



**iDiv**

German Centre for Integrative  
Biodiversity Research (iDiv)  
Halle-Jena-Leipzig

yDiv course

## **Mechanistic spatially-explicit eco-evolutionary biodiversity modelling - Syllabus -**

Lecturers: [Dr Oskar Hagen \(iDiv\)](#), [Dr Benjamin Rosenbaum \(iDiv\)](#),  
[Dr Alexander Skeels \(ETH Zurich\)](#)

Guest lecturer: [Prof. Florian Hartig](#), Head of the Group for Theoretical Ecology  
Faculty of Biology and Pre-Clinical Medicine, University of Regensburg

Website Oskar Hagen: <https://www.hagen.bio>

Target group: Doctoral researchers and Postdocs familiar with the gen3sis  
R-package or with an existing pressing question (critical for advancing  
her/his research) that can be addressed with this tool.

Date: 14-18 November 2022, everyday from 9 am to 5 pm  
A voluntary excursion within Leipzig is planned for Wednesday,  
16 November (public holiday)

Place: iDiv Leipzig, Puschstr. 4, 04103 Leipzig, room Beehive  
At the front entry door, please ring "yDiv".

Contents: Pioneer naturalists such as Whewell, Lyell, Humboldt, Darwin and Wallace acknowledged the interactions between ecological and evolutionary forces, as well as the roles of continental movement, mountain formation and climate variations, in shaping biodiversity patterns. Studies show that linking these processes is necessary to reproduce multiple large-scale biodiversity patterns simultaneously. Recent developments in computer modelling and paleo-environmental reconstruction make it possible to study in silico how biodiversity emerges from eco-evolutionary and environmental dynamic processes and their interactions. This course aims to develop skills required to simulate emergent biodiversity using gen3sis engine, consequently enabling you to design experiments and analyze multiple interconnected hypotheses existing in a largely fragmented scientific landscape.

Didactic elements and aim: You will leave the course confident to create new landscapes and eco-evolutionary rules, conduct simulation experiments (full modeling cycle) and reflect about emergent patterns. Moreover, you will gain knowledge on how to apply and how not to apply such tools, as well as be familiar with its limitations and potentials. The interdisciplinary nature of this course and its participants list should open new scientific pathways and collaborations, facilitating the communication and contemplation of causal implications of complex eco-evolutionary and environmental interaction based on algorithmic formality.

The course will have two components, a seminar component covering an introductory natural philosophical contextualization, mechanistic models and talks by invited lecturers with practical exercises in R, and a "hands-on" component that involves using computer simulations to test hypotheses about how biodiversity is generated and maintained which will be designed by the course participants. We will use mostly simulated data and work on linking processes and patterns.

Prerequisites:

- Good programming, data-manipulation (e.g. list and raster) and data-visualization skills in R
- Read three papers and go through one tutorial:
  1. **Process-based theories** Pontarp et al. (2019) [The latitudinal diversity gradient: Novel understanding through mechanistic eco-evolutionary models](#). Trends in Ecology and Evolution
  2. **Methods paper** Hagen et al. (2021) [gen3sis: A general engine for eco-evolutionary simulations of the processes that shape Earth's biodiversity](#). PLoS biology
  3. **Read at least one applied publication**
    - a. Yannic et al. (2020) [Harnessing paleo-environmental modeling and genetic data to predict intraspecific genetic structure](#). Evolutionary Applications
    - b. Hagen & Skeels\* et al. (2021) [Earth history events shaped the evolution of uneven biodiversity across tropical moist forests](#). PNAS
  4. **Go over this introductory vignette:** <https://cran.r-project.org/web/packages/gen3sis/vignettes/introduction.html>

## Agenda:

<b>Date</b>	<b>Content</b>	<b>Lecturer</b>
<b>14 Nov</b>	Morning – Theory: <ul style="list-style-type: none"> <li>• Introductions, orientation, theory and background lecture. Mechanistic Eco-Evolutionary modelling</li> <li>• Overview and history of R-package gen3sis</li> </ul> Afternoon – Theory and Praxis: <ul style="list-style-type: none"> <li>• Hands on exercises (Familiarization with [Input/Output])</li> <li>• Modify landscapes and eco-evolutionary rules</li> <li>• Troubleshooting</li> </ul>	Oskar Hagen (OH)
<b>15 Nov</b>	Morning: <ul style="list-style-type: none"> <li>• Reflections, Targeted exercises or Troubleshooting (Praxis)</li> <li>• Biodiversity metrics. Measuring biodiversity in R. Summary statistics, short overview on biodiversity metrics and summary statistics (Theory)</li> <li>• Parameter sampling, hypothesis testing using machine learning parameters/patterns correlations (Theory)</li> <li>• Output automation, empirical data and output Comparison (Praxis)</li> </ul> Afternoon: <ul style="list-style-type: none"> <li>• Project definition and kick off with break out rooms</li> </ul>	OH  Benjamin Rosenbaum (BR) Alexander Skeels (AS)
<b>16 Nov</b>	Public holiday / sightseeing in Leipzig	
<b>17 Nov</b>	Morning: <ul style="list-style-type: none"> <li>• Project idealization presentation and discussion (Praxis)</li> </ul> Afternoon: <ul style="list-style-type: none"> <li>• Model-data comparisons and model calibration (Theory)</li> <li>• Hands on workshop with break out rooms</li> </ul>	OH  FH AS, BR, OH
<b>18 Nov</b>	Morning: <ul style="list-style-type: none"> <li>• Hands on workshop with break out rooms</li> </ul>	AS, BR, OH

	Afternoon: <ul style="list-style-type: none"> <li>• Challenges and perspectives and general conclusions (Theory)</li> <li>• Group presentations, discussion on follow up, possible future avenues and feedbacks regarding the course</li> </ul>	OH  Everyone
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Total attendance time: 8h/day

Further required working hours: 6h for reading

Expectations: Active participation and independent thinking is expected from participants. They should present the group's progress in flash talks to the rest of the group.

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