Global biodiversity monitoring databases – new opportunities for macroecological research in the Anthropocene?

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| INTRODUCTION AND OBJECTIVES

Species monitoring consists of the continuous collection of data on some attribute(s) of species in both space and time. Robust monitoring schemes allow to assess biodiversity state and trends, to evaluate and predict possible changes and to relate those with modifications in ecosystem structure and functioning.

Over the years, researchers have been collecting large amounts of information on species. This information can be used in subsequent projects, but it is often lost or stored without ever being fully used in scientific applications. To address this challenge, **BioTIME** (http://biotime.st-andrews.ac.uk/) has been devised as a **global database of species-level monitoring data**. It is aimed at providing the scientific community with a new standard to store, share and analyse this information in a worldwide network of observation spots. Despite the immense potential of this information, it is still under-exploited to obtain meaningful spatiotemporal patterns or trends of biodiversity or to connect it with other high-throughput data streams such as those from Satellite Earth Observations.

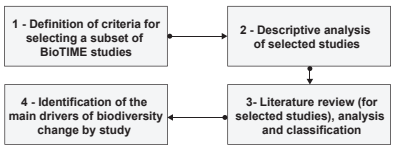
In a world in constant change, the perils of fast biodiversity loss are pushing the scientific community to improve the capacity to link biodiversity changes with modifications occurring in ecosystem structure and function, which are often (directly or indirectly) driven by human activities (e.g., land use/cover change, landscape fragmentation, land degradation, shifts in climate and wildfire regimes). In this context, the aim of this preliminary study is to pre-select a relevant subset of BioTIME monitoring studies, to describe them, to identify the main factors of biodiversity change, and finally to **assess the potential of these datasets to conduct cross-scale analyses connecting top-down Satellite Earth Observations with bottom-up species monitoring data.**

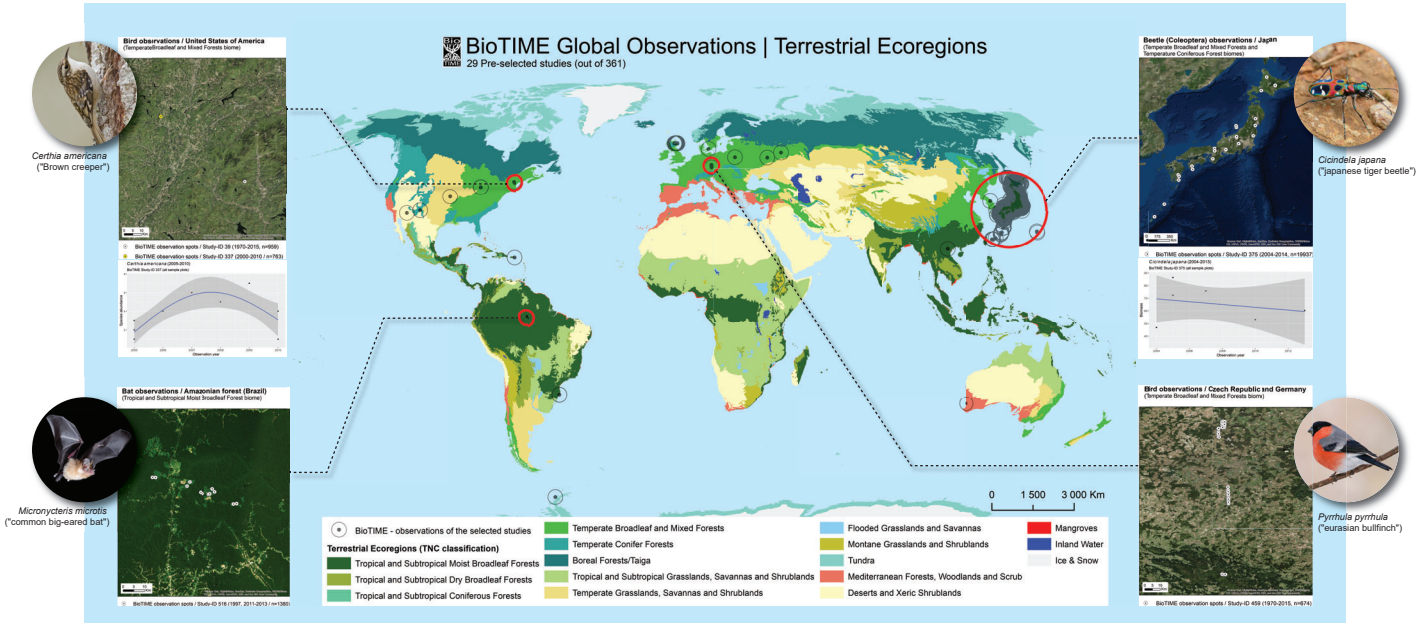
In a broader view, with this study, we want to underline the potential of species monitoring data to support a wide range of possibilities for a better understanding of the human impacts on ecosystems and their effect on the persistence of biological populations and communities. Among others, there is **huge potential to improve the identification of Essential Biodiversity Variables (EBV's) based on Satellite Earth Observations in support of monitoring initiatives in the scope of the Convention on Biological Diversity ("Aichi Targets") and GEO BON.**

| METHODS

[1-2] From the BioTIME database we selected a subset of biodiversity monitoring datasets for the terrestrial domain, starting from the year 2000 and with a duration of at least 5 consecutive years of species monitoring. By applying these criteria, we obtained a subset of BioTIME studies maximizing the relevance and overlap with open-access satellite time series from the MODIS or Landsat platforms. These data were later described in their taxonomic, temporal, spatial and ecoregional coverage.

[3-4] The bibliographic references linked to each pre-selected study (e.g., scientific papers, reports) were reviewed, analysed and classified. We identified the main driving forces responsible for the observed changes or trends in biodiversity as reported by each study. These drivers are mainly linked to regional or local factors, potentially causing shifts in population abundances, composition or diversity. We followed a preliminary classification of biodiversity change factors using the following categories: Natural Disturbances, Seasonal Dynamics (e.g., climatic variability and extremes, resource abundance), Plagues and Diseases, Natural Wildfires, Habitat Degradation, Land Use Change, Landscape Fragmentation, Human economic activities, and Wildfires.





| RESULTS

A total of 29 out of 361 (ca. 8%) of BioTIME studies were selected by applying the criteria defined in steps [1-2].

1) Which groups of organisms are mainly represented in the subset of selected studies?

The selected datasets include observations of four animal groups: Mammals, Birds, Reptiles and Arthropods, with Birds holding the larger number of observations (n=206 457), followed by Arthropods (n= 141 227), Mammals (n=31 457) and Reptiles (n=1549, with a single study).

2) Which continents and ecoregions/biomes are represented in the subset of selected studies?

All continents except Africa were represented by the selected studies. The continent with the largest number of observations was Asia (n= 194 032), whereas Australia was the continent with fewer observations (n=1549).

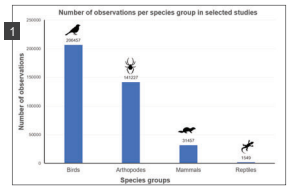
Only 50% of the biomes were represented by the subset of studies, namely: Temperate Broadleaf and Mixed Forest (n=277 414), Temperate Grassland and Savannas and Shrublands (n= 61 769), Tropical and Subtropical Dry Broadleaf Forests (n=21 702), Tropical and Subtropical Moist Broadleaf Forest (n= 9913), Temperate Coniferous Forest (n= 3680), Tundra (n=3050), Aquatic (n=1613), and Mediterranean Forests and Woodlands and Scrub (n=1549).

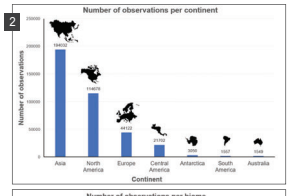
3) How are the data spread out through time?

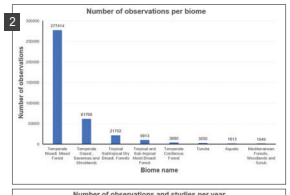
We found that the selected studies range from the 1970s up to the year 2017. We observed a moderate rise in the number of observations starting in the 1990s and a very fast rise after the 2000s, with the peak of data collection occurring around 2010-2014 (with more than 40 000 observations/year in that period).

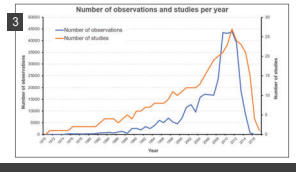
4) Which are the main driving factors of biodiversity change identified through the literature review? Is it possible to disentangle "natural" from "anthropogenic" causes?

From the literature review, we found some difficulties to clearly identify and classify the different driving factors reported in the selected studies. The same was found as to disentangle between "natural" and "anthropogenic". Despite that, we found that natural factors related to **inter-annual and seasonal dynamics** (n=5) were most often identified while natural **wildfires** the (n=1) was the one with fewer associations. Regarding the group of anthropogenic factors, the one most often associated with biodiversity change was **habitat degradation**, and the one with fewer associations was the **presence of non-native/invasive species**.









| DISCUSSION

Do global biodiversity monitoring databases, such as BioTIME, actually, offer new opportunities for macroecological research in the Anthropocene?

YES!!

We foresee a great potential of global databases such as BioTIME to provide the necessary information for macroecological studies, especially those aiming to understand the fundamental contemporary shifts in biodiversity in the Anthropocene. These data also hold a large potential to be combined with temporal satellite observations, allowing us to upscale and link biodiversity dynamics with ecosystem structure and functioning

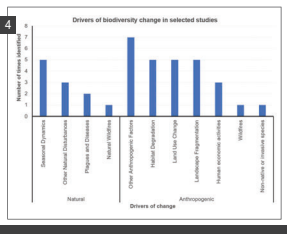
BUT

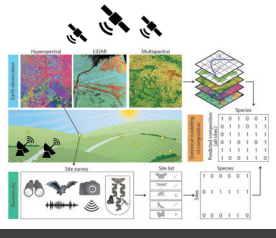
Some biodiversity change factors cannot easily be observed by satellite (e.g., understorey invasive species, micro-scale habitat modifications) and therefore these must be studied with different methods and data. In addition, the spatial, temporal and taxonomic coverage of data is still insufficient, biased and unevenly distributed.

| FUTURE DEVELOPMENTS

CONNECTING GLOBAL SPECIES MONITORING TO SATELLITE EARTH OBSERVATIONS!

Despite their inherent limitations, **global databases such as BioTIME, and others such as LPI or PREDICTS, offer tremendous opportunities to pursue macroecological research aiming to improve both fundamental and applied research in Ecology.** We argue that combining these databases with high-throughput Satellite Earth Observation data streams will **increase our ability to make solid inferences and to select a meaningful set of indicators to inform on the state and trends of biodiversity across different space-time scales**. This will surely enable more adaptive and effective conservation strategies in a world under rapid socio-environmental change.





PROJECT SITE: