



Rational

Birds play a crucial role in maintaining the balance and health of ecosystems worldwide, with their significance extending from ecological functions to cultural symbolism. Ecologically, birds contribute to pest control by preying on insects, regulating populations, and mitigating agricultural damage. They also aid in seed dispersal and pollination, facilitating vegetation growth and plant reproduction. Furthermore, birds serve as environmental indicators, reflecting broader ecological shifts. Recently, the National Ecological Observation Network (NEON) has undertaken the task of monitoring bird populations across various U.S. ecosystems. The project aims to decipher bird abundance patterns during peak growing seasons, synthesizing data on variables such as bird counts, beetle populations, latitude, longitude, tree dimensions, and vegetation productivity during 2017-2022 sourced from NEON databases.

Methodology – Site information

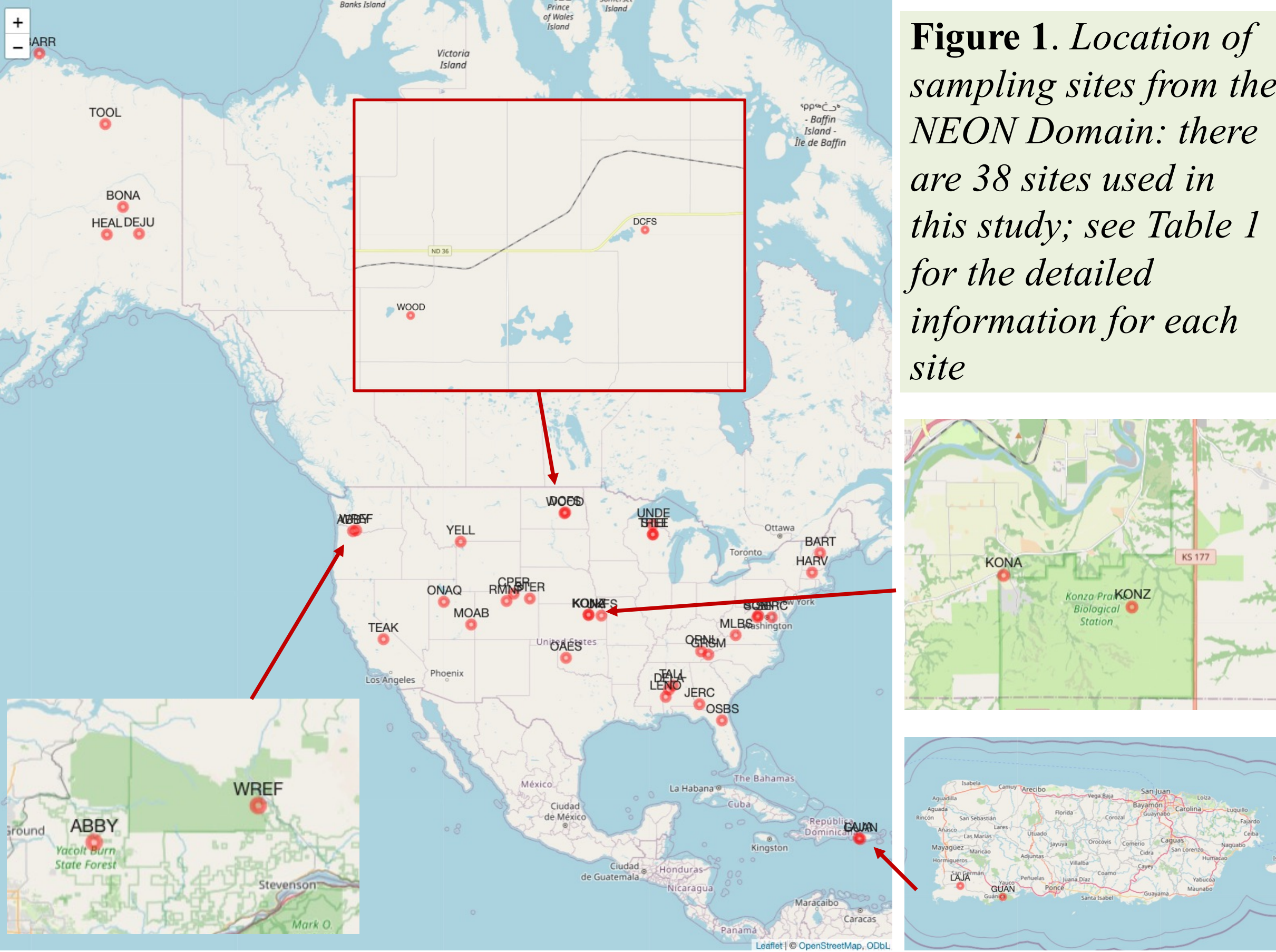


Figure 1. Location of sampling sites from the NEON Domain: there are 38 sites used in this study; see Table 1 for the detailed information for each site

Methodology - Data processing

We compiled bird abundance data and the major bird species for each site across the NEON network. In total, 38 sites were chosen based on data availability. The vegetation (DBH) and beetle data are compiled in same sites by the NEON team; while the climate data are from NEON team but in different categories; GPP (gross primary productivity) is from a publication Jung & Hararuk, (2022)

NEON collects observations of birds at terrestrial field sites to capture interannual variation in the abundance, diversity, and distribution of birds within each NEON domain and across the continent. The sampling protocol is focused on breeding landbirds, including songbirds and other birds that are diurnal and that reside in or migrate through terrestrial habitats during the breeding season, however, all bird species observed are recorded in the data. These open access bird data are available from the NEON data portal.

Sampling locations are proportionally distributed in the dominant habitat classes of each field site to facilitate inference at the scale of the entire site. Bird Grids overlap distributed base plots to allow for comparisons between bird data and other NEON observations of plants, soils, mosquitoes, microbes, and beetles. Field scientists sample 5-15 grids at most NEON field sites depending on the geographic size of each site. Each Bird Grid is composed of nine observation points. Some smaller sites cannot accommodate a minimum of 5 grids with required spacing. At these sites, points are distributed throughout the site according to a stratified-random spatial design used for all Terrestrial Observation System sampling, maintaining a 250 m minimum separation and co-located with the NEON distributed base plots. See NEON website: <https://www.neonscience.org/data-collection/birds>

Site Code	Site Name	Site Type (NEON)	terrain	State
ABBY	Abby Road NEON	GRADIENT	TERRESTRIAL	WA
BARR	Utqiaġvik NEON	GRADIENT	TERRESTRIAL	AK
BART	Bartlett Experimental Forest NEON	GRADIENT	TERRESTRIAL	NH
BLAN	Blandy Experimental Farm NEON	GRADIENT	TERRESTRIAL	VA
BONA	Caribou-Poker Creeks Research Watershed NEON	CORE	TERRESTRIAL	AK
CPER	Central Plains Experimental Range NEON	CORE	TERRESTRIAL	CO
DCFS	Dakota Coteau Field NEON	GRADIENT	TERRESTRIAL	ND
DEJU	Delta Junction NEON	GRADIENT	TERRESTRIAL	AK
DELA	Dead Lake NEON	GRADIENT	TERRESTRIAL	AL
GRSM	Great Smoky Mountains National Park NEON	GRADIENT	TERRESTRIAL	TN
GUAN	Guanica Forest NEON	CORE	TERRESTRIAL	PR
HARV	Harvard Forest & Quabbin Watershed NEON	CORE	TERRESTRIAL	MA
HEAL	Healy NEON	GRADIENT	TERRESTRIAL	AK
JERC	The Jones Center At Ichauway NEON	GRADIENT	TERRESTRIAL	GA
KONA	Konza Prairie Agroecosystem NEON	GRADIENT	TERRESTRIAL	KS
KONZ	Konza Prairie Biological Station NEON	CORE	TERRESTRIAL	KS
LAJA	Lajas Experimental Station NEON	GRADIENT	TERRESTRIAL	PR
LENO	Lenoir Landing NEON	GRADIENT	TERRESTRIAL	AL
MLBS	Mountain Lake Biological Station NEON	GRADIENT	TERRESTRIAL	VA
MOAB	Moab NEON	GRADIENT	TERRESTRIAL	UT
OAES	Marvin Klemme Range Research Station NEON	GRADIENT	TERRESTRIAL	OK
ONAQ	Onaqui NEON	CORE	TERRESTRIAL	UT
ORNL	Oak Ridge NEON	CORE	TERRESTRIAL	TN
OSBS	Ordway-Swisher Biological Station NEON	CORE	TERRESTRIAL	FL
RMNP	Rocky Mountains NEON	GRADIENT	TERRESTRIAL	CO
SCBI	Smithsonian Conservation Biology Institute NEON	CORE	TERRESTRIAL	VA
SERC	Smithsonian Environmental Research Center NEON	GRADIENT	TERRESTRIAL	MD
STEI	Steigerwaldt-Chequamegon NEON	GRADIENT	TERRESTRIAL	WI
STER	North Sterling NEON	GRADIENT	TERRESTRIAL	CO
TALL	Talladega National Forest NEON	CORE	TERRESTRIAL	AL
TEAK	Lower Teakettle NEON	GRADIENT	TERRESTRIAL	CA
TOOL	Toolik Field Station NEON	CORE	TERRESTRIAL	AK
TREE	Treehaven NEON	GRADIENT	TERRESTRIAL	WI
UKFS	KU Field Station NEON	GRADIENT	TERRESTRIAL	KS
UNDE	University of Notre Dame Environmental Research Center	CORE	TERRESTRIAL	MI
WOOD	Chase Lake National Wildlife Refuge NEON	CORE	TERRESTRIAL	ND
WREF	Wind River Experimental Forest NEON	CORE	TERRESTRIAL	WA
YELL	Yellowstone National Park NEON	CORE	TERRESTRIAL	WY

Table 1. Description of sampling sites taken from the NEON Domain

Results

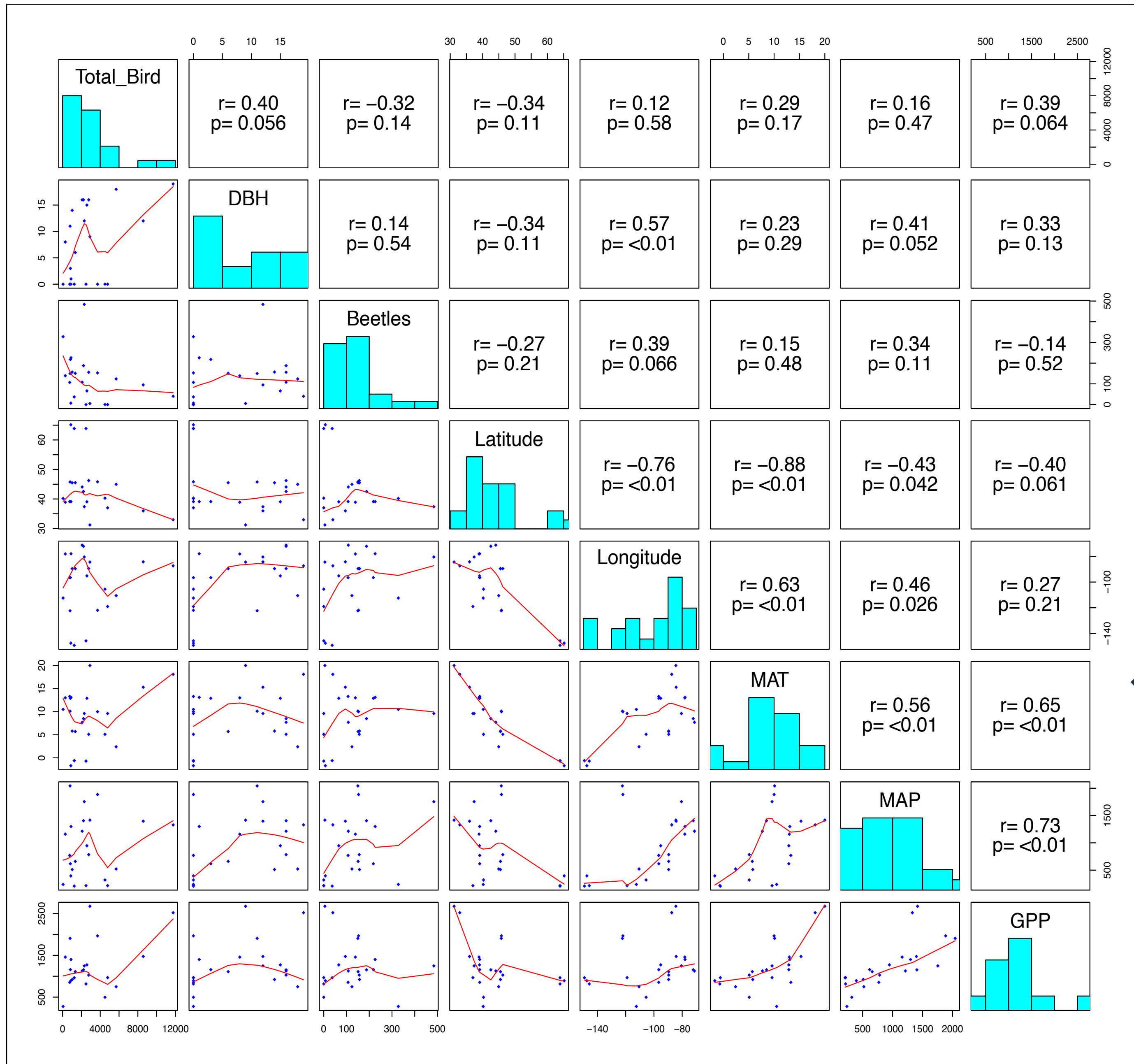


Figure 2. Correlation matrix of bird abundance and environmental factors (DBH: diameter of breast height; Beedle abundance of the habitat; MAT: mean annual temperature; MAP: mean annual precipitation; GPP: gross primary productivity)

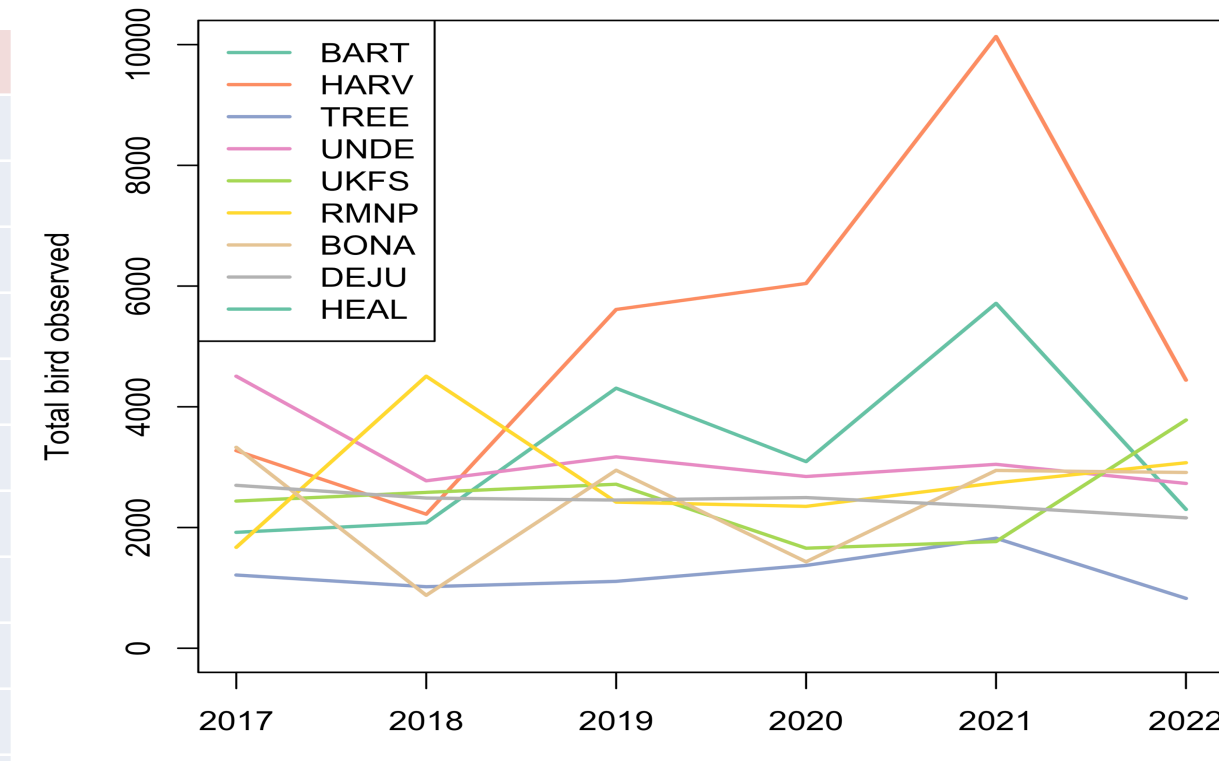


Figure 3. Temporal variation of bird abundance at eight sites (bird abundance data available for all six years)

- 1) Bird abundance ranges from 600 to ~10000 among sites;
- 2) There is strong inter-annual variation in bird abundance.
- 3) Surprisingly, no clear increasing trends were observed for all sites for 6 years, with one site showing a large spike in 2021. This unexpected deviation suggests that it is not a long-term increasing trend.

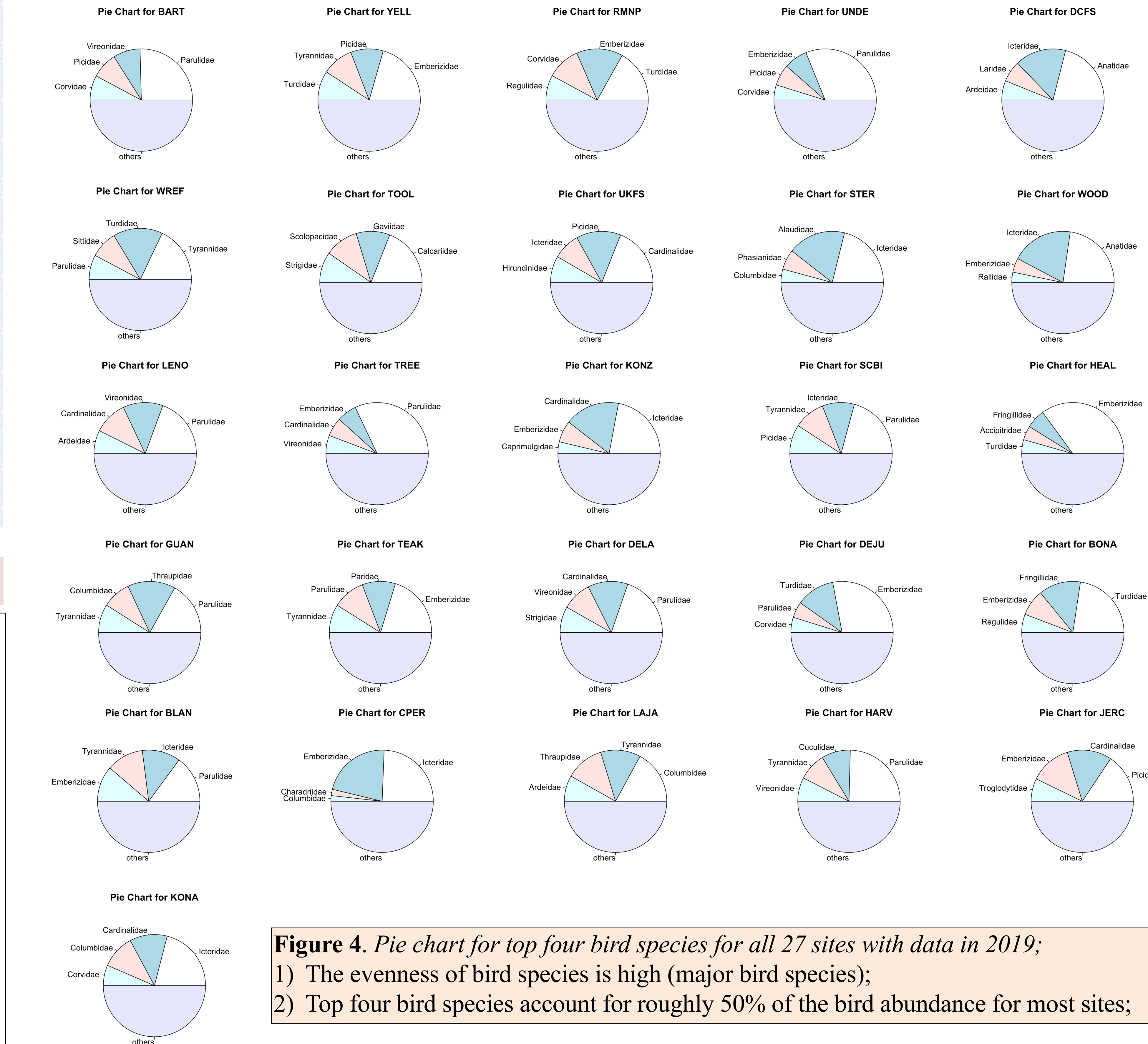


Figure 4. Pie chart for top four bird species for all 27 sites with data in 2019;

- 1) The evenness of bird species is high (major bird species);
- 2) Top four bird species account for roughly 50% of the bird abundance for most sites;

- Refer to Figure 2
- 1) Bird abundance positively correlates with DBH (tree size) and GPP.
 - 2) Bird abundance is negatively correlated with beetle (birds consume beetle) and latitudes.

Take home message

- 1) The findings reveal that bird counts decrease from low to high latitudes.
- 2) Bird abundance depends on vegetation productivity and tree size (DBH).
- 3) Strong inter-annual variations in bird counts were observed nationwide; no clear temporal trends were observed for most of the sites over the six years (2017-2022).
- 4) Birds consume beetles (negatively but weak correlation)
- 5) Vegetation's pivotal role in bird abundance indicates the importance of habitat protection for bird conservation.

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