M8 – Maps of species potential distributions under current and future conditions

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Summary

Milestone M8 – “*Maps of species potential distributions under current and future conditions”*, documents the development and application of a reproducible modelling framework to generate spatially explicit projections of potential habitat suitability for invasive alien species (IAS) across Europe. Building on the aims of Work Package 5 (prioritisation, prediction, horizon scanning and early warning), Task 5.1 aims to deliver high-resolution (~1 km) distribution maps for a rigorously selected set of 120 terrestrial IAS under a historical baseline (≈1971–2024) and two future periods (2041–2070, 2071–2100) under three SSP/RCP socio-climatic pathways (SSP1–2.6, SSP3–7.0, SSP5–8.5). These maps are intended to support EU and national IAS risk assessment and management under climate and land-use change scenarios. The modelled species pool comprises 70 terrestrial taxa recognised as species of Union concern or candidates under EU Regulation 1143/2014, complemented by 50 additional species selected by OneSTOP’s five Living Labs as nationally or regionally important IAS. Species occurrence data were retrieved from GBIF through the wiSDM workflow, with standardised procedures for taxonomic cleaning, coordinate validation, and bias mitigation.

Environmental predictors combine CHELSA v2.1 climate data with land-cover projections from Chen et al. (2022), which provide 1-km global Plant Functional Type (PFT) datasets aligned with CMIP6 SSP/RCP scenarios. PFT classes are reclassified into a reduced set of ecologically meaningful categorical land-cover types, ensuring thematic relevance while keeping model complexity tractable. Together, these predictors provide a consistent, scenario-aligned representation of climate and land cover from which IAS potential suitability can be estimated.

The modelling pipeline is built on an adapted fork of the wiSDM framework, extended in OneSTOP for climate and land-cover integration, multi-GCM ensemble handling, and large multispecies workflows (among other specific features). After filtering/discarding highly correlated predictors, models are fitted using a multi-algorithm ensemble. Ten-fold cross-validation with centred and scaled predictors is used to estimate performance, and variable importance is quantified. Continuous suitability predictions are thresholded to binary outputs by maximising both sensitivity and specificity. Overall, models show high predictive average performance (AUC ≈ 0.97; Sensitivity ≈ 0.91; Specificity ≈ 0.91).

The principal products of Milestone M8 are habitat suitability maps for 120 selected IAS across seven temporal–scenario combinations available in an interactive online SDM Map Gallery (https://onestop-cibio.github.io/OneSTOP_SDM_Map_Gallery) that provides pre-rendered per-species maps by period and scenario. The SDM gallery offers a policy-relevant, user-friendly interface for exploring species potential distributions under current and future conditions, supporting EU-level reporting as well as national and regional management and monitoring. In summary, Milestone M8 delivers a robust and transparent IAS distribution modelling framework, aligned with FAIR and open-science principles, and tailored to OneSTOP's specific requirements. The OneSTOP wiSDM fork underpins the current mapping effort in T5.1, supports the maturation of the wiSDM framework, and fosters methodological comparability with related initiatives, such as GuardIAS. The outputs reported here form the spatial foundation for subsequent tasks T5.4 and T5.5), enabling the derivation of indicators of range shift, expansion risk, and emerging environmental suitability under climate and land-use change, and represent a significant step toward an integrated, science-grounded decision-support system for IAS management in Europe.

List of abbreviations

CMIP	Coupled Model Intercomparison Project
EU	European Union
FAIR	Findable, Accessible, Interoperable, and Reusable
GADM	Database of Global Administrative Areas
GBIF	Global Biodiversity Information Facility
GCM	Global Circulation Model
IAS	Invasive Alien Species
PFT	Plant Functional Traits
RCP	Representative Concentration Pathway
SDM	Species Distribution Models
SSP	Shared Socioeconomic Pathway
WGS	World Geodetic System
WP	Work Package

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1. Context / Introduction

Invasive Alien Species (IAS) are among the foremost threats to biodiversity, ecosystem integrity, and socio-economic wellbeing in Europe. Their capacity to establish and spread is influenced, among other factors, by environmental conditions, including climate, land cover/use, habitat connectivity, and is further modulated by global change and anthropogenic pathways. Effective IAS management requires robust spatial tools that predict where species could occur under current and future conditions, thus guiding prevention, early detection, and rapid response.

The OneSTOP project aims to transform IAS management by integrating technologies, data flows, and decision-support systems across Europe. As stated in Groom et al. (2025), OneSTOP aims to minimise the introduction, establishment, and spread of IAS via an interoperable suite of tools that includes predictive distribution modelling of species under current and future environmental scenarios.

Within this framework and goal, Work Package 5 (WP5) is tasked with prioritisation, prediction, horizon scanning, early warning, including also modelling and scenario analysis of IAS risk. More specifically, Task 5.1 focuses on generating spatially explicit maps depicting potential suitable distribution for a broad suite of IAS under baseline and future conditions. Milestone M8, titled “Maps of species potential distributions under current and future conditions”, represents a key checkpoint of Task 5.1 progress, encompassing the production of high-resolution distribution maps across Europe for a priority list of IAS of Union concern plus 50 species (not listed in the EU priority list) selected by OneSTOP’s Living Labs, under historical conditions (1971–2024) and for two future periods (2041–2070; 2071–2100) under three socio-climatic pathways (SSP1–2.6, SSP3–7.0, SSP5–8.5).

To develop these outputs, the modelling workflow relies on an adapted version of the wiSDM framework (Davis et al., 2024), tailored for reproducibility, open science, and the integration of both climatic and land-cover projections. Using ~1 km-resolution predictors from CHELSA v2.1 climate data (Karger et al., 2017, 2021) and recently developed land-cover projections from Chen et al. (2022), the ensemble modelling pipeline estimates environmental suitability for each species across multiple future scenarios. While the resulting maps provide a valuable resource for strategic IAS management, it is critical to emphasise their role as potential distribution outputs, rather than predictions of realised present or future occurrence or colonisation. In addition, uncertainties in these estimates arise from several factors, including biases or gaps in occurrence data, model assumptions (including niche conservatism), algorithmic variation, and the absence of dispersal, biotic interactions, or management layers. As such, considering these uncertainties is fundamental for appropriate interpretation and usage.

The maps provided at this stage in Milestone M8 serve as spatially explicit projections of baseline and future potential suitability that will feed subsequent indicator development, prioritisation tools, horizon scanning, and decision-support workflows in OneSTOP. Milestone M8 aims to establish a robust spatial modelling foundation for WP5’s downstream work, including quantifying range shifts, identifying hotspots of emerging suitability and/or invasion risk, ranking species by expansion risk, and coupling with management-oriented indicators. It also reflects the OneSTOP project’s commitment to deliver FAIR, transparent, and scientifically valid outputs that align with EU-level IAS policy and management imperatives.

2. Data and methods

2.1. Selected species

In Task 5.1, a comprehensive species selection process was undertaken to identify the taxa to be modelled within the OneSTOP T5.1 framework (see the complete list in Annex 7.1). The initial component of this selection focused on Invasive Alien Species of Union concern, as defined by EU Regulation 1143/2014, complemented by candidate species under consideration for future listing. This priority set yielded 70 terrestrial taxa, spanning a wide range of ecological strategies, pathways of introduction, and invasion histories relevant to European risk assessment. Species were classified as terrestrial based on their ecological traits and habitat associations, ensuring they occur and establish primarily in land-based environments. These criteria were discussed and fine-tuned among the project team and in communication with GuardIAS (https://guardias.eu) team members, who are also responsible for species assessments and modelling of aquatic species in our sister project.

To expand the relevance of modelling outputs to local management needs and stakeholder priorities, an additional 50 species were identified through the project's five Living Labs (Belgium, Finland, Portugal, Romania, and the United Kingdom), with each Living Lab nominating 10 species of highest national or regional concern. These jointly constitute the 120 OneSTOP species pool modelled in Task 5.1, ensuring representation of both EU-level priorities and geographically specific threats, and providing a robust foundation for producing spatially explicit, scenario-based assessments of potential distributions under current and future environmental conditions.

2.2. Study area/modelling region

The spatial extent used for species distribution modelling within Task 5.1 corresponds to the set of countries belonging to the Council of Europe, supplemented by Belarus, Kosovo, and Vatican City to ensure complete coverage of the European region relevant to OneSTOP's IAS policy and management contributions.

This definition provides a consistent geographic frame aligned with the project's European focus. National boundaries were extracted from GADM v4.1 (Global Administrative Areas dataset), using the level-0 (country) polygons as the reference administrative units. The countries of interest were explicitly listed and verified against the GADM dataset to ensure complete correspondence, after which only the selected polygons were retained. The resulting country set was reprojected to the coordinate system of the environmental rasters (i.e., WGS 1984/Lambert Cylindrical Equal Area) and buffered by 100 km to create a modelling envelope that avoids edge effects during projection. All boundary preparation steps follow the reproducible workflow implemented in R, culminating in the export of the selected countries as GeoPackage layers for integration into the Species Distribution Modelling (SDM) pipeline.

2.3. Species occurrence data

Occurrence records were retrieved from the Global Biodiversity Information Facility (GBIF) using automated download procedures integrated into the wiSDM workflow (GBIF.org, retrieved at 24/07/2025; DOI: 10.15468/dl.8gz9ut; and 31/10/2025; DOI: 10.15468/dl.25phrt). The pipeline includes standardised steps for taxonomic name resolution, coordinate validation, removal of georeferencing errors, and mitigation of sampling biases. A taxonomic occurrence grid (bias grid), summarising sampling effort across related taxa, was used to guide background and pseudo-absence generation.

2.4. Environmental predictors

Climate predictors

Climatic variables were obtained from CHELSA v2.1 (URL: https://www.chelsa-climate.org/datasets; access date: June 2025), including a suite of bioclimatic variables characterising temperature and precipitation regimes. Beyond the standard bioclimatic predictors, the modelling workflow also incorporated a suite of BIOCLIM+ variables from CHELSA, including growing-season length, growing-season precipitation, growing-season mean temperature, growing-degree days above 0 °C, 5 °C and 10 °C, and net primary productivity, providing a richer representation of climatic conditions relevant to species' ecological requirements.

For future projections, CHELSA v2.1 provides CMIP6-derived scenarios for two future periods (2041–2070, 2071–2100) across three SSP/RCP pathways (SSP1–2.6, SSP3–7.0, SSP5–8.5). To ensure scenario consistency with land-cover datasets, projections from five CMIP6 Global Circulation Models, including GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0, were averaged to produce a single ensemble climate surface per scenario.

Land-cover predictors

Land-cover data used in T5.1 model development were derived from the global high-resolution 1-km Plant Functional Type (PFT) projections of Chen *et al.* (2022), which provide harmonised historical and future land-cover projections under socio-climatic scenarios matched to the SSP/RCP framework. The dataset offers global 1-km land-cover projections from 2015 to 2100, subdivided into 20 Plant Functional Types (PFTs), and was selected for T5.1 development because it meets all required criteria in terms of spatial resolution, thematic detail, accuracy (OA = 0.929; Kappa = 0.864; FoM = 0.102), and alignment with CMIP6 SSP-RCP scenarios.

This dataset combines top-down land-use demands from the Land-Use Harmonization 2 (LUH2) dataset with bottom-up spatial simulations based on the Future Land Use Simulation (FLUS) model, a cellular-automata and machine-learning hybrid widely used in global land-change studies (Figure 1). FLUS estimates land-type suitability using artificial neural networks informed by a suite of socioeconomic drivers (GDP, population density, proximity to urban centres, road networks) and environmental drivers (temperature, precipitation, topography, soil quality), and then allocates land cover types competitively through probabilistic CA dynamics. The resulting land-cover projections are entirely consistent with CMIP6 Tier-1 and Tier-2 SSP-RCP scenario trajectories and capture spatially explicit transitions at a resolution suitable for ecological modelling, thereby substantially improving upon coarser LUH2 products. These characteristics make the Chen *et al.* (2022) dataset particularly well-suited for integration into SDMs, enabling OneSTOP to incorporate scenario-consistent, ~1km resolution fine-scale land-cover change at the global level alongside climate projections in assessments of invasive species' potential distributions.

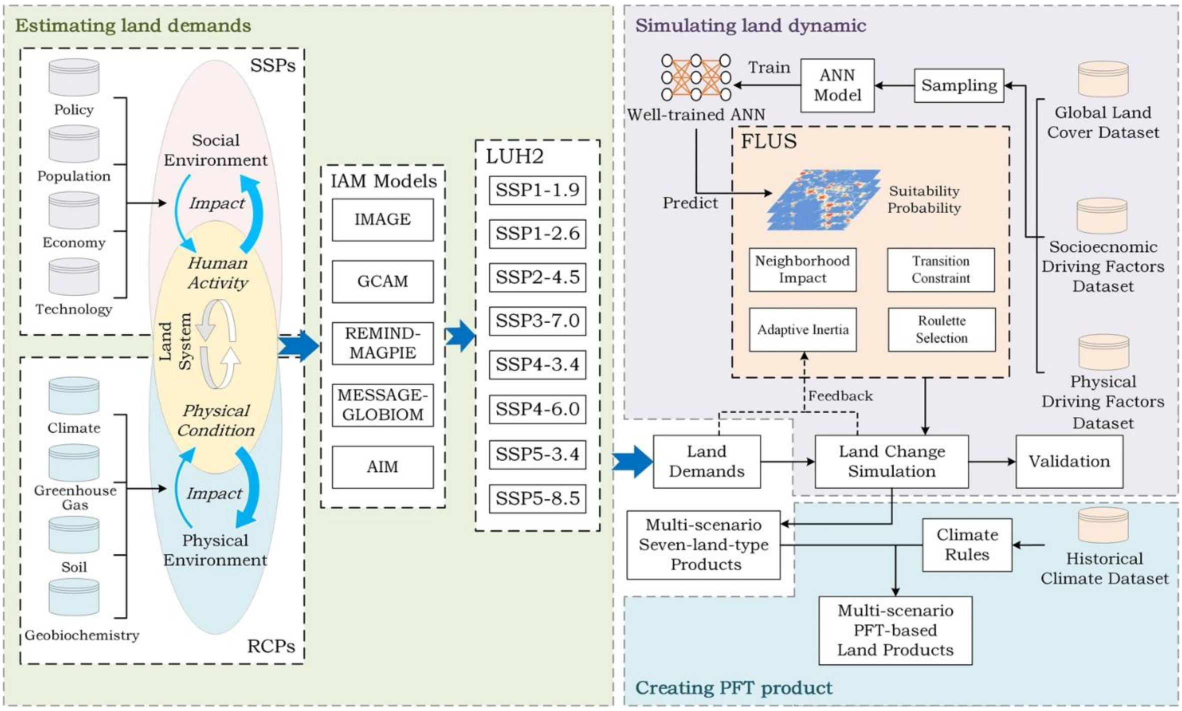

Figure 1 – Process used to generate future global land-cover datasets at 1-km resolution under SSP-RCP scenario conditions (original image from Chen et al. 2022; https://www.nature.com/articles/s41597-022-01208-6.

To integrate land cover information from Chen *et al.* (2022) into the modelling workflow, the original dataset's detailed Plant Functional Type classes were simplified via reclassification. The native scheme, while ecologically detailed, included numerous subclasses (e.g., C3/C4 grasslands, macro-climatic forest types) that would unnecessarily increase model complexity and computational demand. To streamline model development and ensure compatibility across historical and scenario-based projections, a harmonised categorical scheme was developed by aggregating related PFT classes into a reduced set of broad land-cover categories (e.g., forests, shrublands, grasslands, croplands, urban). This reclassification (Table 1) preserved the ecological categories potentially relevant to IAS establishment while enabling stable and reproducible inclusion of land-cover predictors in the wiSDM-based modelling pipeline.

Table 1 – Proposed reclassification scheme of the original PFT/ land cover classes of Chen et al. (2022).

Original code	Original class	New code	New class
1	Water	1	Water
2	Broadleaf evergreen tree, tropical	2	Broadleaf evergreen forest
3	Broadleaf evergreen tree, temperate		
4	Broadleaf deciduous tree, tropical	3	Broadleaf deciduous forest
5	Broadleaf deciduous tree, temperate		
6	Broadleaf deciduous tree, boreal		
7	Needleleaf evergreen tree, temperate	4	Needleleaf evergreen forest
8	Needleleaf evergreen tree, boreal		
9	Needleleaf deciduous tree	5	Needleleaf deciduous forest
10	Broadleaf evergreen shrub, temperate	6	Broadleaf evergreen shrubland
11	Broadleaf deciduous shrub, temperate	7	Broadleaf deciduous shrubland
12	Broadleaf deciduous shrub, boreal		
13	C3 grass, arctic	8	Grasslands
14	C3 grass		
15	C4 grass		
16	Mixed C3/C4 grass		
17	Barren	9	Barren
18	Cropland	10	Cropland
19	Urban	11	Urban
20	Permanent snow and ice	12	Permanent snow and ice

2.5. The wiSDM Modelling Framework

The modelling pipeline employed in Task T5.1 is based on an adaptation of the wiSDM ("Workflow for Invasive Species Distribution Modelling") framework (
Figure 2) published by Davis et al. (2024), and developed under the TrIAS project (Belgium) to enable fully reproducible, open, and standardised SDM workflows (URL: https://github.com/trias-project/risk-modelling-and-mapping). Core features of wiSDM include:

- Standardised environmental data preparation (automated download, organisation, and harmonisation);
- Global occurrence download directly from GBIF (requiring GBIF credentials);

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- Automated pseudo-absence generation, constrained to the same ecoregions as presences, areas of low suitability predicted by an initial global model, and areas with sufficient sampling effort based on the taxonomic occurrence grid;

- Multi-algorithm ensemble modelling, combining several statistical and machine-learning methods into a meta-model, which acknowledges that algorithm choice strongly influences SDM outputs;

- Removal of highly correlated predictors to minimise multicollinearity;

- Assessment of spatial autocorrelation in residuals, with diagnostics prompting thinning when necessary;

- Scenario-based projections and confidence maps at 1-km resolution.

The original wiSDM workflow includes the following sequence:

- Prepare files and folders, download environmental data;

- Download global occurrences for each species;

- Fit a global climate-only model;

- Fit a regional (European) model based on climate and land use continuous predictors;

- Produce European or country-level projections under multiple climate scenarios.

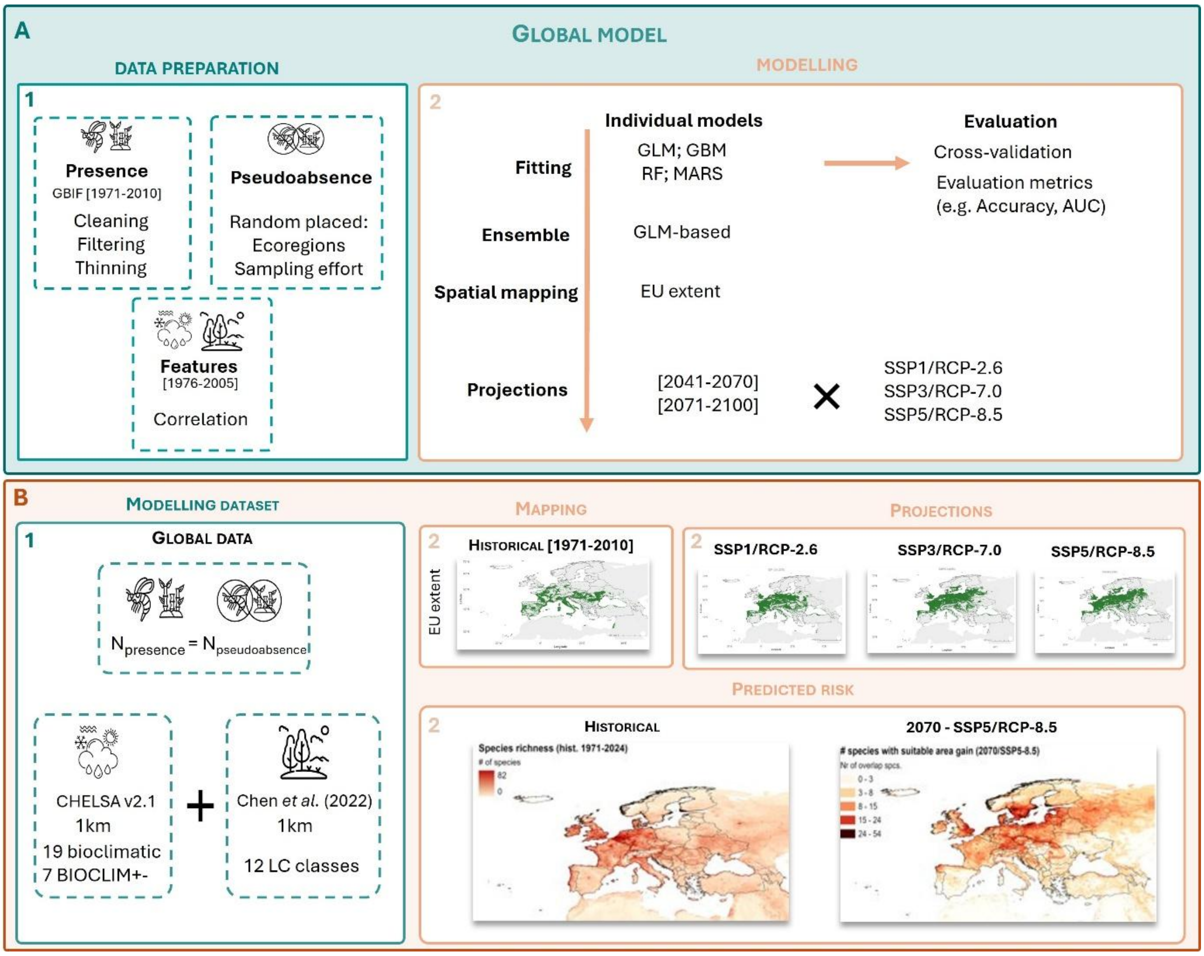

Figure 2 – The modelling/analysis steps in the OneSTOP adapted wiSDM workflow.

2.6. Adaptations of the wiSDM framework for the OneSTOP Project

For OneSTOP, the wiSDM workflow was substantially extended and adapted, as documented in progress updates and project meetings used to discuss these alterations. The main modifications/enhancements include:

- Addition of scripts for data downloading and pre-processing for climate and land cover layers, ensuring scenario alignment and ensemble climate preparation;
- Addition of scripts for climate and land cover data uploading in Zenodo (see Annex 7.2 for the detailed list of datasets uploaded);
- Joint integration of climate and categorical land-cover variables (from Chen *et al.* 2022) directly into SDMs for historical and future conditions, including a consistent scenario structure: historical, 2041–2070, 2071–2100 for scenarios: SSP1–2.6, SSP3–7.0, SSP5–8.5;

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- Use of averaged multi-GCM ensembles to ensure compatibility with land-cover projections;

- Harmonised handling of climate and land-cover projections across time periods and scenarios (multiple projection stacks are built prior to the prediction step);

- Reprojection of all climate layers to match land-cover CRS while preserving numerical integrity (reproject continuous, not categorical data);

- Automated species-list downloading from a dedicated repository at: https://github.com/OneSTOP-CIBIO/Data, which is then used to scrape/search data from GBIF;

- Revised modelling strategy with the OneSTOP fork, employing a global modelling for each species rather than two-stage, global-then-European modelling. This modelling option is intended to maximise niche coverage, avoid niche truncation (at the european level) and reduce non-analogous environmental extrapolation;

- Improved pseudo-absence and bias handling;

- Updated pseudo-absence placement rules and parameterisation;

- Enhanced bias-grid usage and reprojection;

- Map exportation routines were implemented to produce binary suitability maps for all species and scenarios at ~1 km resolution, with the outputs feeding an interactive visualisation SDM map gallery (in GitHub Pages: https://onestop-cibio.github.io/OneSTOP_SDM_Map_Gallery);

- Implementation of simple routines to detect previously completed model runs and automatically skip or resume workflows, thereby preventing unnecessary repetition and enabling recovery from errors or partial failures;

- Generation of potential species richness and categorised dynamics (i.e., range gain, loss, stable) maps by period/scenario.

It is relevant to note that a dedicated fork of the wiSDM framework is in alignment with OneSTOP requirements of specific functionalities, such as integrating climate and categorical land-cover data, harmonising multi-GCM climate ensembles, automating large multispecies workflows with a predefined species list that can be independently updated, and producing spatial projections for future climate and land cover scenarios currently available from CMIP-6. This fork structure is intended to extend beyond the core wiSDM system's general, flexible architecture. Thereby, maintaining the OneSTOP fork ensures that these project-specific components can be implemented, tested, and updated without compromising or constraining the upstream and more general wiSDM framework.

2.7. Model fitting and thresholding

Models were trained using an ensemble framework implemented within the OneSTOP-adapted wiSDM workflow. Prior to model fitting, a correlation matrix of all climatic and land-cover predictors was computed, and only predictors with absolute correlations below 0.7 were kept.

The modelling step employed a multi-algorithm ensemble built with the *caret* and *caretEnsemble* R packages, using 10-fold cross-validation and standardised predictors (centred and scaled). Four complementary algorithms: (i) GLM – Generalised Linear Models, (ii) GBM – Gradient Boosting Machines, (iii) RF – Random Forests, and (iv) MARS – Multivariate Adaptive Regression Splines were trained on the same occurrence/environment dataset, allowing both linear and complex non-linear responses to be captured while reducing reliance on any single method.

Model outputs were generated as continuous suitability surfaces and subsequently converted to binary maps using thresholds that jointly maximise sensitivity and specificity, ensuring consistent and comparable suitability classifications across species and scenarios.

Variable importance was calculated using the caret package “varImp” function, which provides model-specific measures of each predictor’s contribution to the fitted ensemble. For each algorithm in the ensemble (i.e., glm, gbm, rf, earth), “varImp” extracts relevant importance statistics, such as coefficient magnitudes, split-based importance, boosting contributions, and reductions in cross-validation error, and scales them into a unified importance profile for each species.

2.8. Projection scenarios

Species models trained on historical conditions were projected onto:

- Historical baseline (≈1971–2024) based on CHELSA bioclimatic+ layers
- Future 2041–2070: SSP1–2.6, SSP3–7.0, SSP5–8.5
- Future 2071–2100: SSP1–2.6, SSP3–7.0, SSP5–8.5

Projections were produced at ~1 km resolution for the European extent adopted by OneSTOP. The final outputs include binary suitability maps for all species across seven temporal/scenario combinations. These maps represent potential suitability driven by environmental conditions (climate and land cover) and do not account for biotic processes or management interventions.

3. Results

All model outputs generated under Task 5.1 are made accessible through an interactive online Map Gallery (URL: https://onestop-cibio.github.io/OneSTOP_SDM_Map_Gallery; Figures

Figure 3 and Figure 4), which provides a centralised way for visualising the potential distributions of each modelled species across historical and future environmental scenarios. The gallery allows users to explore pre-rendered images of binary suitability maps at ~1 km resolution, compare projections across time periods and SSP/RCP pathways, and navigate among species using an intuitive/user-friendly interface. By consolidating all SDM outputs in a publicly accessible platform, the map gallery enhances the usability of the modelling results for researchers, policymakers, and stakeholders, while supporting reproducibility and broader dissemination of OneSTOP project outcomes.

The Python code used to produce the gallery is available at: https://github.com/OneSTOP-CIBIO/OneSTOP_SDM_Map_Gallery, along with a readme that describes the modelling inputs, processes, and outputs.

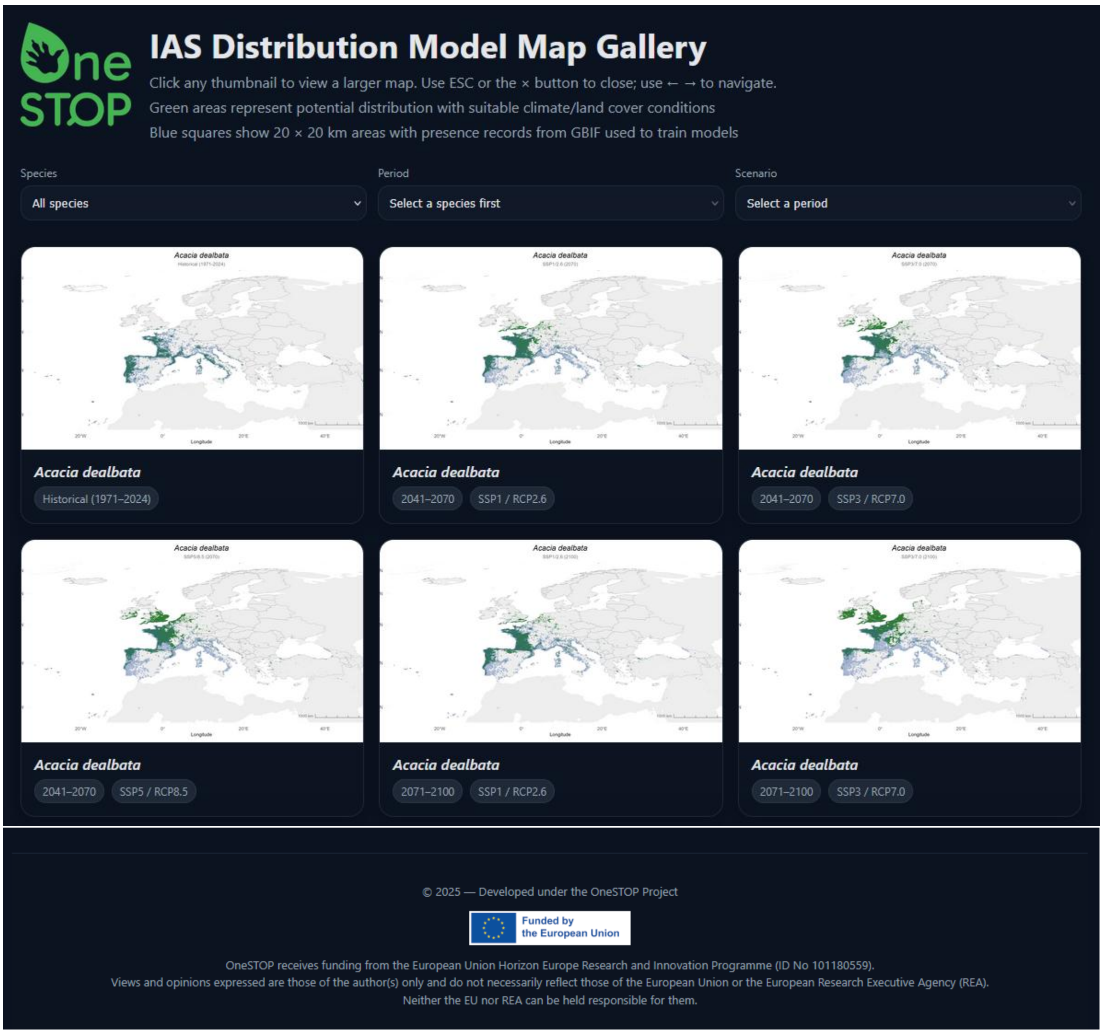

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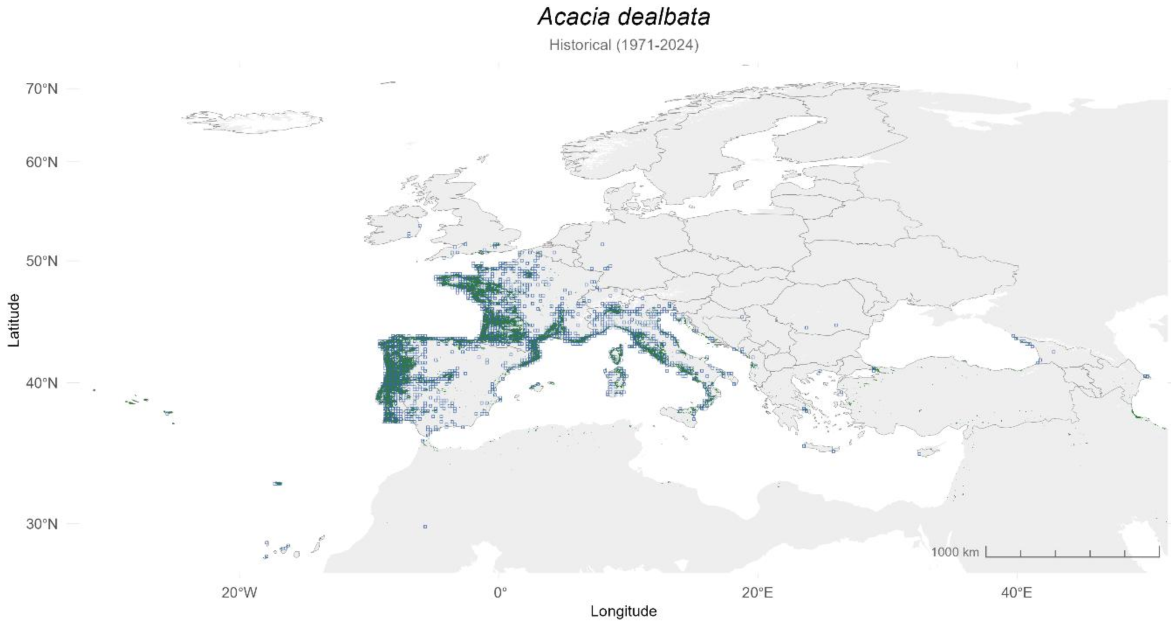
Figure 3 – SDM map gallery containing pre-rendered maps by species, period, and scenario for the OneSTOP selected taxa.

Overall, modelling results (Figure 5) for 10-fold cross-validation showed high mean predictive performance (n=118), with an Area Under the Receiver Operating Characteristic (AUC) of 0.97 ± 0.02, Sensitivity of 0.91 ± 0.03, and Specificity of 0.91 ± 0.03.



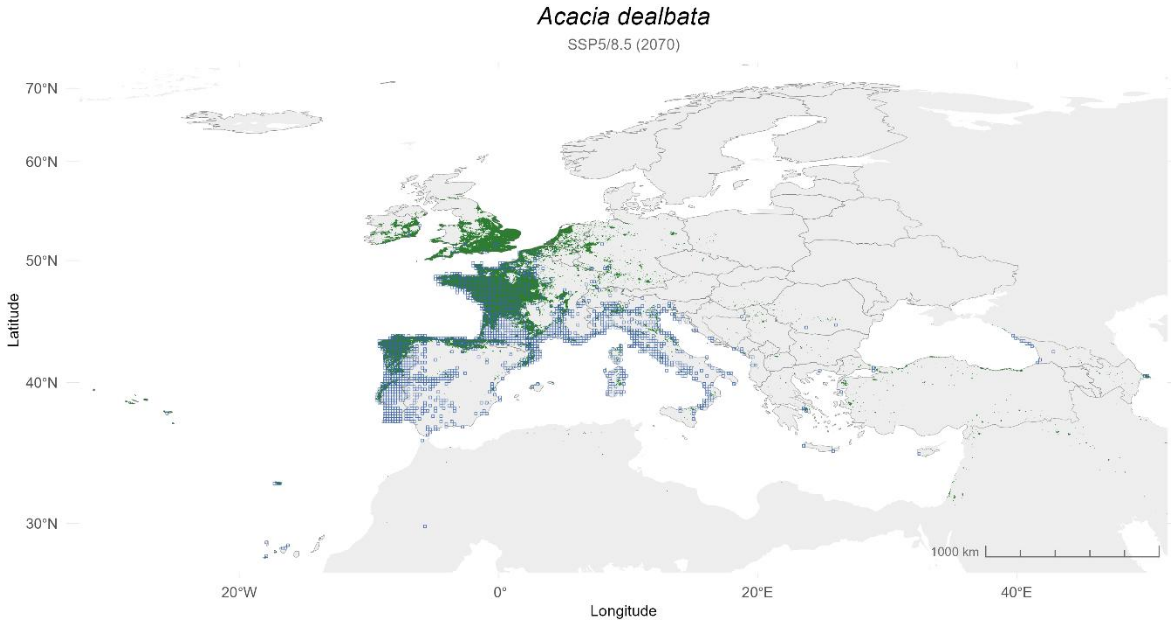


Figure 4 – Example of SDM-based distribution map available in the map gallery for Acacia dealbata under two scenarios: historical (1971-2024) and future (2070/SSP5-8.5). Note the latitudinal N-NE expansion of this species in Europe.

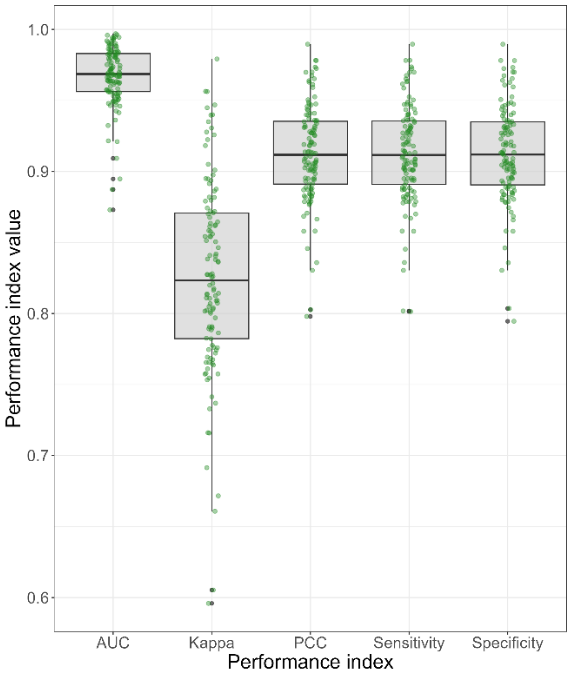


Figure 5 – Model performance distribution. Each dot represents a species (n=118). Performance indices are: AUC (Area Under the ROC); Kappa (Cohen's Kappa); PCC (Percent Correct Classification); and Sensitivity and Specificity.

4. Final remarks

The work completed under Task 5.1 has successfully delivered a robust, transparent, and fully operational modelling framework that fulfils the objectives of Milestone M8 and advances the broader aims of Work Package 5. By extending and adapting the wiSDM workflow, we now incorporate SSP/RCP scenario-aligned climate and land-cover model training and spatiotemporal projections, multi-GCM ensemble handling, and an automated multispecies pipeline (among other requirements specific to OneSTOP). These contributions not only enhance reproducibility but also strengthen the necessary computational basis for developing wiSDM as an R package. These developments also enable methodological harmonisation and comparability between OneSTOP and related initiatives, such as GuardIAS, reinforcing coherence across European IAS modelling efforts and projects within the scope of the EU's Horizon Europe Research and Innovation Programme.

The SDM Map Gallery, which constitutes a key output of the efforts under Task 5.1, provides an accessible, policy-relevant platform for visualising potential species distributions across current and future conditions. Its relevance spans institutional scales, from informing EU- and international-level reporting to supporting national and regional management, monitoring, and education. The gallery will be progressively expanded to include continuous suitability maps, dynamics of range change under each SSP/RCP scenario, and indicators of potential extrapolation and uncertainty, thereby enhancing its interpretative depth and value for decision-making. Collectively, the outputs generated herein establish the modelling and data infrastructure required for Tasks 5.4 and 5.5, enabling the calculation of meaningful indicators related to risk, expansion potential, and emergent threats under climate and land-use change. This milestone, therefore, represents a significant step toward delivering a coherent, FAIR, and science-grounded decision-support system for invasive alien species across Europe.

5. Acknowledgements

Special thanks to all OneSTOP team members for their contributions to the discussions and the revision of this work and document.

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Views and opinions expressed are those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency (REA). Neither the EU nor REA can be held responsible for them.

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7. Annex

7.1. Complete list of selected species

Scientific name	Living Lab country
Acacia mearnsii De Wild.	
Acacia saligna (Labill.) H.L.Wendl.	
Acridotheres cristatellus (Linnaeus, 1758)	
Acridotheres tristis Linnaeus, 1766	
Ailanthus altissima (Mill.) Swingle	
Alopochen aegyptiacus Linnaeus, 1766	
Andropogon virginicus L.	
Arthurdendyus triangulatus (Dendy, 1894) Jones & Gerard (1999)	
Asclepias syriaca L.	
Axis axis (Erxleben, 1777)	
Baccharis halimifolia L.	
Bipalium kewense Moseley, 1868	
Broussonetia papyrifera (L.) L'Hér ex Vent.	
Callosciurus erythraeus Pallas, 1779	
Callosciurus finlaysonii (Horsfield, 1823)	
Cardiospermum grandiflorum Sw.	
Castor canadensis Kuhl, 1820	
Celastrus orbiculatus Thunb.	
Cenchrus setaceus (Forssk.) Morrone	
Cervus nippon Temminck, 1838	
Cortaderia jubata (Lemoine ex Carrière) Stapf	
Corvus splendens Viellot, 1817	
Delairea odorata Lem.	
Ehrharta calycina Sm.	
Gunnera tinctoria (Molina) Mirbel	
Hakea sericea Schrad. & J.C.Wendl.	
Heracleum mantegazzianum Sommier & Levier	
Heracleum persicum Fischer	
Heracleum sosnowskyi Mandenova	
Herpestes javanicus (É.Geoffroy Saint-Hilaire, 1818)	
Humulus scandens (Lour.) Merr.	
Impatiens glandulifera Royle	
Koenigia polystachya (Wall. ex Meisn.) T.M.Schust. & Reveal	
Lampropeltis getula (Linnaeus, 1766)	
Lespedeza cuneata (Dum.Cours.) G.Don	
Lygodium japonicum (Thunb.) Sw.	

Lysichiton americanus Hultén and St. John	
Microstegium vimineum (Trin.) A. Camus	
Muntiacus reevesi Ogilby, 1839	
Myocastor coypus Molina, 1782	
Nasua nasua Linnaeus, 1766	
Neogale vison (Schreber, 1777)	
Nyctereutes procyonoides Gray, 1834	
Obama nungara Carbayo, Álvarez-Presas, Jones & Riutort, 2016	
Ondatra zibethicus Linnaeus, 1766	
Oxyura jamaicensis Gmelin, 1789	
Pachycondyla chinensis (Emery, 1895)	
Parthenium hysterophorus L.	
Persicaria perfoliata (L.) H. Gross	
Platydemus manokwari de Beauchamp, 1963	
Procyon lotor Linnaeus, 1758	
Prosopis juliflora (Sw.) DC.	
Pueraria montana (Lour.) Merr. var. lobata (Willd.)	
Pycnonotus cafer (Linnaeus, 1766)	
Pycnonotus jocosus (Linnaeus, 1758)	
Reynoutria × bohemica Chrtek & Chrtková	
Reynoutria japonica Houtt.	
Reynoutria sachalinensis (F. Schmidt) Nakai	
Sciurus carolinensis Gmelin, 1788	
Sciurus niger Linnaeus, 1758	
Solenopsis geminata (Fabricius, 1804)	
Solenopsis invicta Buren, 1972	
Solenopsis richteri Forel, 1909	
Tamias sibiricus Laxmann, 1769	
Threskiornis aethiopicus Latham, 1790	
Trachemys scripta Schoepff, 1792	
Triadica sebifera (L.) Small	
Vespa mandarinia Smith, 1852	
Vespa velutina nigrithorax de Buysson, 1905	
Wasmannia auropunctata (Roger, 1863)	
Alnus cordata (Loisel.) Duby	Belgium
Apis florea Fabricius, 1787	Belgium
Elaphe taeniura (Cope, 1861)	Belgium
Fagus orientalis Lipsky	Belgium
Impatiens capensis Meerb.	Belgium
Isodontia mexicana (de Saussure, 1867)	Belgium
Lindernia dubia (L.) Pennell	Belgium
Pachysandra terminalis Siebold & Zucc.	Belgium
Pterocarya fraxinifolia (Poir.) Spach	Belgium

Zizania latifolia (Griseb.) Hance ex F.Muell.	Belgium
Agrilus planipennis Fairmaire, 1888	Finland
Alchemilla mollis (Buser) Rothm.	Finland
Ambrosia artemisiifolia L.	Finland
Aruncus dioicus (Walter) Fernald	Finland
Buddleja davidii Franch.	Finland
Cornus sericea L.	Finland
Lysimachia nummularia L.	Finland
Spiraea × billardii Hérincq	Finland
Spiraea alba Du Roi	Finland
Symphytum officinale L.	Finland
Acacia dealbata Link	Portugal
Acacia longifolia (Andrews) Willd.	Portugal
Acacia melanoxylon R.Br.	Portugal
Arundo donax L.	Portugal
Baccharis spicata (Lam.) Baill.	Portugal
Carpobrotus edulis (L.) N.E.Br.	Portugal
Cotula coronopifolia L.	Portugal
Phytolacca americana L.	Portugal
Robinia pseudoacacia L.	Portugal
Tradescantia fluminensis Vell.	Portugal
Ambrosia tenuifolia Spreng.	Romenia
Ambrosia trifida L.	Romenia
Amorpha fruticosa L.	Romenia
Arion vulgaris Moquin-Tandon, 1855	Romenia
Cameraria ohridella Deschka & Dimić, 1986	Romenia
Corythucha arcuata (Say, 1832)	Romenia
Cyclachaena xanthiifolia (Nutt.) Fresen.	Romenia
Elaeagnus angustifolia L.	Romenia
Metcalfa pruinosa (Say, 1830)	Romenia
Varroa destructor Anderson & Trueman, 2000	Romenia
Australoplana sanguinea (Moseley, 1877)	United Kingdom
Cortaderia selloana (Schult. & Schult.f.) Asch. & Graebn.	United Kingdom
Ehrharta erecta Lam.	United Kingdom
Lamium galeobdolon subsp. argentatum (Smejkal) J.Duvign.	United Kingdom
Linepithema humile (Mayr, 1868)	United Kingdom
Muehlenbeckia complexa (A.Cunn.) Meisn.	United Kingdom
Paulownia tomentosa (Thunb.) Steud.	United Kingdom
Petasites pyrenaicus (L.) G.López	United Kingdom

Psittacula krameri (Scopoli, 1769)	United Kingdom
Thaumetopoea processionea (Linnaeus, 1758)	United Kingdom

7.2. List of datasets used in modelling uploaded to Zenodo

Title	URL	DOI
Reclassified Global Land-Cover Plant Functional Type Dataset (1 km) for baseline (2015) and future SSP/RCP scenarios based on Chen et al. (2022, DOI:10.1038/s41597-022-01208-6) — OneSTOP Project Task 5.1	https://zenodo.org/records/17655743	10.5281/zenodo.17655742
CHELSA Bioclimatic and Environmental Predictors for Species Distribution Models (OneSTOP Project – Task 5.1): SSP5-8.5 Scenario (2071–2100)	https://zenodo.org/records/17655356	10.5281/zenodo.17655355
CHELSA Bioclimatic and Environmental Predictors for Species Distribution Models (OneSTOP Project – Task 5.1): SSP3-7.0 Scenario (2071–2100)	https://zenodo.org/records/17655228	10.5281/zenodo.17655227
CHELSA Bioclimatic and Environmental Predictors for Species Distribution Models (OneSTOP Project – Task 5.1): SSP1-2.6 Scenario (2071–2100)	https://zenodo.org/records/17655051	10.5281/zenodo.17655050
CHELSA Bioclimatic and Environmental Predictors for Species Distribution Models (OneSTOP Project – Task 5.1): SSP5-8.5 Scenario (2041–2070)	https://zenodo.org/records/17654923	10.5281/zenodo.17654922
CHELSA Bioclimatic and Environmental Predictors for Species Distribution Models (OneSTOP Project – Task 5.1): SSP3-7.0 Scenario (2041–2070)	https://zenodo.org/records/17654440	10.5281/zenodo.17654439
CHELSA Bioclimatic and Environmental Predictors for Species Distribution Models (OneSTOP Project – Task 5.1): SSP1-2.6 Scenario (2041–2070)	https://zenodo.org/records/17651614	10.5281/zenodo.17651613
CHELSA Bioclimatic and Environmental Predictors for Species Distribution Models (OneSTOP Project – Task 5.1): Historical Baseline (1981–2010)	https://zenodo.org/records/17644815	10.5281/zenodo.17644814

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