

Databases used for modelling

The following databases were used modelling probability of presence, relative density and trend index maps for the Bird Atlas of Hungary. For detailed methods see <https://www.mme.hu/filebrowser/download/261>, page 50.

Survey characteristics

covered: coverage of 2.5×2.5 km UTM squares by bird survey (based on number of 0.5 km segments);

duration: duration of the survey (minute);

day: date of the survey within the year (1=1st of January);

start_min: start of survey compared to sunrise (sunrise calculated for each observation based on datum and position).

Species were categorised into 12 10-day intervals (60–170, 1 = first day of the year) in which in maximum probability of observation was to be expected, based on the dates of when they were seen. Moreover, maximum observation probability during the day was also established and observations were assigned to six categories (<=0, 1–29, 30–59, 60–89, 90–119, >=120; 0 = time of sunrise) (*Figure 12*). Models considered differences from yearly and daily maximum.

identify_skill: skill of observer (see <https://www.mme.hu/filebrowser/download/224>).

If identification skill of the observer for a given species was unknown or uncertain, data were excluded from calculations.

Climate data (1970–2000) (Fick and & Hijmans 2017) used in the model:

BIO1: annual average temperature (°C);

BIO5: highest temperature in the hottest month (°C);

BIO6: lowest temperature in the coldest month (°C);

BIO12: annual rainfall (mm);

BIOBP: rainfall during the breeding period (April–July) (mm);

BIOBT: average temperature during the breeding period (April–July) (°C);

EVAPO: annual evaporation (Mu *et al.* 2013).

Altitude data

alt_hu: altitude (European Environmental Agency, Elevation map of Europe).

Ecosystem Map of Hungary (NÖSZTÉP)

This database, covering all of Hungary, shows the actual distribution, extent and frequency of ecosystems on national level. The map categorises urban areas (7 subcategories), agricultural areas (3), grasslands and other herbaceous vegetation (6), forests and scrubs (17), and rivers and lakes (3) on a 20×20 m raster (Agrárminisztérium 2019, or see <http://alapterkep.termesztetem.hu>).

perc_11 Urban areas, Buildings (merging 1110–1120: Low buildings, High buildings)

perc_1210 Urban areas, Paved roads

perc_1220 Urban areas, Dirt roads

perc_1230 Urban areas, Railways

perc_1310 Urban areas, Other paved or non-paved artificial areas

perc_1410 Urban areas, Green urban areas with trees

perc_1420 Urban areas, Green urban areas without trees

perc_2100 Croplands, Arable land

perc_2210 Croplands, Vineyards

perc_222 Croplands, Permanent crops (merging 2220–2230: Fruit and berry plantations, Energy crops)

perc_2300 Croplands, Complex cultivation pattern (merging 2310–2320: Complex cultivation patterns with scattered buildings, Complex cultivation patterns without buildings)

perc_3110 Open sand steppes

perc_3120 Closed sand steppes

perc_3200 Salt steppes and meadows (grasslands affected by salinisation included)

perc_33 Open rocky grasslands (merging 3310–3320: Calcareous open rocky grasslands, Siliceous open rocky grasslands)

perc_3400 Closed grasslands in hills and mountains or on cohesive soil

perc_3500 Other herbaceous vegetation (Heather, Natural pioneer vegetation of wet substrates, Semi-desert vegetation on loess cliffs, Open vegetation of shaded cliffs and screes, Other treeless vegetation, Stands

- of invasive forbs, Trampled and ruderal vegetation, Ruderal tall-herb vegetation, Semi-natural grasslands of abandoned arable field etc.)
- perc_4100** Forests without excess water excluding 4101–4110 categories (e.g. Native poplar dominated forests, Pioneer forests at medium and high elevations, Pedunculate oak forests, monospecific or mixed with ash, Other mixed deciduous forests)
- perc_4101** Beech forests
- perc_4102** Sessile oak-hornbeam forests
- perc_4103** Turkey oak forests
- perc_4104** Downy oak forests
- perc_4105** Scots pine stands of Western Transdanubia
- perc_4107** Deciduous forest mixed with coniferous trees (merging 4106–4107 Deciduous stands of Western Transdanubia mixed with Scots pine, Other deciduous forest mixed with coniferous trees)
- perc_4108** Lowland pedunculate oak forests
- perc_4109** Pedunculate oak-hornbeam forests
- perc_4110** Non-native tree dominated forests without excess water
- perc_42** Natural riverine (gallery) forests (merging 4201–4204: Riverine willow-poplar woodlands, Riverine hardwood forests, Floodland alder forests, Other natural riverine forests)
- perc_43** Other forests with excess water (merging 4300–4307: Alder forests, Pedunculate oak-hornbeam forests (with excess water), Pedunculate oak-Turkey oak forests, Willow woods outside the floodplain, Poplar woods outside the floodplain, Birch woodlands, Non-native tree dominated forests with excess water, Other forests with excess water)
- perc_4401** Coniferous dominated plantations (merging 4401–4405: Scots pine stands, Black pine stands, Norway spruce stands, Other coniferous stands, Coniferous dominated mixed forests)
- perc_4406** Black locust plantations, Black locust dominated mixed plantations (merging 4406–4407)
- perc_4408** Plantations of other non-native tree species (merging 4408–4411: Non-native poplar and willow plantations, Plantations of other non-native tree species, Non-native poplar and willow dominated mixed plantations, Other deciduous dominated mixed plantations)
- perc_45** Non-wooded areas registered as forest, or areas under reforestation (merging 4501–4503: Clearcuts, Forest stands under regeneration)
- perc_46** Other ligneous vegetation, woodlands (e.g. spontaneously forested or scrubbed areas, dams and ridges covered with ligneous vegetation, some forest clearings, abandoned areas with ligneous vegetation)
- perc_51** Herbaceous-dominated wetlands (merging 5110–5120: Tall-herb vegetation of marshes and fens standing in water, Fens and mesotrophic wet meadows, grasslands with periodic water effect)
- perc_52** Wetlands dominated by lignaceous vegetation (merging 5210–5220: Willow marshes, Swamp woodlands)
- perc_61** Water bodies

Modelling used percentage of above mentioned categories in 2×2 km EOVS (Hungarian National Projection) squares. We used a preliminary version of the database (NÖSZTÉP 4.0, 08.08.2018.). The codes of the public, 5.0 version of the database differ in some cases (Agrárminisztérium 2019, Tanács *et al.* 2019).

Soil data (European Soil Data Centre – ESDAC) (Hiederer 2013):

soil_bd: bulk density (g/cm³)

soil_clay: clay content (%)

soil_silt: silt content (%)

soil_sand: sand content (%)

soil_gravel: gravel content (%)

soil_oc: organic carbon content (%)

soil_depth_roots: depth available to roots (cm)