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Section 1: Introduction to the learning unit

Title		Species Distribution Modeling			
Duration		This learning unit should be taught in 20 hours			
Introduction		<p>The primary objective of this learning unit is to equip learners with the knowledge and skills necessary to understand and apply species distribution models. Learners will develop competencies in data handling, spatial analysis, and ecological modeling using open-source tools (R and QGIS). The unit emphasizes both the theoretical foundations of SDM and the practical ability to prepare, analyze, and interpret species occurrence and environmental data.</p> <p>Biodiversity conservation requires identifying where species are likely to occur under current and future environmental conditions. However, field data on species distributions are often incomplete or biased. Learners will be challenged with the task of predicting the potential distribution of a species within a defined study area using a combination of occurrence records and environmental variables.</p>			
Module	Topic	Learning outcome	Duration	Material	
Module01	Introduction to Species Distribution	<p><i>By the end of the learning unit, learners should be able to:</i></p> <p><i>Explain</i> the fundamental concepts, principles, and applications of species distribution modelling (SDM).</p>	4h	Youtube Tutorial	
Module02	Getting started with R and Qgis	<ul style="list-style-type: none"> Conduct an analysis using R software <p>Load raster and shape files in Qgis.</p>	8h	Laptop and Youtube Tutorial	
Module03	Modeling	<ul style="list-style-type: none"> Apply basic modelling techniques using R and QGIS to generate and visualize species distribution maps Interpret and critically evaluate environmental and species occurrence data relevant for building SDMs. Predict the distribution of a given species Display and Interpret the results <p>Use Qgis to refine the output from R</p>	8h	Laptop, R-Script, dataset and powerpoint file	
Readings, Key Literature		<p>For further understanding, the learners can read the following articles:</p> <p>Beever, E. A., Westover, M. L., Smith, A. B., Gerraty, F. D., Billman, P. D., & Smith, F. A. (2025). Combining past and contemporary species occurrences with</p>			

	<p>ordinal species distribution modeling to investigate responses to climate change. <i>Ecography</i>, 2025(2), e07382. https://doi.org/10.1111/ecog.07382</p> <p>Zhao, Y., Liu, J., Wang, Q., Huang, R., Nie, W., Yang, S., ... & Li, M. (2025). Occurrence Data Sources Matter for Species Distribution Modeling: A Case Study of <i>Quercus variabilis</i> Based on Biomod2. <i>Ecology and Evolution</i>, 15(5), e71390. https://doi.org/10.1002/ece3.71390</p> <p>Naqinezhad, A., & Babanezhad, H. (2024). Species Distribution Models in plant conservation science: a comprehensive review with a focus on Iran. <i>Natural History Sciences</i>. https://doi.org/10.4081/nhs.2024.788</p>
Learning Materials	<p>The mandatory materials for this learning unit include:</p> <ul style="list-style-type: none"> • Laptop • Dataset (occurence) • Image (link) • Open-source software (R and QGIS), • Script (link).
Engagement and Assessments	<p>To foster active participation and connect new knowledge with learners' prior experiences, the following engagement and assessment questions are designed to activate pre-knowledge and link course content to professional practice.</p> <p>Pre-knowledge activation</p> <ul style="list-style-type: none"> • What do you already know about how species are distributed in nature? • How do environmental factors (climate, land use, soil, etc.) influence the presence or absence of species in your local context? <p>Link to professional experience</p> <ul style="list-style-type: none"> • In your field (conservation, ecology, education, etc.), how might predicting species distributions be useful? • Have you ever used or observed data-driven decision-making in biodiversity or land management? How might SDM improve that process?
Metadata	<p>Authoring: DIALLO Birama, DOSSA Hubert, AVOCEVOU Romuald, LEVY Mejia & JENIFER Samwel.</p> <p>LearningResourceType: Interactive learning</p> <p>Description: A comprehensive learning unit to understand and apply Species Distribution modeling techniques for understanding the impact of climate change on species.</p> <p>Keyword(s): Species, predict, modeling, climate change</p> <p>Language: English</p> <p>License: Species Distribution modeling by DIALLO Birama (Mali), Dossa Hubert (Benin), AVOCEVOU Romuald (Bénin), LEVY Mejia & JENIFER Samwel. is licensed under CC BY- SA 4.0 Attribution-ShareAlike 4.0 International</p>

Section 2: Input

Module01: Introduction to Species Distribution modeling (4h)

This module introduces the fundamentals of species distribution modeling (SDM), including ecological niche theory, key concepts, and applications in biodiversity, conservation, and climate change research. Species distribution models (SDMs) are a popular tool in quantitative ecology and constitute the most widely used modelling framework in global change impact assessments for projecting potential future range shifts of species [video1](#).

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For further reading, read the linked article [link](#)

Module02: Getting started with R and Qgis (8h)

This module provides an introduction to R and QGIS ([tutorial2](#)), two open-access tools essential for data analysis, visualization, and spatial modeling.

Module03: Modeling (6h)

In this module, learners will use R to pre-process datasets obtained from both field surveys and online repositories, ensuring the data are clean, formatted, and ready for analysis. Additionally, the module introduces the most commonly used modeling approaches in species distribution research, with a focus on MaxEnt, Random Forest, and other related methods, [slide](#).

Species occurrence data will be obtained from online databases [Occurrence data](#), while present and future bioclimatic variables (under the RCP4.5 scenario) will be downloaded from the WorldClim database [bioclim](#).

- Data pre-processing
- Model implementation

For this purpose, we will apply MaxEnt, a widely used predictive modeling approach in species distribution studies. In addition, model evaluation metrics will be explained in detail to assess performance and reliability

- Mapping in Qgis

Since learners have already acquired basic knowledge of QGIS in Module 2, they will now apply these skills to load raster files generated in R into QGIS for further refinement.

- Visualization and Interpretation of the results

Please access the evaluation question:— [QUIZ](#)

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For further reading, read the linked articles [one](#) and [two](#)

Section 3: Application / Learning Activities / Tasks

This section is devoted to the practical implementation of species distribution models, allowing learners to apply the concepts introduced in previous sessions, [script](#) and other resources are available for that purpose.

GeoTraining

Learners will be asked to select a species of their choice and use R to predict its current and future distribution. The results will be saved as raster files, imported into QGIS, and interpreted to draw meaningful conclusions.

Section 4: Assessment and Wrap up

To ensure learners actively process new knowledge and skills in SDM by connecting them with prior knowledge, professional practice, and future applications.

Engagement through Reflection Questions;

Learning experience

- After running your first SDM, what surprised you about the outputs?
- How did the model results align or conflict with your expectations of where species should be found?

Action-oriented reflection

- How could SDM tools be applied to solve real-world issues in your context (e.g., habitat conservation, climate change adaptation, invasive species management)?

Assessment Activities

- **Formative (during learning);** Think–Pair–Share: Learners discuss how one key environmental variable (e.g., rainfall) might affect the distribution of a chosen species. After a practical exercise (R & QGIS), students write two things they learned and one question they still have.
- **Summative (end of learning resource);** Case study analysis: Given a dataset and scenario (e.g., climate change impacts on bird species in Osnabruck), learners reflect on: The process of building the model, the interpretation of results & the implications for biodiversity management.

Section 5: Appendix

Materials

Beever, E. A., Westover, M. L., Smith, A. B., Gerraty, F. D., Billman, P. D., & Smith, F. A. (2025). Combining past and contemporary species occurrences with ordinal species distribution modeling to investigate responses to climate change. *Ecography*, 2025(2), e07382.

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<https://doi.org/10.1002/ece3.71390>

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