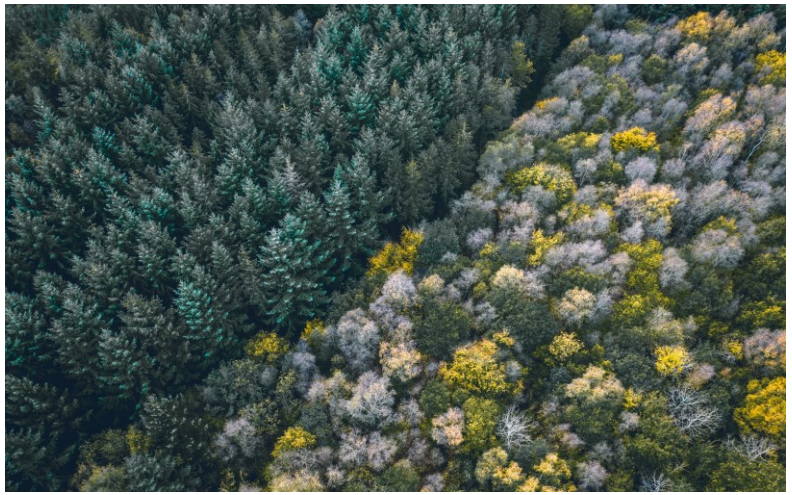


Exploring the role of vegetation height heterogeneity through LiDAR information for biodiversity estimation

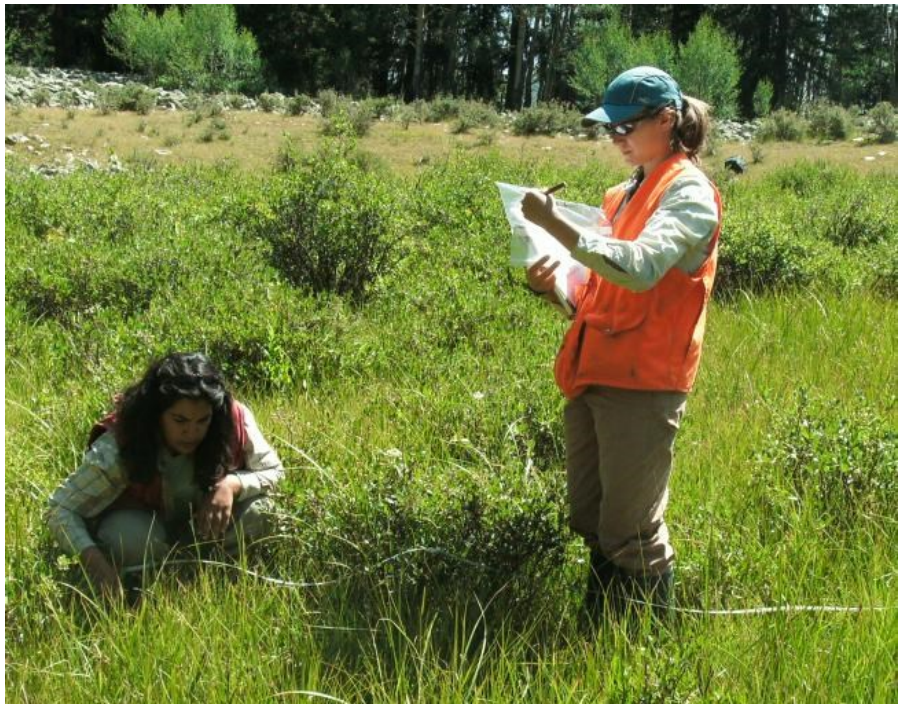
Michele Torresani[1], Moudrý Vítězslav[2] , Duccio Rocchini[2,3] , Perrone Michela[3], Tognetti Roberto[1]

1.Free University of Bolzano/Bozen (Italy), Faculty of Agricultural, Environmental and Food Sciences, Bolzano, Italy

2. Department of Spatial Sciences, Faculty of Environmental Sciences, Czech University of Life Sciences Prague, Praha-Suchdol, Czech Republic

3. BIOME Lab, Department of Biological, Geological and Environmental Sciences, Alma Mater Studiorum University of Bologna, Bologna, Italy

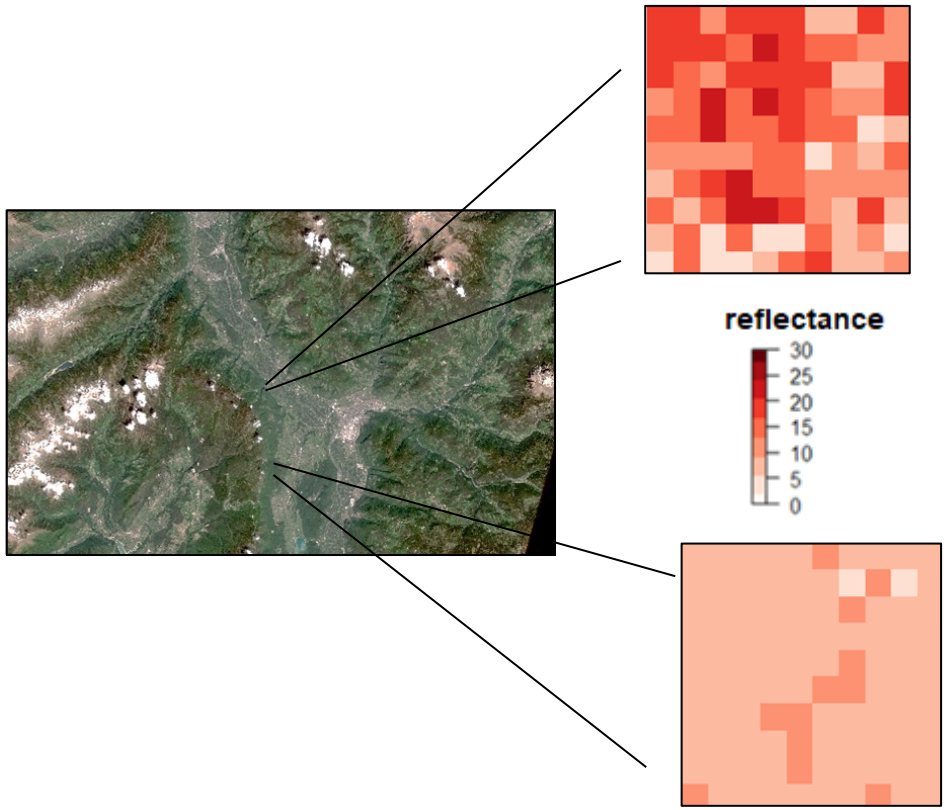
Biodiversity assessment



VS

Biodiversity assessment: The Spectral Variation Hypothesis

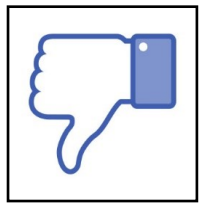
Spectral Heterogeneity (SH) of optical images



Environmental Heterogeneity (E.H.)

E.H.

E.H.



Species diversity

Biodiversity assessment: The Spectral Variation Hypothesis

Contents lists available at ScienceDirect

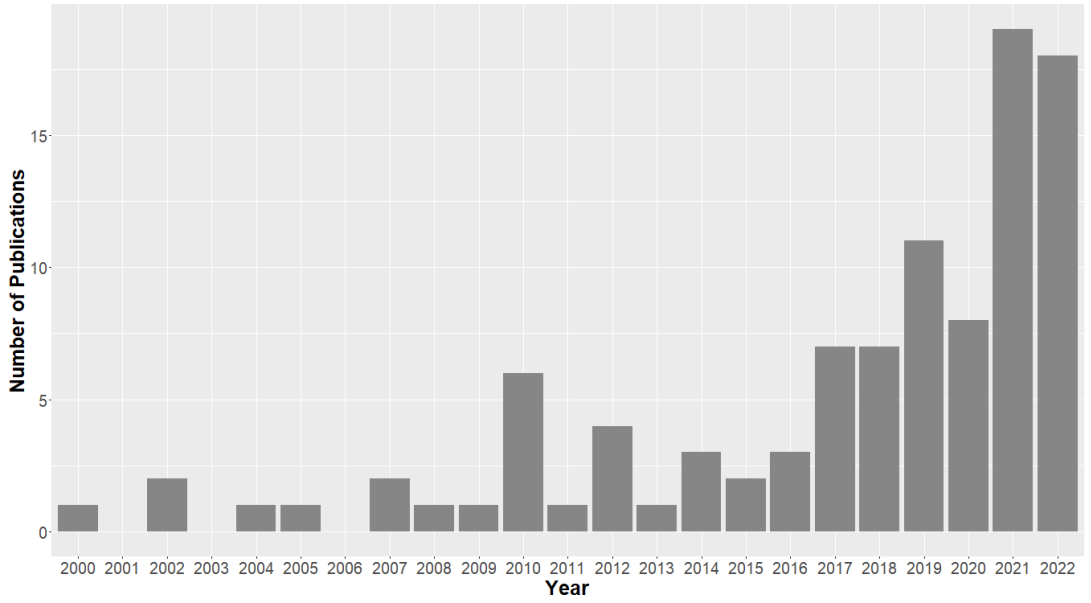
Ecological Informatics

journal homepage: www.elsevier.com/locate/ecolinf

Reviewing the Spectral Variation Hypothesis: Twenty years in the tumultuous sea of biodiversity estimation by remote sensing

Michele Torresani [a,*], Christian Rossi [b], Michela Perrone [c], Leon T. Hauser [d], Jean-Baptiste Féret [e], Vítězslav Moudrý [c], Petra Simova [c], Carlo Ricotta [f], Giles M. Foody [g], Patrick Kacic [h], Hannes Feilhauer [i], Marco Malavasi [j], Roberto Tognetti [a], Duccio Rocchini [c,k]

[a] Free University of Bolzano/Bozen, Faculty of Agricultural, Environmental and Food Sciences, Piazza Università / Universitätsplatz 1, 39100 Bolzano/Bozen, Italy
[b] Swiss National Park, Department of Geoinformation, Zernez, Switzerland
[c] Czech University of Life Sciences Prague, Faculty of Environmental Sciences, Department of Spatial Sciences, Kamýcka 129, Praha, Suchdol 16500, Czech Republic
[d] Department of Geography, University of Zurich, Winterthurerstrasse 190, 8057 Zurich, Switzerland
[e] TETIS, INRAE, AgroParisTech, CIRAD, CNRS, Université Montpellier, Montpellier, France
[f] Department of Environmental Biology, University of Rome 'La Sapienza', Rome, Italy
[g] School of Geography, University of Nottingham, University Park, Nottingham NG7 2RD, UK
[h] University of Würzburg, Institute of Geography and Geology, Department of Remote Sensing, John Skilton Str. 4a, 97074 Würzburg, Germany
[i] Remote Sensing Centre for Earth System Research, RSC4Earth, Talstr. 35, 04103 Leipzig, Germany
[j] Department of Chemistry, Physics, Mathematics and Natural Sciences, University of Sassari, Via Vienna 2, Sassari 07100, Italy
[k] BIOME Lab, Department of Biological, Geological and Environmental Sciences, Alma Mater Studiorum University of Bologna, via Irnerio 42, 40126 Bologna, Italy



Do not miss out!

The death of the Spectral Variation Hypothesis and the rise of its useful 'Zombies'

Christian Rossi[1,2], Michele Torresani[3], Michela Perrone[4], Leon Hauser[1]

Ecosystem Function and Functional Diversity

Today 12:00pm-1:30pm · Location: Magellan meeting room

Two decades of Spectral Variation Hypothesis: advances and challenges in estimating biodiversity with remote sensing

Michela Perrone[1], Christian Rossi[2], Duccio Rocchini[1,3], Leon T. Hauser[4], Jean- Baptiste Féret[5], Vítězslav Moudrý[1], Petra Šímová[1], Carlo Ricotta[6], Giles M. Foody[7], Patrick Kacic[8], Hannes Feilhauer[9], Marco Malavasi[10], Roberto Tognetti[11], Michele Torresani[11]

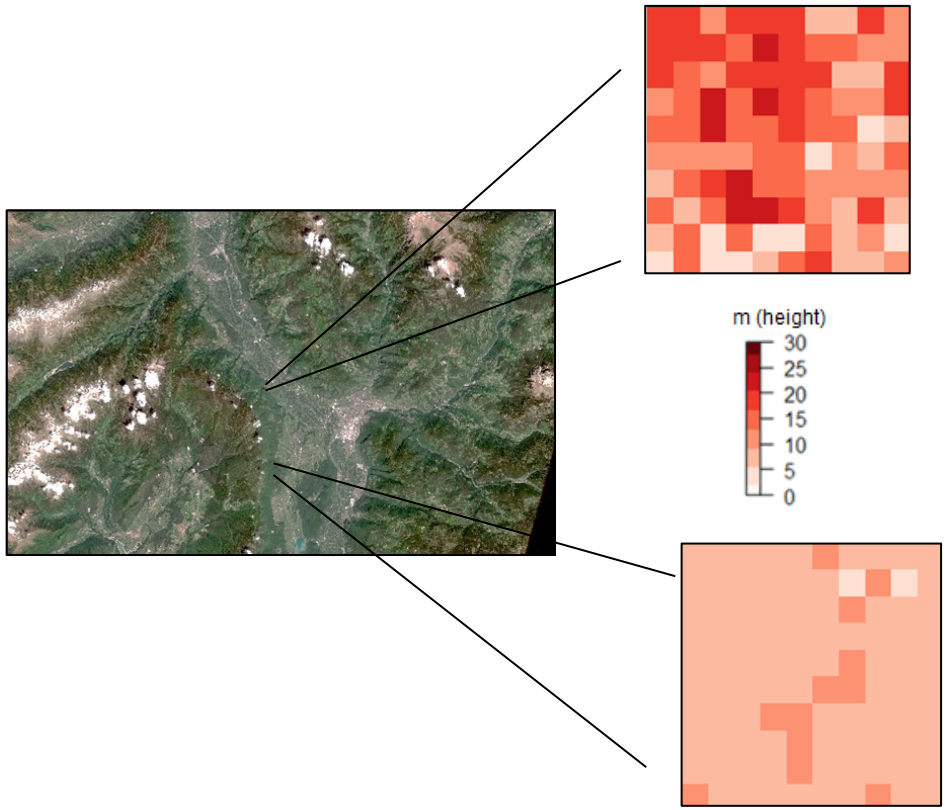
POSTER SESSION I

Today 6:30pm-8:00pm · Location: Big Tent

Biodiversity assessment:
The Spectral Variation Hypothesis

Biodiversity assessment: The ~~Spectral~~ Height Variation Hypothesis

~~Spectral~~ Height Heterogeneity (~~SH~~ HH) from ~~optical images~~ LiDAR data

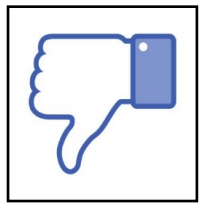


Environmental Heterogeneity (E.H.)

E.H.

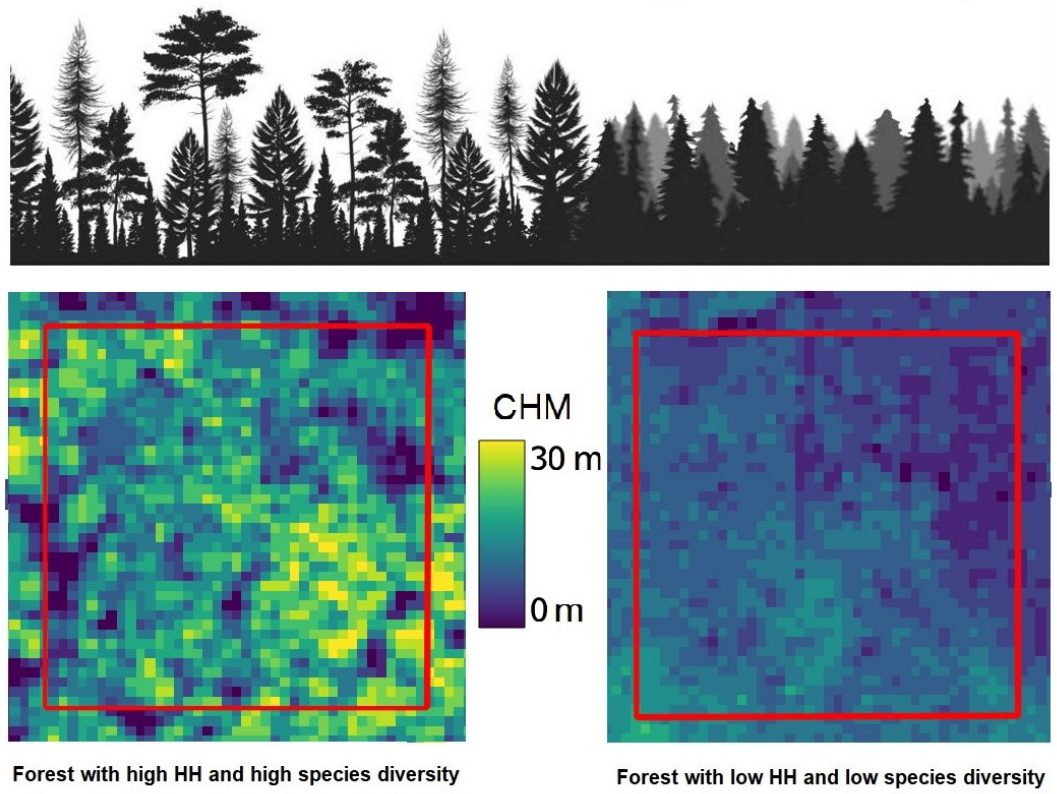
Species diversity

E.H.

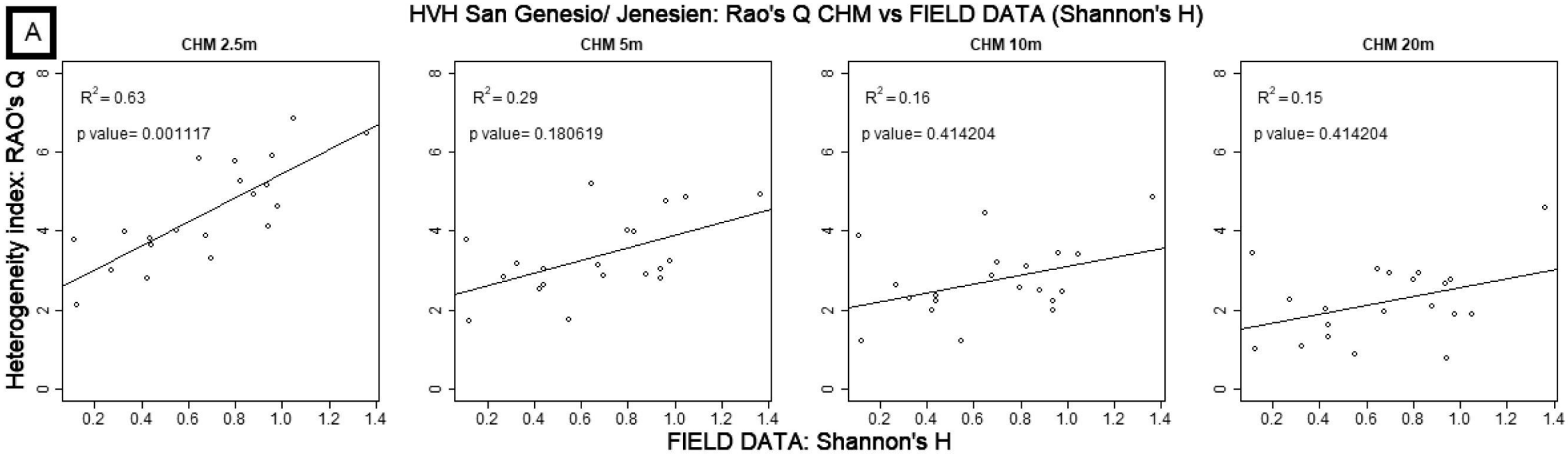


The Height Variation Hypothesis

Link between the Habitat Structural Heterogeneity and Biodiversity



The Height Variation Hypothesis in Forest Ecosystems: estimation of tree species diversity



ELSEVIER

Ecological Indicators
Volume 117, October 2020, 106520

Height variation hypothesis: A new approach for estimating forest species diversity with CHM LiDAR data

Michele Torresani [a], Duccio Rocchini [b, c], Ruth Sonnenschein [d], Marc Zebisch [d], Heidi C. Hauffe [e], Michael Heym [f], Hans Pretzsch [f], Giustino Tonon [a]

Assessment of Structural Heterogeneity

Received: 13 December 2020 | Accepted: 8 February 2021
DOI: 10.1111/2041-210X.13583

APPLICATION

Methods in Ecology and Evolution | BRITISH ECOLOGICAL SOCIETY

rasterdiv—An Information Theory tailored R package for measuring ecosystem heterogeneity from space: To the origin and back

Duccio Rocchini[1,2] | Elisa Thouverai[1] | Matteo Marcantonio[3] | Martina Iannacito[4] | Daniele Da Re[5] | Michele Torresani[6] | Giovanni Bacaro[7] | Manuele Bazzichetto[8] | Alessandra Bernardi[9] | Giles M. Foody[10] | Reinhard Furrer[11,12] | David Kleijn[13] | Stefano Larsen[14,15] | Jonathan Lenoir[16] | Marco Malavasi[2] | Elisa Marchetto[1] | Filippo Messori[1] | Alessandro Montaghi[17] | Vítězslav Moudrý[2] | Babak Naimi[18] | Carlo Ricotta[19] | Micol Rossini[20] | Francesco Santi[1] | Maria J. Santos[21] | Michael E. Schaepman[22] | Fabian D. Schneider[23] | Leila Schuh[11] | Sonia Silvestri[1] | Petra Šímová[2] | Andrew K. Skidmore[24,25] | Clara Tattoni[26] | Enrico Tordoni[7] | Saverio Vicario[27] | Piero Zannini[1] | Martin Wegmann[28]

Community Ecology (2021) 22:1–11
https://doi.org/10.1007/s42974-021-00042-x

ORIGINAL ARTICLE

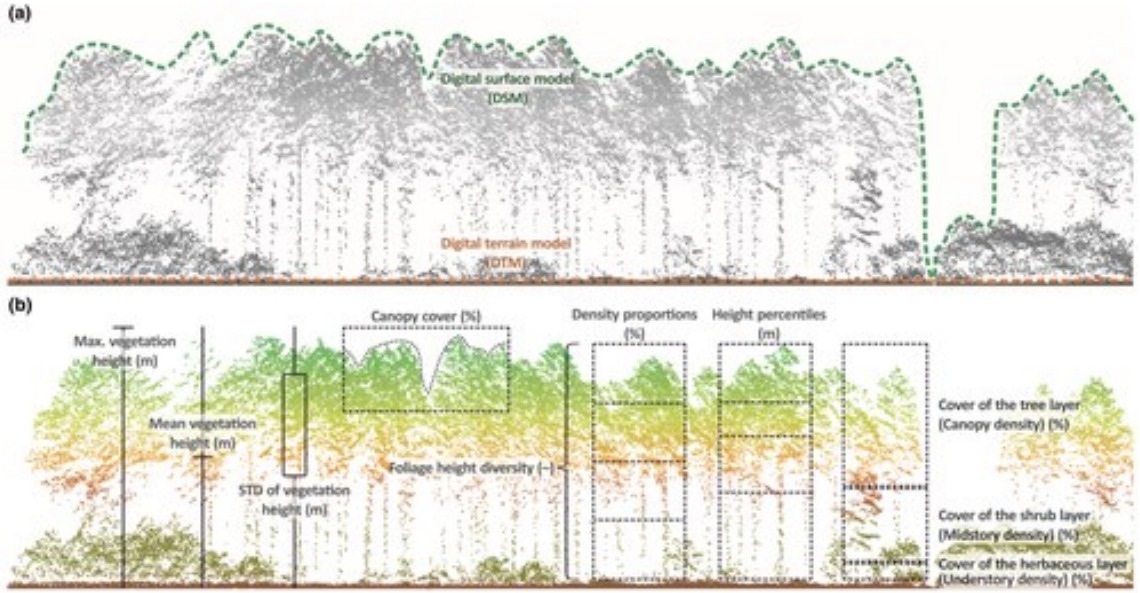
Check for updates

Measuring diversity from space: a global view of the free and open source `rasterdiv` R package under a coding perspective

Elisa Thouverai[1] · Matteo Marcantonio[2,10] · Giovanni Bacaro[3] · Daniele Da Re[4] · Martina Iannacito[5] · Elisa Marchetto[1] · Carlo Ricotta[6] · Clara Tattoni[7] · Saverio Vicario[8] · Duccio Rocchini[1,9]

Received: 9 November 2020 / Accepted: 3 March 2021 / Published online: 8 April 2021

The Height Variation Hypothesis in Forest Ecosystems: best LiDAR metric?



Moudrý, V., et al.(2023). Vegetation structure derived from airborne laser scanning to assess species distribution and habitat suitability: The way forward. *Diversity and Distributions*, *29*(1), 39-50.

remote sensing

MDPI

Article

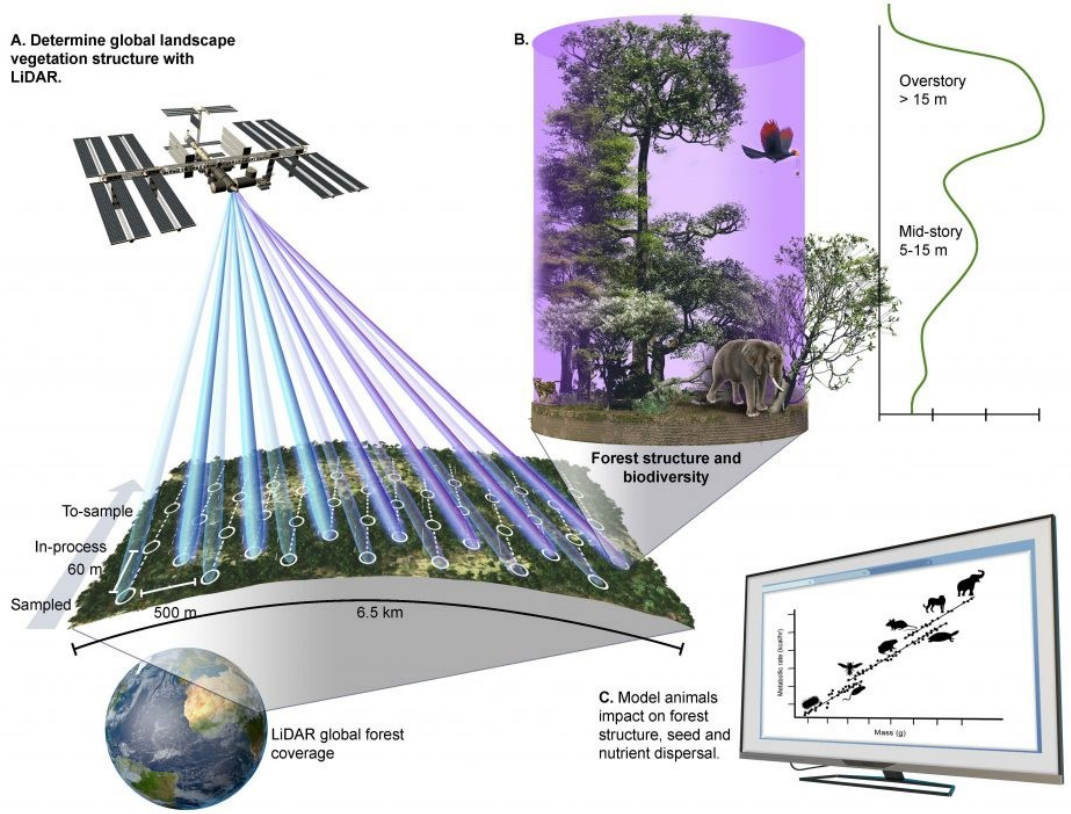
Testing the Height Variation Hypothesis with the R *rasterdiv* Package for Tree Species Diversity Estimation

Daniel Tamburlin [1,*], Michele Torresani [1], Enrico Tomelleri [2], Giustino Tonon [2] and Duccio Rocchini [1,3]

[1] BIOME Laboratory, Department of Biological, Geological and Environmental Sciences, Alma Mater Studiorum University of Bologna, Via Irnerio 42, 40126 Bologna, Italy; michele.torresani@unibo.it (M.T.); duccio.rocchini@unibo.it (D.R.)
[2] Faculty of Science and Technology, Free University of Bozen-Bolzano, Piazza Universitá/Universitätsplatz 1, 39100 Bolzano, Italy; Enrico.Tomelleri@unibz.it (E.T.); giustino.tonon@unibz.it (G.T.)
[3] Department of Applied Geoinformatics and Spatial Planning, Faculty of Environmental Sciences, Czech University of Life Sciences Prague, Kamýcka 129, Suchdol, 16500 Praha, Czech Republic
* Correspondence: daniel.tamburlin@studio.unibo.it

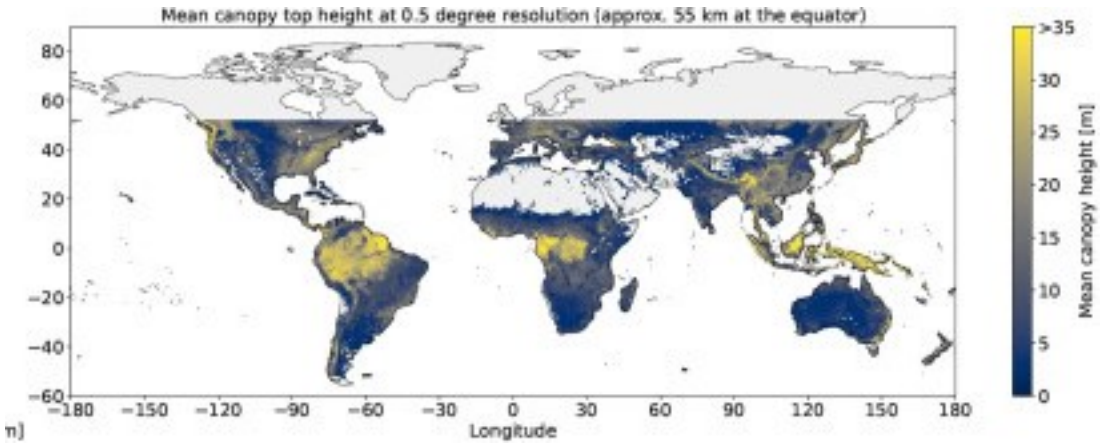
The Height Variation Hypothesis in Forest Ecosystems: From Air-borne to Space-borne LiDAR

GEDI
ECOSYSTEM LIDAR



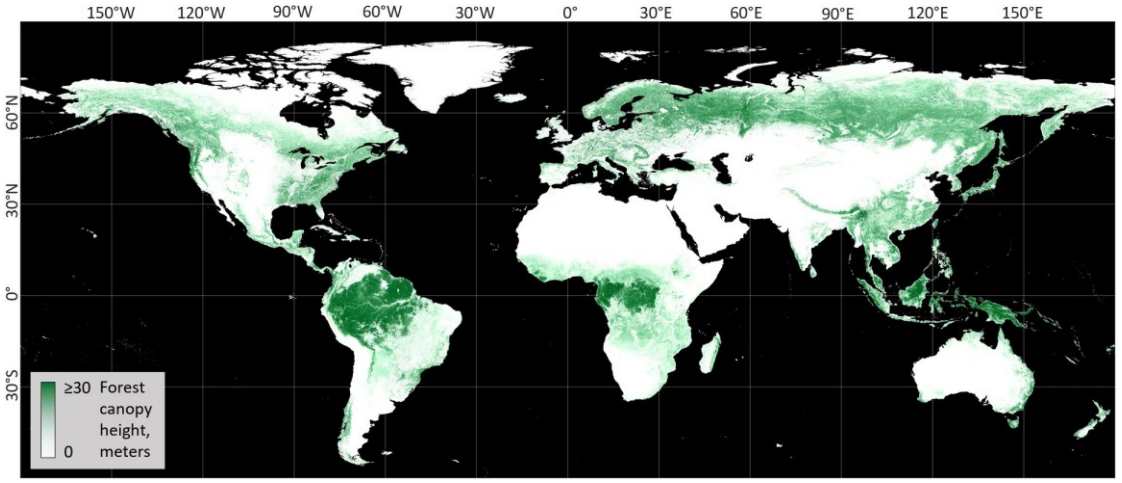
The Height Variation Hypothesis in Forest Ecosystems: From Air-borne to Space-borne LiDAR

CHM 10 m



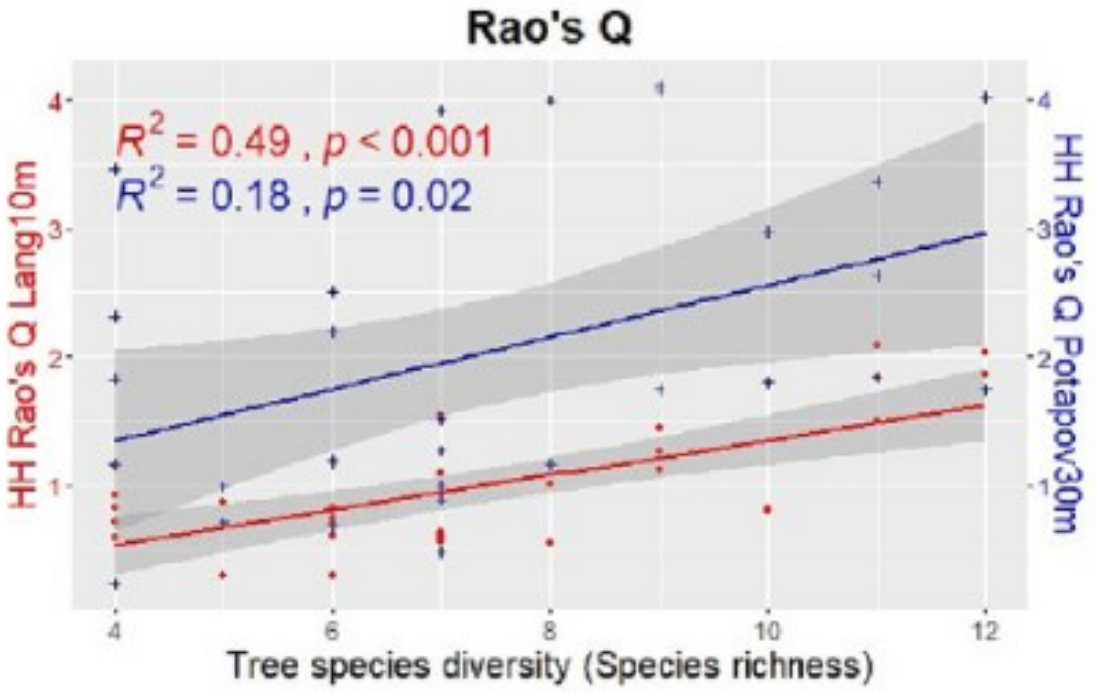
Lang et al. 2022 *Global canopy height regression and uncertainty estimation from GEDI LIDAR waveforms with deep ensembles*

CHM 30 m



Potapov et al. 2021 Mapping global forest canopy height through integration of GEDI and Landsat data

The Height Variation Hypothesis in Forest Ecosystems: From Air-borne to Space-borne LiDAR



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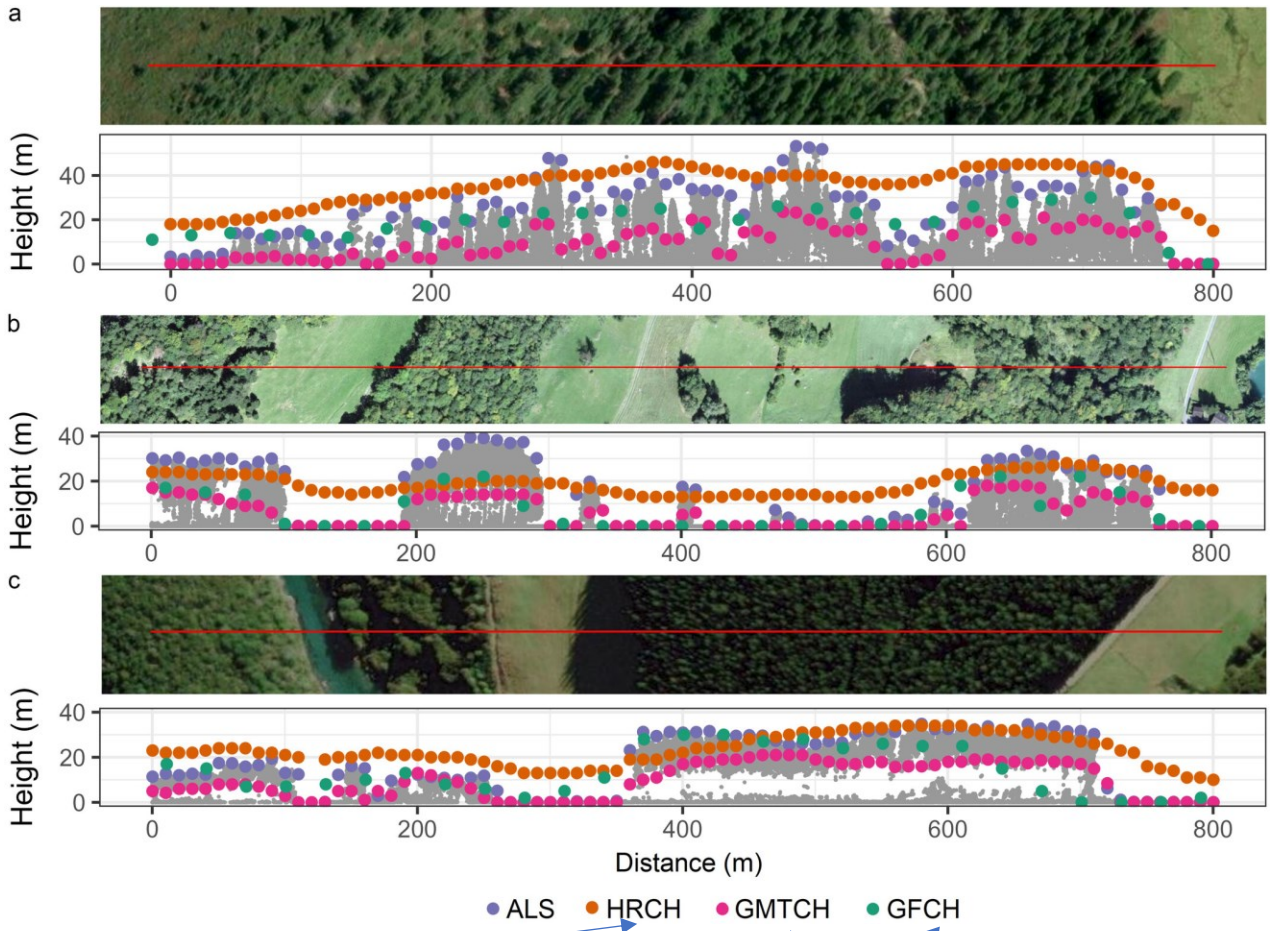
journal homepage: www.elsevier.com/locate/ecolinf

LiDAR GEDI derived tree canopy height heterogeneity reveals patterns of biodiversity in forest ecosystems

Michele Torresani [a,*], Duccio Rocchini [b,c], Alessandro Alberti [a], Vítězslav Moudrý [c], Michael Heym [d], Elisa Thouverai [b], Patrick Kacic [e], Enrico Tomelleri [a]

[a] Free University of Bolzano/Bozen, Faculty of Agricultural, Environmental and Food Sciences, Piazza Università/Universitätsplatz 1, 39100 Bolzano/Bozen, Italy
[b] BIOME Lab, Department of Biological, Geological and Environmental Sciences, Alma Mater Studiorum University of Bologna, via Irnerio 42, 40126, Bologna, Italy
[c] Czech University of Life Sciences Prague, Faculty of Environmental Sciences, Department of Spatial Sciences, Kamýcka 129, Praha - Suchdol 16500, Czech Republic
[d] Bavarian State Institute of Forestry (LWF), Hans-Carl-von-Carlowitz-Platz-1, 85354 Freising, Germany
[e] Department of Remote Sensing, Institute of Geography and Geology, University of Würzburg, Würzburg, Germany

The Height Variation Hypothesis in Forest Ecosystems: From Air-borne to Space-borne LiDAR



DOI: 10.1002/ecs2.70026

ECOSPHERE
AN ESA OPEN ACCESS JOURNAL

ARTICLE
Emerging Technologies

Comparison of three global canopy height maps and their applicability to biodiversity modeling: Accuracy issues revealed

Vítězslav Moudrý[1,2,3] | Lukáš Gábor[1] | Suzanne Marselis[4] | Petra Pracná[1] | Vojtěch Barták[1] | Jiří Prošek[1,3] | Barbora Navrátilová[5] | Jan Novotný[5] | Markéta Potůčková[6] | Kateřina Gdulová[1] | Pablo Crespo-Peremarch[7] | Jan Komárek[1] | Marco Malavasi[1,8] | Duccio Rocchini[1,9] | Luis A. Ruiz[7] | Jesús Torralba[7] | Michele Torresani[10] | Roberto Cazzolla Gatti[9] | Jan Wild[1,3]

Lang et al. 2023 10m **META (Tolan et al. 2024) 1m reseampled to 10m** **Potapov et al. 2021 30m**

The Height Variation Hypothesis at landscape level for assessment of bird biodiversity

ELSEVIER

Basic and Applied Ecology
Volume 70, August 2023, Pages 38-49

RESEARCH PAPER

Habitat heterogeneity promotes bird diversity in agricultural landscapes: Insights from remote sensing data

Matteo Anderle [a b c], Mattia Brambilla [c d], Andreas Hilpold [a], Joy Giovanni Matabishi [a e], Chiara Paniccia [a], Duccio Rocchini [f g], Jennifer Rossin [a f], Erich Tasser [a], Michele Torresani [h], Ulrike Tappeiner [a b], Julia Seeber [a b]

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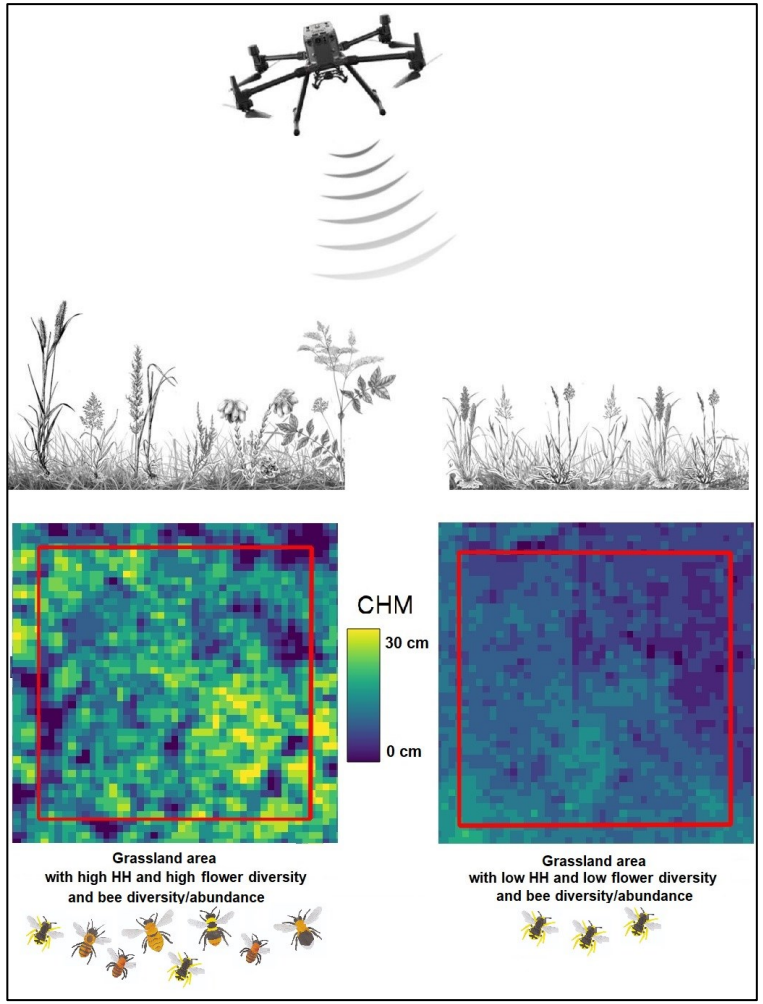
Linking Bird Biodiversity and Structural Diversity in South Tyrol's Riparian Forests: Insights from Remote Sensing and Acoustic Data

Chiara Salvatori[1,2], Irene Menegaldo[2], Michele Torresani[2], Enrico Tomelleri[2]

POSTER SESSION I

Tomorrow 6:30pm-8:00pm · Location: Big Tent

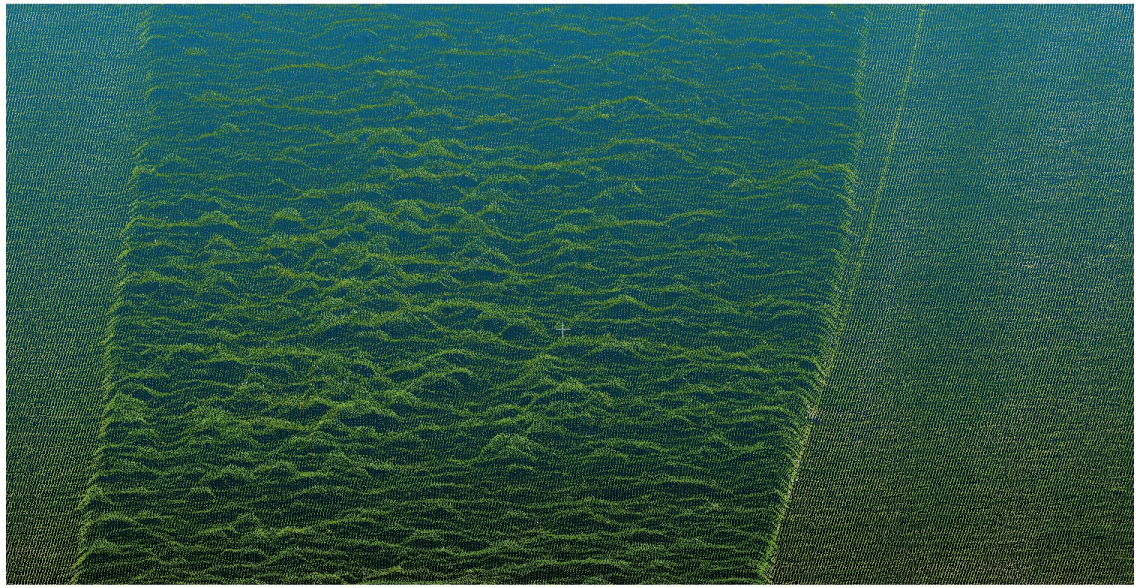
The Height Variation Hypothesis at grassland level for vegetation and bee diversity estimation



The Height Variation Hypothesis at grassland level for vegetation and bee diversity estimation

Grassland high height heterogeneity

A

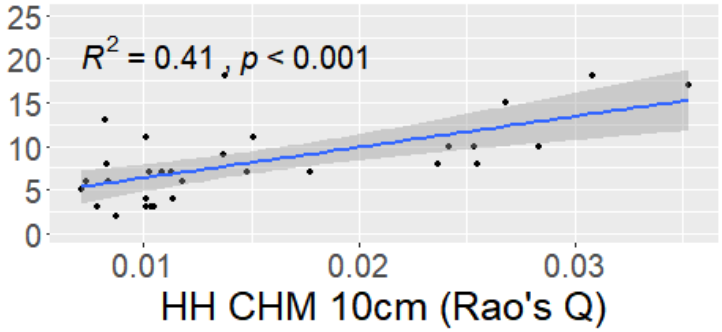


Grassland low height heterogeneity

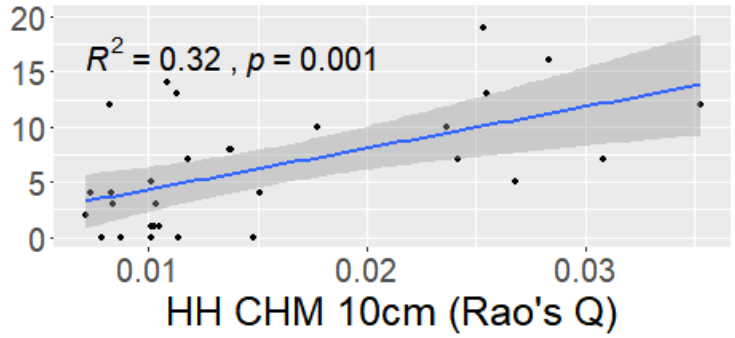
B

The Height Variation Hypothesis at grassland level for vegetation and bee diversity estimation

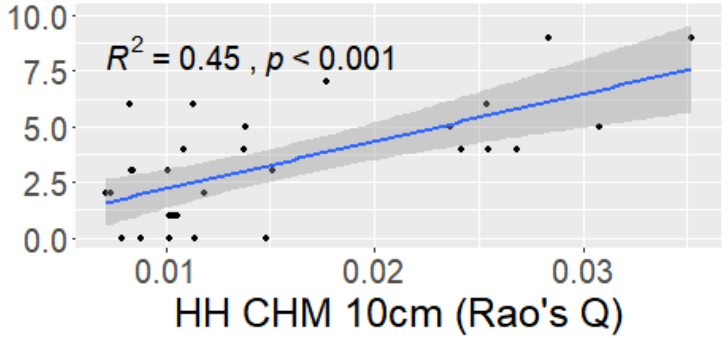
Flower species richness



Bee abundance



Bee species diversity



scientific reports

OPEN

Grassland vertical height heterogeneity predicts flower and bee diversity: an UAV photogrammetric approach

Michele Torresani[1], Duccio Rocchini[2,3✉], Giada Ceola[2], Jan Peter Reinier de Vries[4], Hannes Feilhauer[5,6,7], Vítězslav Moudrý[3], Harm Bartholomeus[8], Michela Perrone[3], Matteo Anderle[9,10], Hannes Andres Gamper[1], Ludovico Chieffallo[2], Enrico Guatelli[11], Roberto Cazzolla Gatti[2] & David Kleijn[4]

In conclusion

- Structural Heterogeneity assessed by RS data (LiDAR, photogrammetry) is linked to environmental heterogeneity and can be considered a good approach for **the assessment of different aspects of biodiversity**

- Interesting results **across various ecosystems** (forests, grasslands, and at landscape level), regarding the assessment of biodiversity **at different taxonomic levels** including vegetation, bees, and birds.

- The approach holds true with **different remote sensing data** (ALS LiDAR, Space-borne LiDAR, UAV photogrammetry)

- Limitations

- **Next steps?**

Interreg

Cofinanziato dall'Unione Europea

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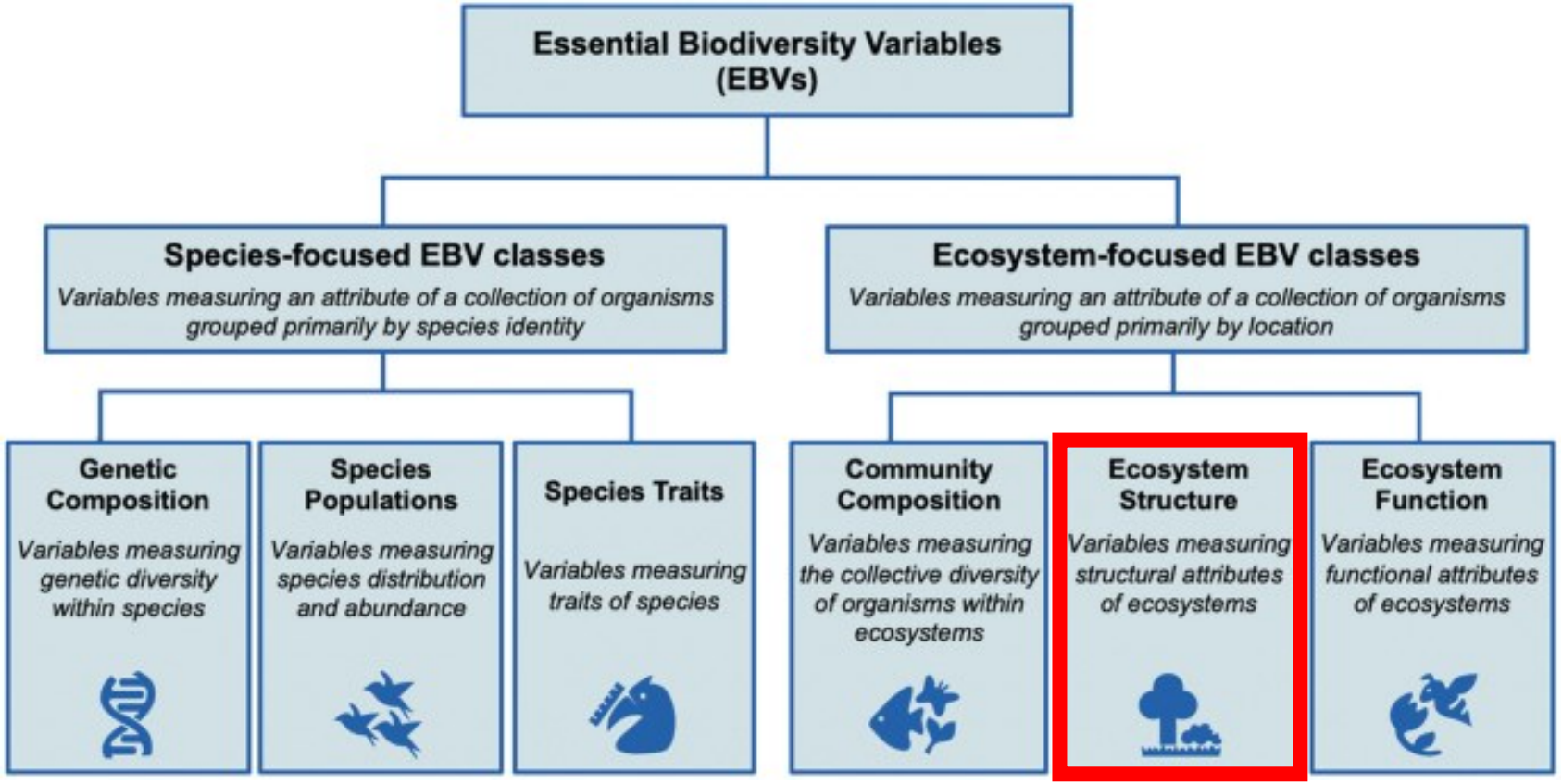
Thank you for your attention

Michele Torresani
michele.torresani@unibz.it

The Height Variation Hypothesis



Assessment of Structural Heterogeneity

Rao's Q index

$$Q = \sum_{i=1}^{F-1} \sum_{j+i=1}^{F} d_{ij} * p_i * p_j$$

p = relative abundance of a pixel value in a selected image (F)
d_{ij} = spectral distance between the i-th and j-th pixel value ($d_{ij} = d_{ji}$ and $d_{ii} = 0$)
i = pixel i
j = pixel j

Home > Theoretical Ecology > Article

On the mathematical properties of spatial Rao's Q to compute ecosystem heterogeneity

Research | Open access | Published: 11 July 2024
Volume 17, pages 247–254, (2024) Cite this article

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Duccio Rocchini, Michele Torresani & Carlo Ricotta

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Ecological Complexity

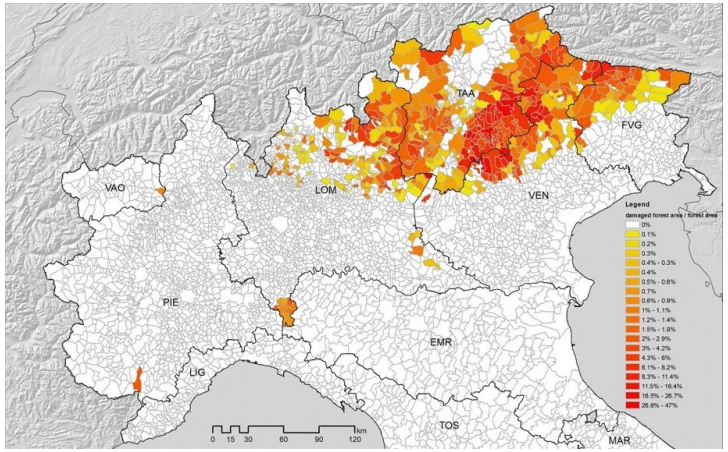
journal homepage: www.elsevier.com/locate/ecocom

Original research article

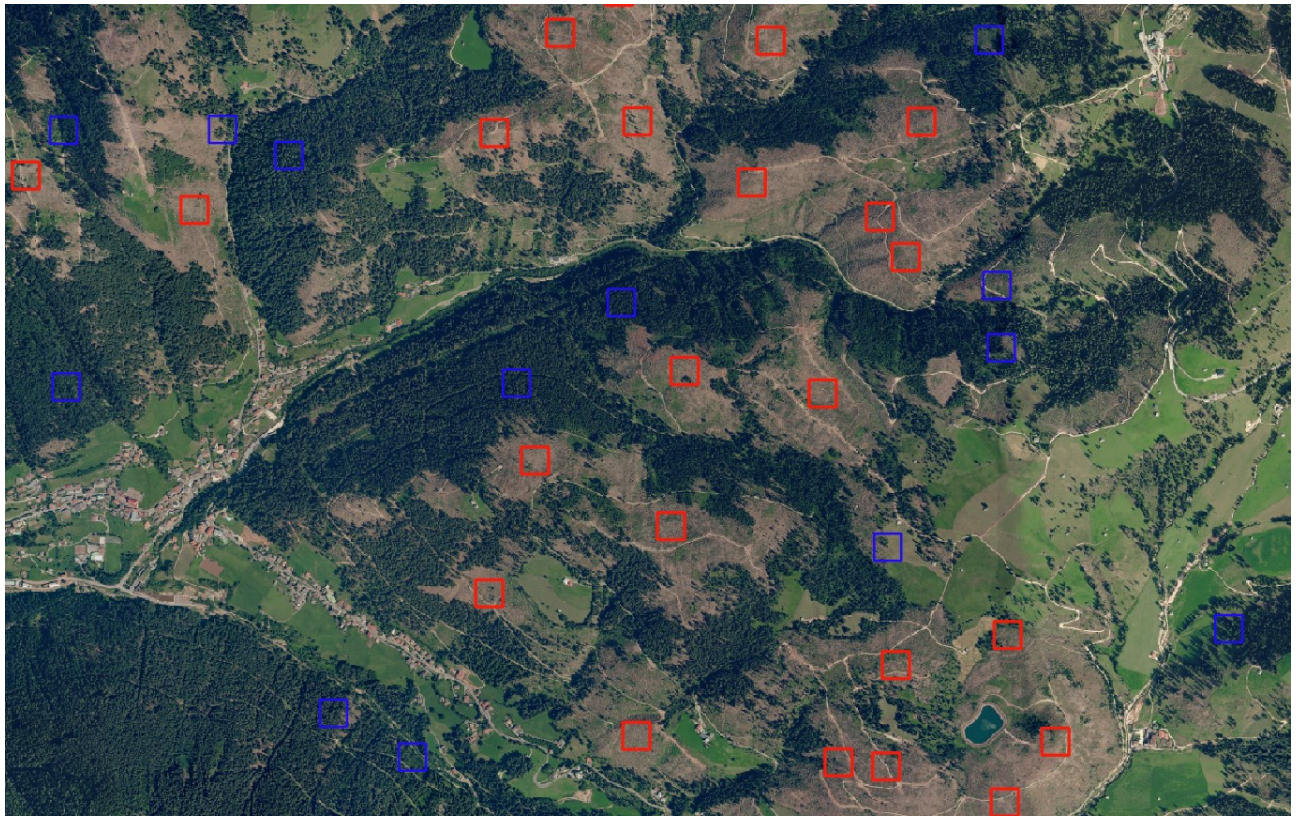
Integrals of life: Tracking ecosystem spatial heterogeneity from space through the area under the curve of the parametric Rao's Q index

Elisa Thouverai [a,*,1], Matteo Marcantonio [b,1], Jonathan Lenoir [c], Mariasole Galfré [a], Elisa Marchetto [a], Giovanni Bacaro [d], Roberto Cazzolla Gatti [a], Daniele Da Re [b], Michele Di Musciano [a,e], Reinhard Furrer [f], Marco Malavasi [g], Vítězslav Moudrý [h], Jakub Nowosad [i], Franco Pedrotti [j], Raffaele Pelorosso [k], Giovanna Pezzi [a], Petra Šímová [g], Carlo Ricotta [l], Sonia Silvestri [m], Enrico Tordoni [n], Michele Torresani [o], Giorgio Vacchiano [p], Piero Zannini [a,q,r], Duccio Rocchini [a,g]

The Height Variation Hypothesis in Forest Ecosystems. Applications: assessment of forest stability during extreme events



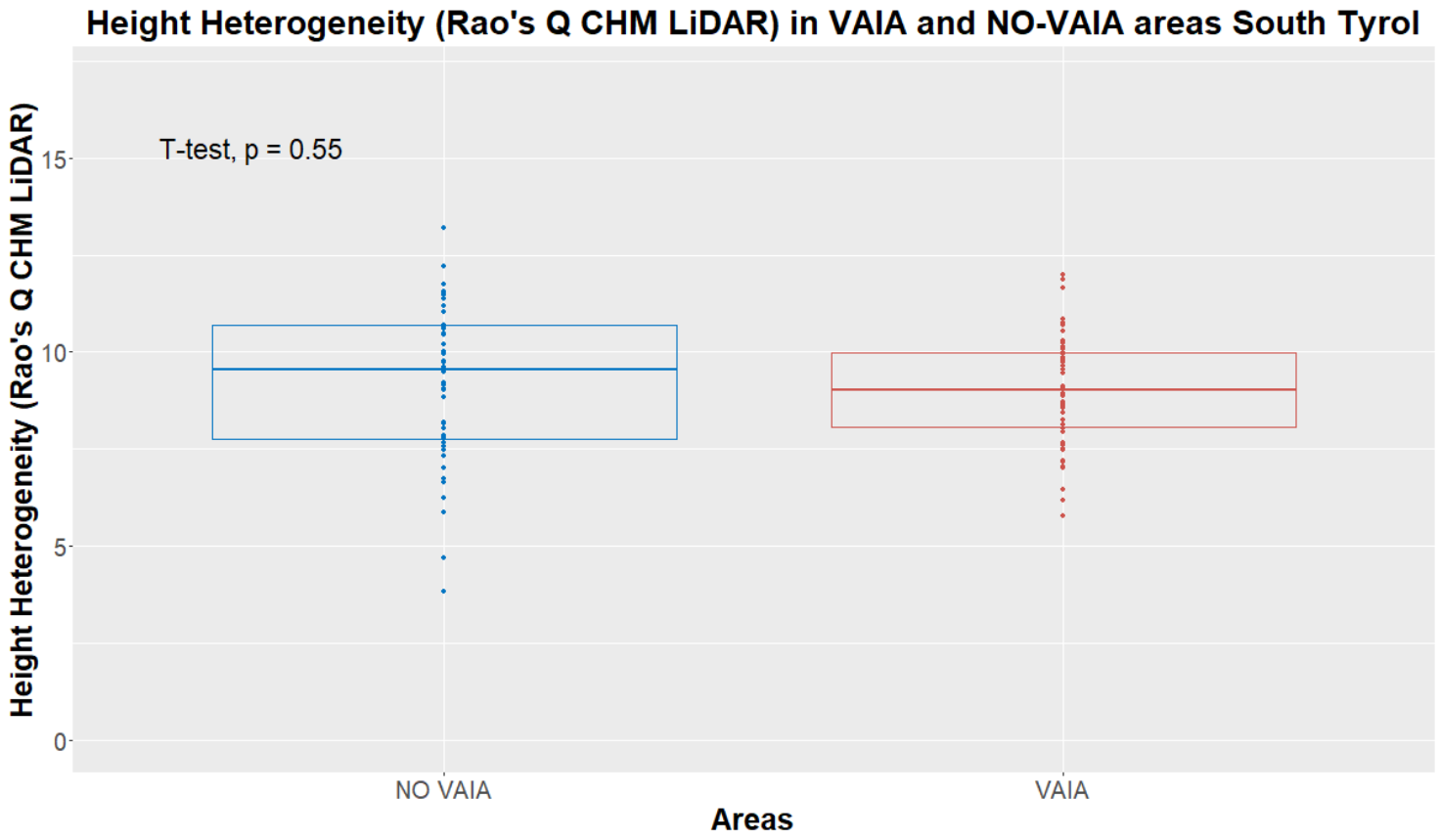
The Height Variation Hypothesis in Forest Ecosystems: Applications (the VAIA windstorm)



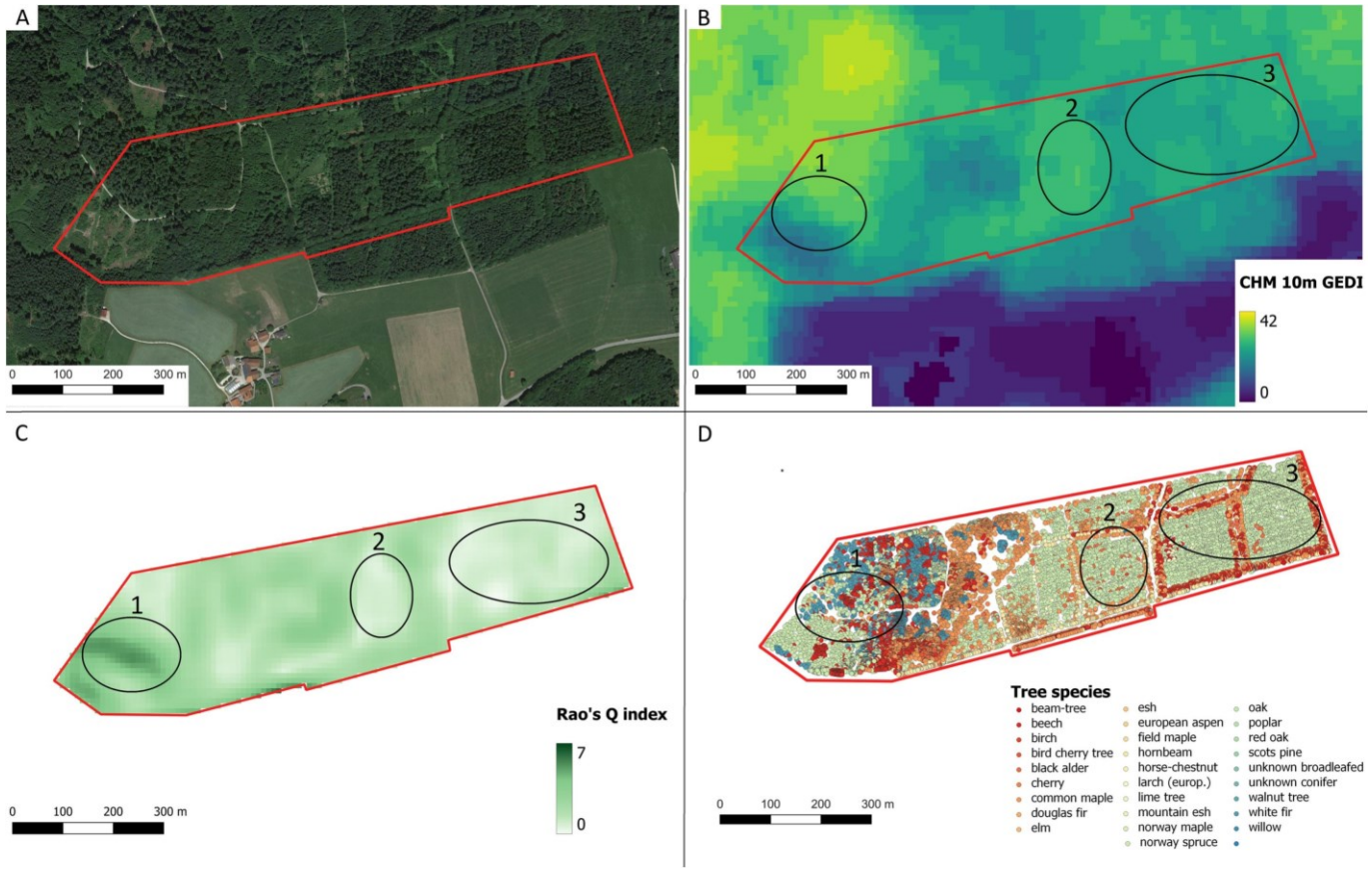
No VAIA

VAIA

The Height Variation Hypothesis in Forest Ecosystems: Applications (the VAIA windstorm)



The Height Variation Hypothesis in Forest Ecosystems: From Air-borne to Space-borne LiDAR



The 2030 EU biodiversity strategy

EU's biodiversity strategy for 2030 is a comprehensive and ambitious plan.

The strategy aims to protect nature and reverse ecosystem degradation.

The goal is to achieve biodiversity recovery in Europe by 2030.

The strategy includes specific actions and commitments.

Cost of inaction

Economic and social costs of inaction

Biodiversity loss and ecosystem collapse is one of the biggest threats facing humanity in the next decade. **Economic and social costs of inaction** would be huge. The world already lost an estimated €3.5-18.5 trillion per year in ecosystem services from 1997 to 2011, and an estimated €5.5-10.5 trillion per year from land degradation. Biodiversity underpins EU and global food security. Biodiversity loss risks puts our food systems and nutrition at risk.

Biodiversity loss is intrinsically linked to and exacerbates climate change.