Climate-Driven Habitat Suitability Modeling for Megaloptera in Thailand Using MaxEnt

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Introduction

Freshwater ecosystems face compounding threats from climate change, urbanization, and land-use modification. Among freshwater insects, Megaloptera (dobsonflies, fishflies, alderflies) are one of the most ancient insect lineages (~210–215 million years), with fully aquatic larvae confined to cool, oxygen-rich headwater streams. Their sensitivity to water quality makes them valuable bioindicators of ecosystem health.
Despite their ecological importance, predictive habitat modeling of Megaloptera under climate change scenarios remains largely absent in Thailand and Southeast Asia. This study addresses that gap using Maximum Entropy modeling (MaxEnt) to assess current and future habitat suitability across Thailand's freshwater ecoregions.



Figure1: Megaloptera: Corydalidae: Corydalinae

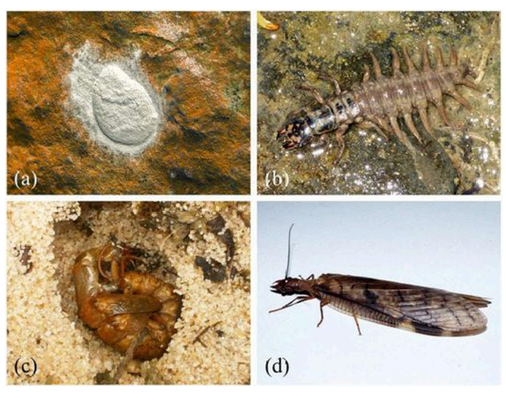


Figure2: Life cycle of Megaloptera

Objectives

1. Map suitable habitat across Thailand's 10 freshwater ecoregions under current conditions
2. Identify key environmental drivers of habitat suitability
3. Project future habitat change under four SSP climate scenarios (2050s & 2090s)

Materials & Methods

Occurrence Data 116 records compiled from GBIF and literature → spatially thinned to **54** localities (spThin, 5 km minimum distance) to reduce sampling bias
Environmental Variables 13 predictors selected from 19 bioclimatic variables (WorldClim v2.1) + 5 landscape variables after Pearson correlation screening (|r| > 0.8 excluded):

Group	Variables
Bioclimatic (8)	BIO1, BIO2, BIO3, BIO4, BIO7, BIO12, BIO14, BIO15
Landscape (5)	Distance to forest, agriculture, urban, river; Elevation

Modeling

- Algorithm: MaxEnt (maxnet in R) with 10,000 background points
- Tuning: ENMeval — 24 candidate models
  (3 feature classes × 8 regularization multipliers)
- Selection: Lowest AICc → optimal model: LQ, RM = 1.0
- Validation: 10-fold cross-validation (AUC)
- Future scenarios: MPI-ESM1-2-HR model, SSP126 / SSP245 / SSP370 / SSP585 for 2050s (2041–2060) and 2090s (2081–2100)

Results & Discussion

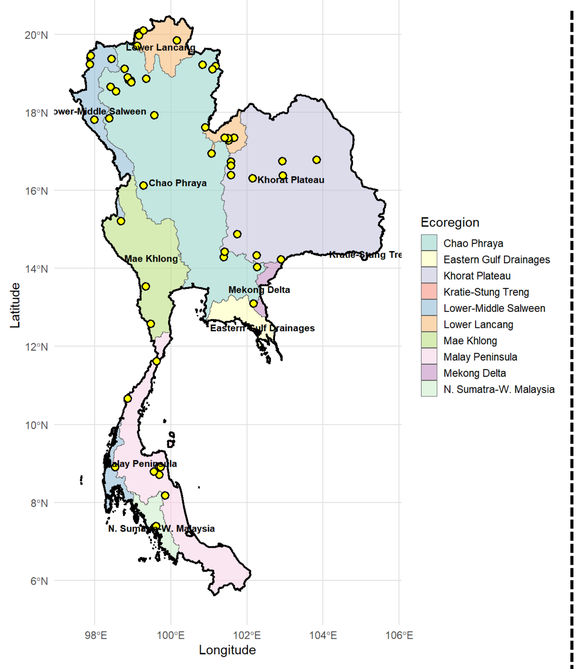


Figure3: Occurence points by freshwater ecoregion

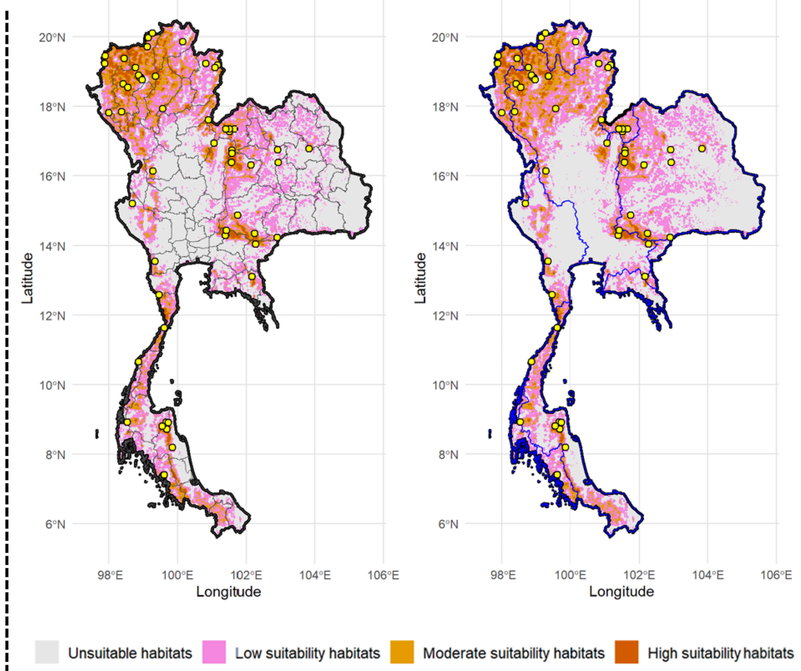


Figure4: Current habitat suitability map

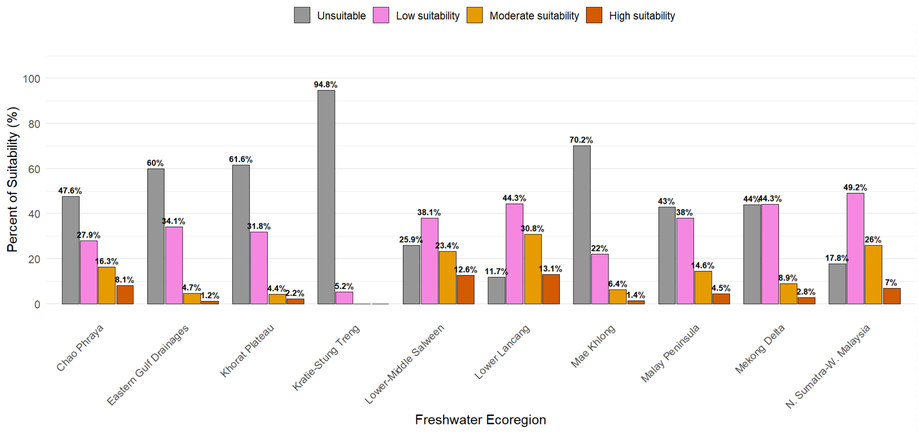


Figure5: Habitat suitability distribution by freshwater ecoregion

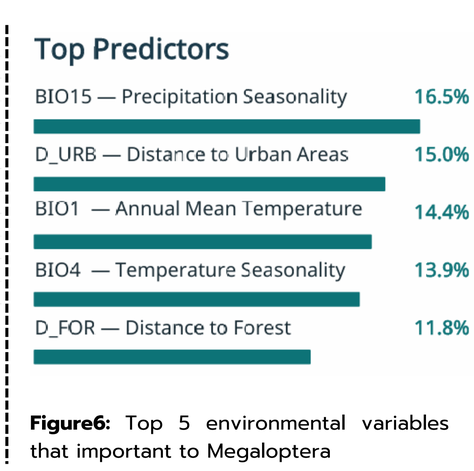


Figure6: Top 5 environmental variables that important to Megaloptera

Lower Lancang and **Lower-Middle Salween** has the **highest suitable** area.
These ecoregions are characterized by **steep terrain**, **high forest cover**, and relatively **stable precipitation** regimes, conditions that favor the persistence of Megaloptera populations. Most important key evironmental drivers to Megaloptera is BIO15.

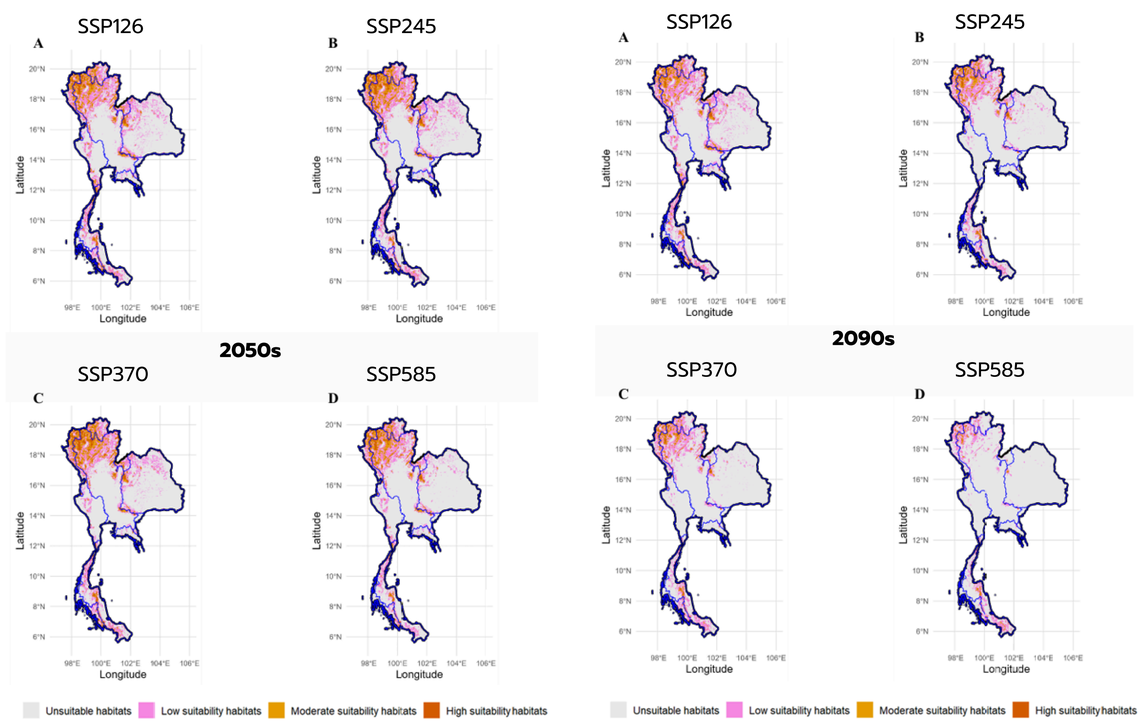


Figure7: Future projection of 4 SSP climate scenarios (2050s & 2090s)

Suitability area decreased by **the time** and **worse climate scenarios**

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