental Research Letters*
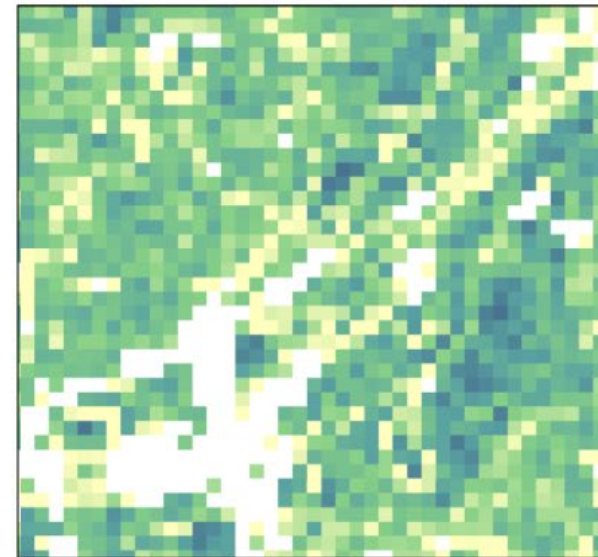
Time to let the SVH rest in peace as a one-size-fits-all straightforward solution to estimate biodiversity from space
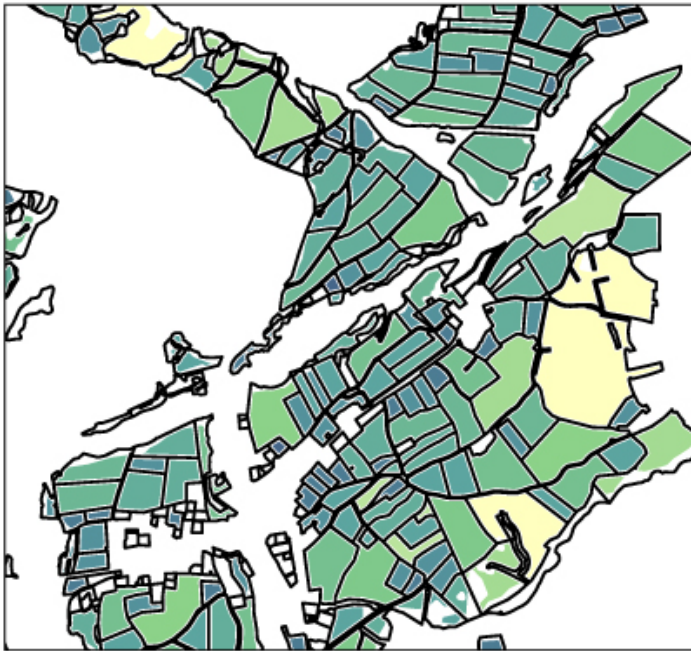
'SVH zombies' emerge providing valuable insights on biodiversity from space

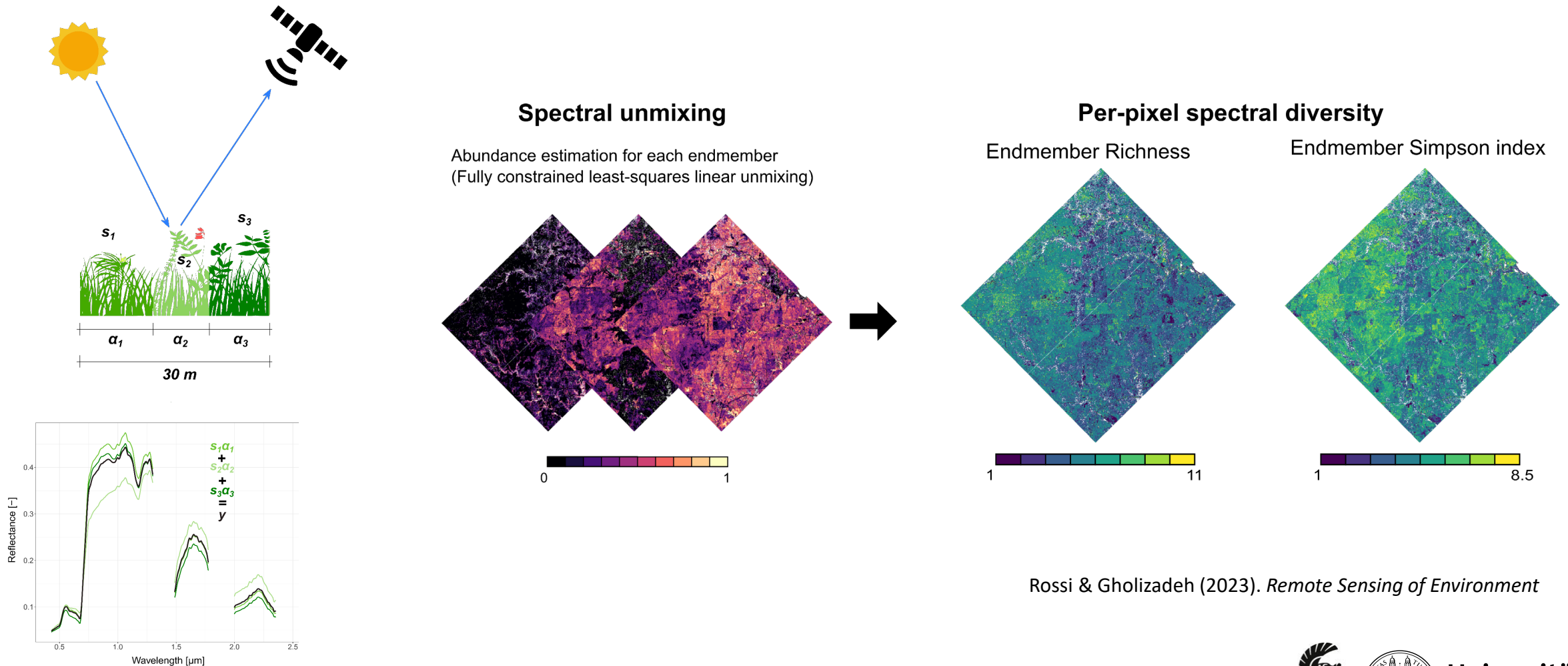# First zombie: SVH combined with ancillary data

d) Parcel based approach

Grassland parcels

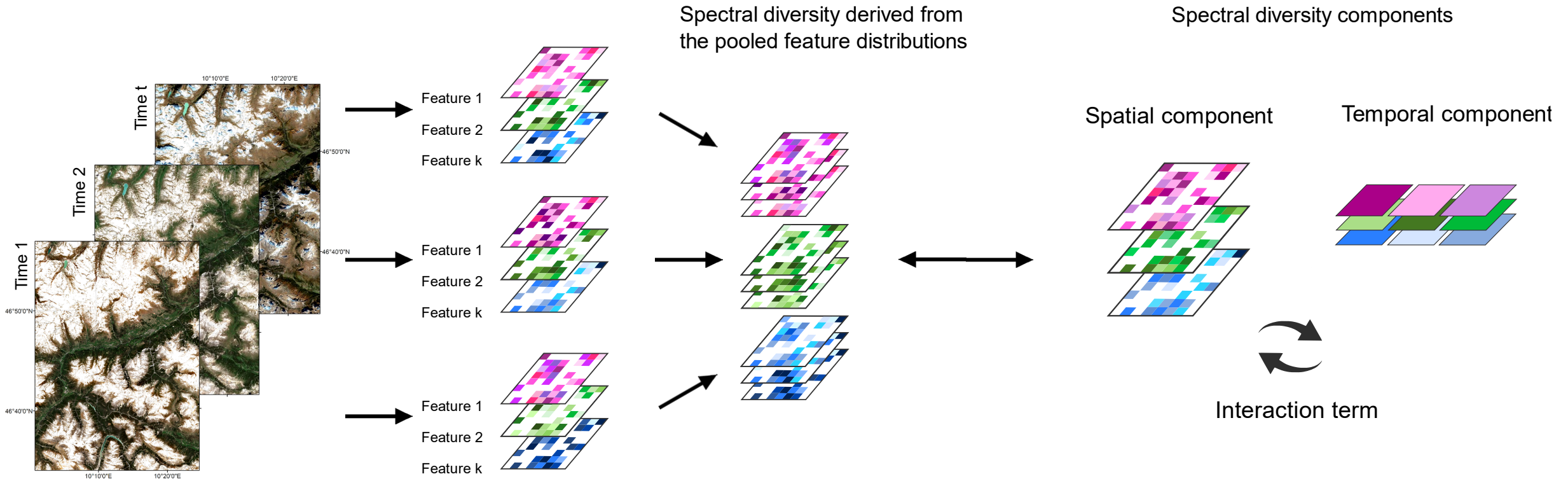**Calculating the spectral diversity at the parcel-level:**

- Mitigates field edges and varying management stages

- Mitigates misregistration problems

- Parcels as spatial units that relate to ecology and management

Rossi et al (2024). *Environmental Research Letters*

Second zombie: Spectral metrics at the subpixel

Spectral unmixing

Abundance estimation for each endmember
(Fully constrained least-squares linear unmixing)

Per-pixel spectral diversity

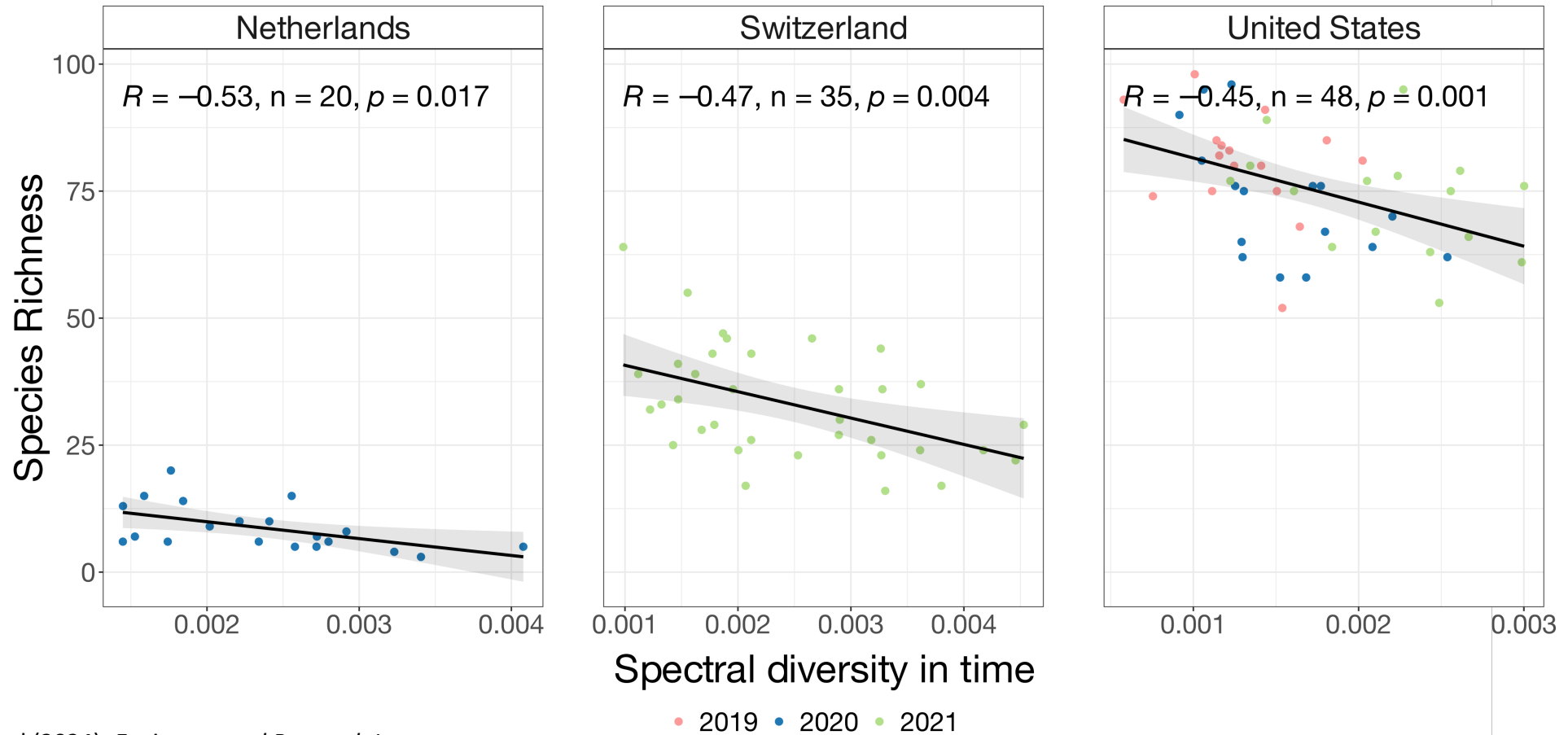Endmember Richness

Endmember Simpson index

Rossi & Gholizadeh (2023). *Remote Sensing of Environment*

Third zombie: Extending the SVH to the temporal dimension

Spectral diversity derived from the pooled feature distributions

Spectral diversity components

Spatial component

Temporal component

Interaction term

Rossi et al (2021). *Ecological Indicators*

Temporal dimension relates to plant diversity

Netherlands: $R = -0.53$, n = 20, $p = 0.017$

Switzerland: $R = -0.47$, n = 35, $p = 0.004$

United States: $R = -0.45$, n = 48, $p = 0.001$

Species Richness vs Spectral diversity in time

Legend: 2019, 2020, 2021

Rossi et al (2024). *Environmental Research Letters*

Spectral diversity to quantify intraspecific variation
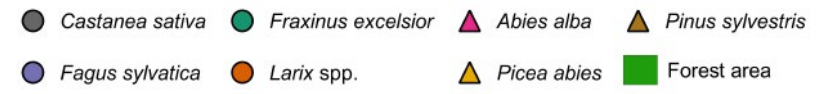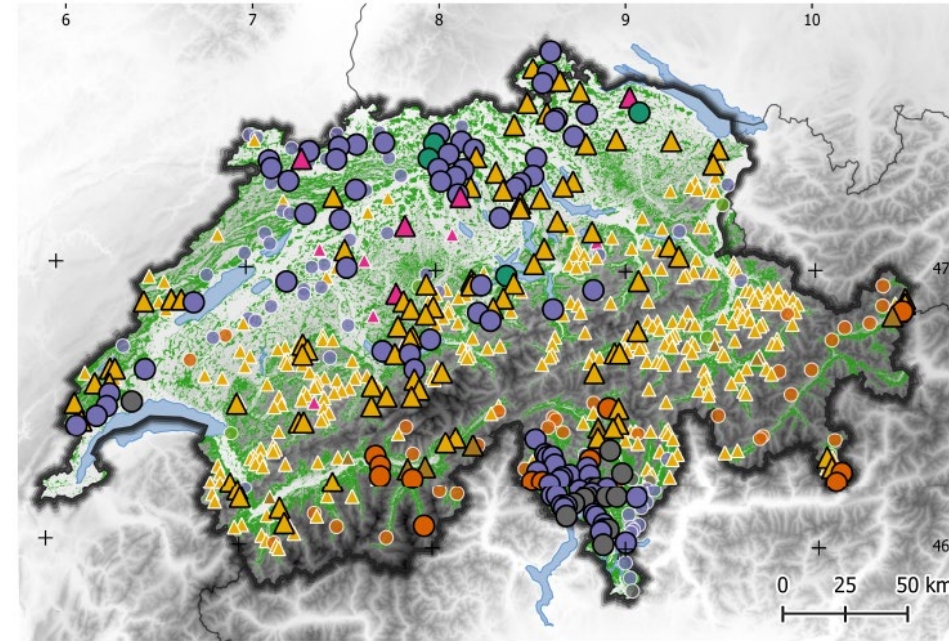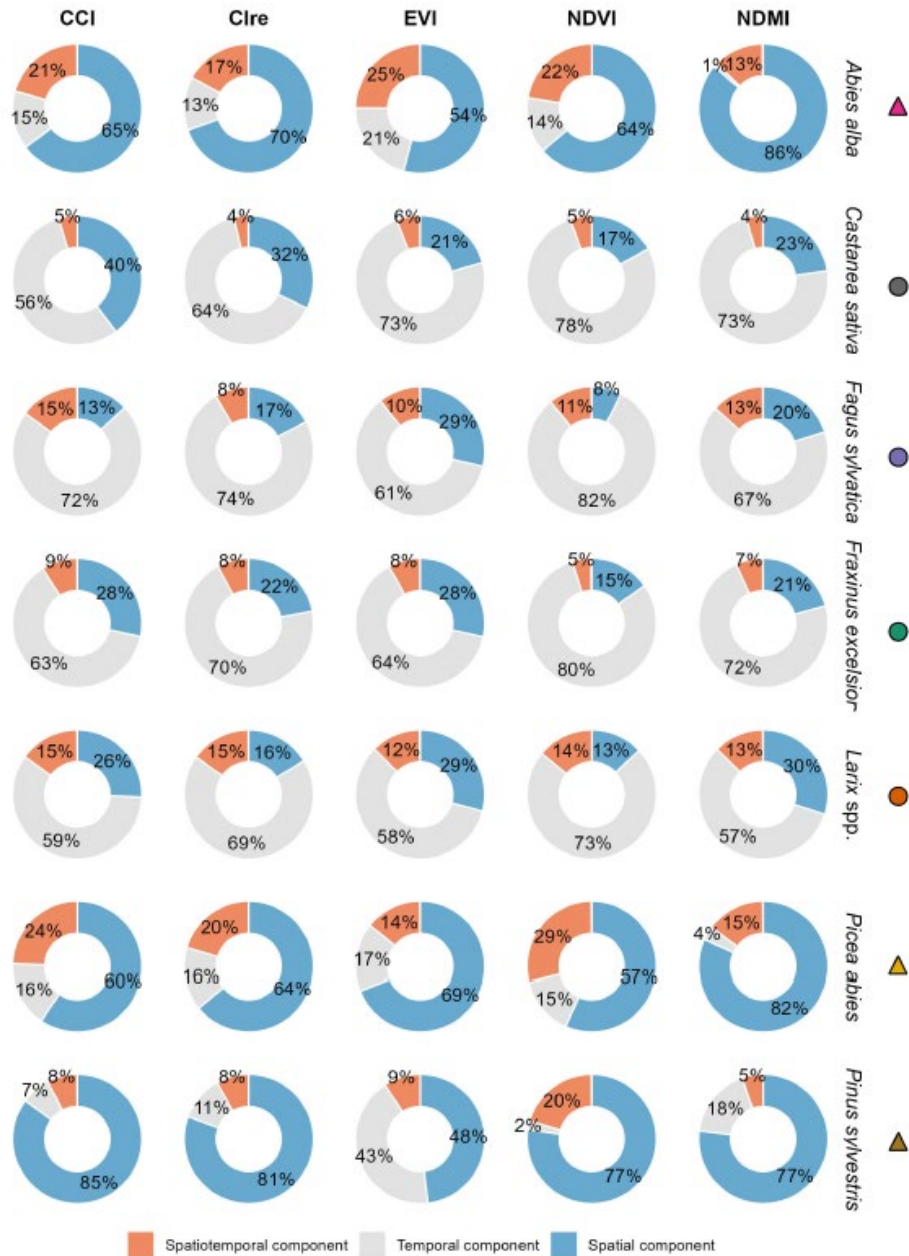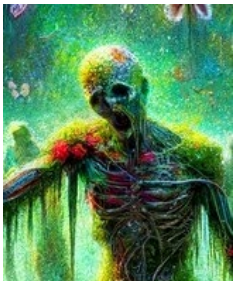

Koch et al., in Review.

Concluding remarks and recommendations

SVH can be improved with ancillary data: biodiversity is highly localized, complex and needs contextualization

SVH works mainly in seminatural systems - unmixing potential to mitigate coarse spatial resolution of spaceborne imaging spectrometers

Spectral diversity in time and spectral asynchrony have the potential to be integrated in plant diversity and phenotypic plasticity estimations

Future 'SVH zombies':

- Models combining multiple biodiversity-relevant predictors, i.e., spectral diversity as one piece of the puzzle
- Zombies to understand model performances
- Uncertainty estimation: The zombie antidote?

WORKSHOP THURSDAY 13 February 15:00 – 18:30
Big Hall - In-situ and SRS integration: **From Integrated In-Situ and Remote Sensing Campaigns to Open, Operational Biodiversity Data Products: Priorities, Gaps, and Opportunities**

POSTER SESSION I TODAY 6:30pm-8:00pm
Big Tent: **Two decades of Spectral Variation Hypothesis: advances and challenges in estimating biodiversity with remote sensing**
Michela Perrone et al.

Christian Rossi

Swiss National Park - University of Zurich

christian.rossi@geo.uzh.ch

Coauthors: Michele Torresani, Michela Perrone, Leon Hauser, Jan Schweizer, Hamed Gholizadeh, Anita Risch, Mathias Kneubühler, Michael Schaepman, Martin Schütz, Ruedi Haller

OBSGESSION
Observation of Ecosystem Changes for Action

parc naziunal svizzer

Universität Zürich UZH

15