Call for a 27-month Post-Doc fellowship (Assegno di Ricerca) within the framework of the BIODIVERSA+ project MOTIVATE- Monitoring Of Terrestrial habitats by Integrating Vegetation Archive Time series in Europe

Expected Start

Nov 1, 2024

Objective of the project

The candidate will be employed on the BIODIVERSA+ project: *MOTIVATE - Monitoring Of Terrestrial habitats by Integrating Vegetation Archive Time series in Europe* whose main objective is to combine vegetation-plot resurveys covering the entirety of Europe (EU and non-EU) with innovative, human-focused qualitative data collection methods in order to generate knowledge and sustainable practices about biodiversity in European landscapes. These data will be upscaled from individual locations to the broader European context and integrated with remote sensing products.

MOTIVATE's core objectives and hypotheses correspond to seven work packages that aim to 1) analyse both habitat-specific and 2) species-specific trends based on vegetation time series; 3) develop workflows for upscaling results with remote sensing and 4) attributing drivers to the observed changes; 5) mobilise further time series in Europe and establish a data sharing and evaluation platform to motivate vegetation scientists to fill gaps in resurvey coverage; 6) explore how biodiversity data can be integrated with broader stakeholder perceptions to facilitate their use by decision-makers; and 7) work together with national agencies to deliver change indicators that can facilitate future reporting. The hired candidate will be working mainly on work package 4), but will also interact with the international MOTIVATE team to address the other objectives of the project.

Activity Plan

The winning candidate will:

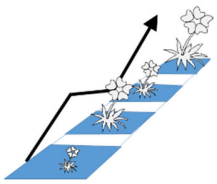
- Support the Italian PIs to perform the activities of WP4 "Attribution of drivers and extrapolating to the regional scale with remote sensing", specifically:
- 1) Gather a set of spatially explicit environmental predictors and land use/land cover proxies based on remote sensing, which relate to biodiversity change across Europe;
- 2) Calibrate and validate models of biodiversity change across Europe in a spatially explicit way,
- 3) Create time-resolved large-area maps of plant biodiversity change over the last 35 years,
- 4) Identify global change drivers behind observed species and habitat changes, as derived from time-series vegetation plot data.
- Support other Research Units for a successful realization of the MOTIVATE project
- Support the coordination of the activities of the WP and contribute to the organization of project meetings
- Prepare scientific manuscripts for publication in international peer-reviewed journals

Expertise and skills required:

- Excellent publication record on the topics of plant ecology, vegetation science, earth system science, conservation biology, forest ecology, biodiversity modelling, geomatics
- Proved experience in biodiversity modelling in R or other programming environments. The use of *dplyr* syntax and the other *tidyverse* packges in R is a plus

- Understanding of the most commonly used statistical approaches to biodiversity analysis (multivariate analysis, GLMM, spatial statistics). Previous knowledge of Generalized Dissimilarity Models and\or temporal time series is a plus.
- Expertise in the use of Geographical Information Systems (QGis, ArcGis), or equivalent spatial data manipulation in R or Python, and experience working with large global environmental layers (CHELSA; ISRIC; WORLDCLIM; EARTHENV)
- Experience in vegetation plot data collection and analysis of large vegetation-plot databases
- Experience with the handling and analysis of functional trait data
- Previous experience on stakeholder engagement or other approaches from social geography, or willingness to learn
- Experience on the best practices for reproducible data science (e.g., git, github) and reporting (RMarkdown, Jupiter, Quarto, LaTex) is highly desirable

MOTIVATE - Monitoring Of Terrestrial habitats by Integrating Vegetation Archive Time series in Europe



Abstract

Reversing the biodiversity crisis requires precise quantification of the spatial patterns and temporal trends of biodiversity loss, as well as knowledge of links to the main drivers of global change. Monitoring the trajectory of biodiversity is therefore a cornerstone of EU environmental legislation. Following the establishment of the Natura 2000 network, a system has been established for monitoring the change in extent and quality of more than 230 habitat types, together with the status and trends of more than 1,000 species identified by the Habitats Directive (HD) depending on these habitats. While the current reporting system of HD's Annex 1 habitats has proved principally useful, the assessments are not yet well harmonised across countries. In particular, there is a lack of empirical data on biodiversity change detail and on habitat quality and extent. Thus, there is significant room for improvements.

MOTIVATE aims at improving the characterisation and reporting on the state and trends of European habitats and plant biodiversity, in order to provide a deeper understanding of the pressures and drivers underlying biodiversity changes in Europe. To do this, MOTIVATE will integrate expertise and techniques across different knowledge domains, namely vegetation science, biodiversity modelling, remote sensing and human geography. At its core, MOTIVATE will leverage a database of vegetation-plot time series that the members of the proposed research team have already compiled in a community-owned initiative called ReSurveyEurope, integrating on-the-ground data with ongoing monitoring under the HD. These data will be used to produce both habitat- and species-specific assessments of plant biodiversity status and trends. MOTIVATE will also develop workflows for upscaling these results using remote sensing and for attributing drivers to the observed changes based on biodiversity modelling. In addition, MOTIVATE will establish pipelines to collect additional vegetation-plot time series in the future, and invest in capacity-building to secure the involvement of future generations in the continued sampling of time-series. Knowledge exchange among multiple stakeholders will help understanding how biodiversity data can be integrated with broader public perceptions. This will improve how monitoring data is put into practice by decision-makers. Critical to MOTIVATE's mission is co-designing a data information platform that facilitates future reporting of biodiversity change indicators together with national conservation agencies. This platform will link local time series to spatial information on habitat extent and potential drivers from remote sensing, and to the institutional HD reporting schemes. This will improve data standardisation and accessibility for nature conservation managers and decision makers. In summary, MOTIVATE strives to develop a novel, integrated, transboundary, transdisciplinary and transgenerational approach to biodiversity monitoring.

Keywords

Cross-scale models, Drivers of habitat change, Habitats Directive, Natura 2000, Remote Sensing, Stakeholders, Standardisation of reporting, Time series, Vegetation-plot resurveys

V. Description of the project

V.A. Detailed description of the research area and research plan and approach to stakeholder engagement and expected societal and/or policy impact

Scientific context and relevance

The European Green Deal is the EU's response to the increasing political and societal awareness of the biodiversity crisis[1,2]. Among other aims, it calls for strengthening scientific monitoring to safeguard biodiversity, and overcoming the current spatial and temporal fragmentation of monitoring schemes across habitats in Europe[3] and globally[4]. Based on the Habitats Directive (HD, Council Directive 92/43/EEC), the monitoring programme of Annex 1 habitats is by far the most comprehensive and consistent monitoring approach in Europe[5]. The EU member states regularly report the conservation status for habitats and species (HD Article 17[6]), but **monitoring and assessment systems are not yet well harmonised across countries, where the type and quality of the data reported vary substantially, hampering interoperability**[7]. This has been revealed by the Horizon 2020 EuropaBON project, in which the coordinator of this proposal and her team are core members. More than 60% of EU countries struggle with high levels of missing information; 11% of all member states base more than half of their reporting on expert opinion (rather than on data) or lack adequate methodological information; and only 7% base more than half of their methods on complete surveys[8]. As a result, the reports are often based on an insufficient data basis. The main challenges identified by EuropaBON[7] include: lack of accessible (raw) data, insufficient spatial coverage, insufficient standardization of survey protocols, lack of data integration, both across geographic scales and between in-situ and remote sensing data. **MOTIVATE sets out to fill these gaps by mobilizing, analysing and operationalizing vegetation resurvey data**.

Objectives and novelty

We will combine vegetation-plot resurveys covering the entirety of Europe (EU and non-EU) with innovative, human-focused qualitative data collection methods in order to generate knowledge and sustainable practices about biodiversity in European landscapes. These data will be upscaled from individual locations to the broader European context and integrated with remote sensing products. In particular, MOTIVATE's objectives address research themes 1 and 3 of the call.

General hypotheses (Fig. 1)

General approach and study design

To accomplish MOTIVATE's research goals, we have assembled a team with excellent and complementary expertise and competencies across a broad range of fields: vegetation science, databases and big data, nature conservation, remote sensing, biodiversity modelling, human geography and cultural anthropology, stakeholder engagement and research co-design.

We will build upon the work of ReSurveyEurope, a community initiative we established in 2020 to compile and analyse existing records from resurveyed vegetation plots in Europe, led by three of MOTIVATE's researchers (Chytrý, Essl, Bruelheide). By March 2023, the ReSurveyEurope 1.0 database contained 155 datasets and 449 individual resurvey projects with a total of 327,144 plot observations in 78,102 plots (Fig. 2). All plots were resurveyed at least once, but many represent decades-long time series. ReSurveyEurope also integrates other databases, such as forestREplot[9], GLORIA[10], LOTVS[11] and ReSurveyGermany[12]. Spanning up

Our overarching hypotheses are that analyses of long-term trends of Annex 1 habitats through vegetation resurvey data will
(hypothesis WP1) complement the results obtained from more recent national monitoring programmes,
(hypothesis WP2) reveal hotspots and coldspots of species abundance changes and range extensions,
(hypothesis WP3) provide ecosystem property trends when being combined with remote sensing data, and
(hypothesis WP4) identify habitat-, species- and ecosystem property-specific drivers of change.
Further objectives are to
(objective WP5) provide a public online vegetation resurvey data sharing platform, which motivates scientists to carry out vegetation resurveys in Europe,
(objective WP6) include the personal perceptions of vegetation surveyors, which provides insights into changes that are not captured by other sources, and
(objective WP7) complement the national monitoring programmes and facilitate reporting by delivering Essential Biodiversity Variables (EBVs).

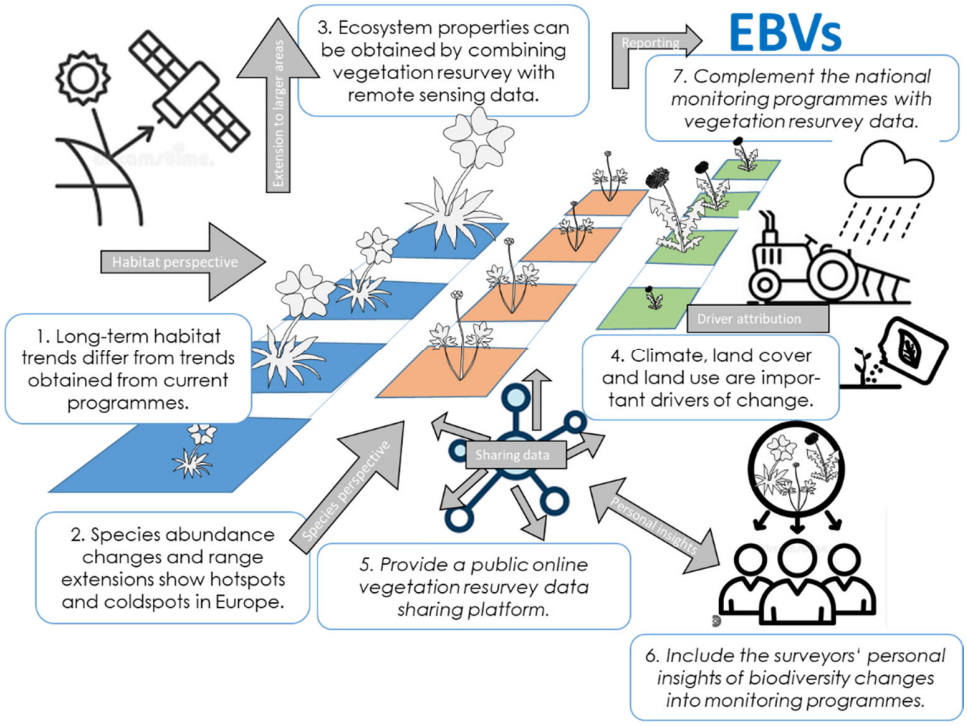


Figure 1: Overarching hypotheses (WP 1-4) and general objectives (WP 5-7 in italics)

to 111 years (1911 to 2022), these data precede the onset of systematic plant species monitoring programmes. Besides allowing the reconstruction of retrospective trends of the past century, resurvey data are useful benchmarks in monitoring, for a) having been carried out in a standardised way; b) including abundance/cover information in addition to presence/absence of species, therefore allowing for further quantitative analyses[13]; and c) reporting true absences, whose lack is a major problem for monitoring data at larger grain sizes. In recent years, vegetation-plot time series have been increasingly used to document the impact of climate change[14], land-use change[15], eutrophication[15,16] and biological invasions[17]. Going beyond merely showing trends in species richness, resurvey data have been used to reveal the dynamics of individual species, showing that a few winner species are expanding at the expense of many receding species in Germany[13]. Due to limited data availability, such analyses mostly had a regional or national extent. MOTIVATE will overcome this limitation.

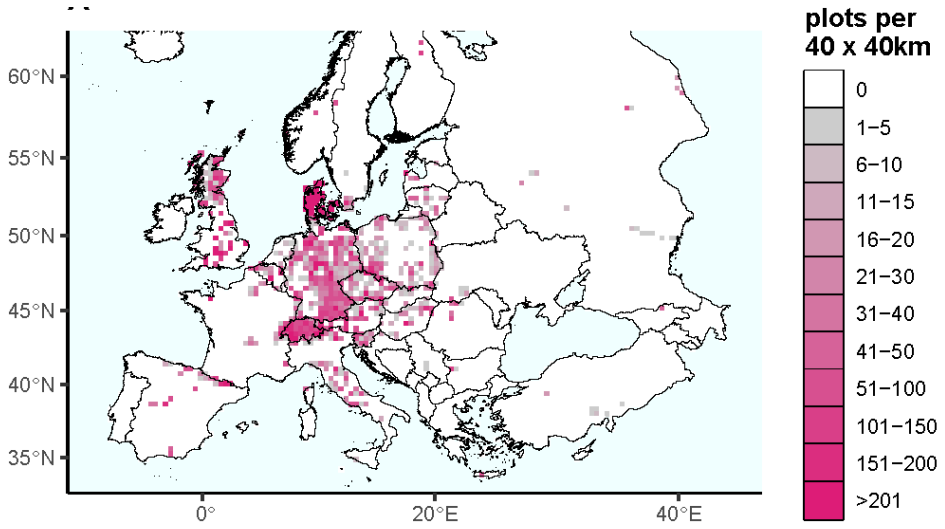


Figure 2: Distribution of the 78,102 plots across Europe contained in ReSurveyEurope version 1.0. Colours of grid cells indicate the different number of plots per 40 x 40 km² grid cells.

MOTIVATE's core objectives and hypotheses correspond to seven work packages (Fig. 3) that aim to 1) analyse both habitat-specific and 2) species-specific trends based on vegetation time series; 3) develop workflows for upscaling results with remote sensing and 4) attributing drivers to the observed changes; 5) mobilise further time series in Europe and establish a data sharing and evaluation platform to motivate vegetation scientists to fill gaps in resurvey coverage; 6) explore how biodiversity data can be integrated with broader stakeholder perceptions to facilitate their use by decision-makers; and 7) work together with national agencies to deliver change indicators that can facilitate future reporting.

Despite large spatial coverage across a wide range of habitats and environmental settings, vegetation-plot time series are essentially point observations in space. Their full potential for biodiversity monitoring is only achieved when combined with data that is available at the same spatial grain but with complete spatial coverage, such as remote sensing. MOTIVATE will capitalize on recent methodological advances in modelling to combine such data sources across scales[18–20]. ReSurveyEurope time series will be used to **calibrate habitat-specific models** that predict the trend of Annex 1 habitats' extent and conservation status, thus **delivering clearly defined Essential Biodiversity Variables (EBVs)**[21], which are summary indicators for biodiversity monitoring.

Stakeholder engagement and expected societal/policy impact

MOTIVATE is innovative in that it integrates historically collected vegetation time-series data and Europe-wide databases of vegetation plots with remote sensing technologies and advanced biodiversity modelling. Stakeholder participation and the co-design of a data sharing platform ensures that MOTIVATE will have significant added values transnationally, by improving both the detail of future reporting of the status and trends of biodiversity and its harmonization across member states. Finally, involving a new generation of vegetation scientists in resurvey efforts and motivating colleagues to adopt resurvey plots in countries where resurveys have not yet been carried out ensures a transgenerational perspective beyond the lifetime of the project.

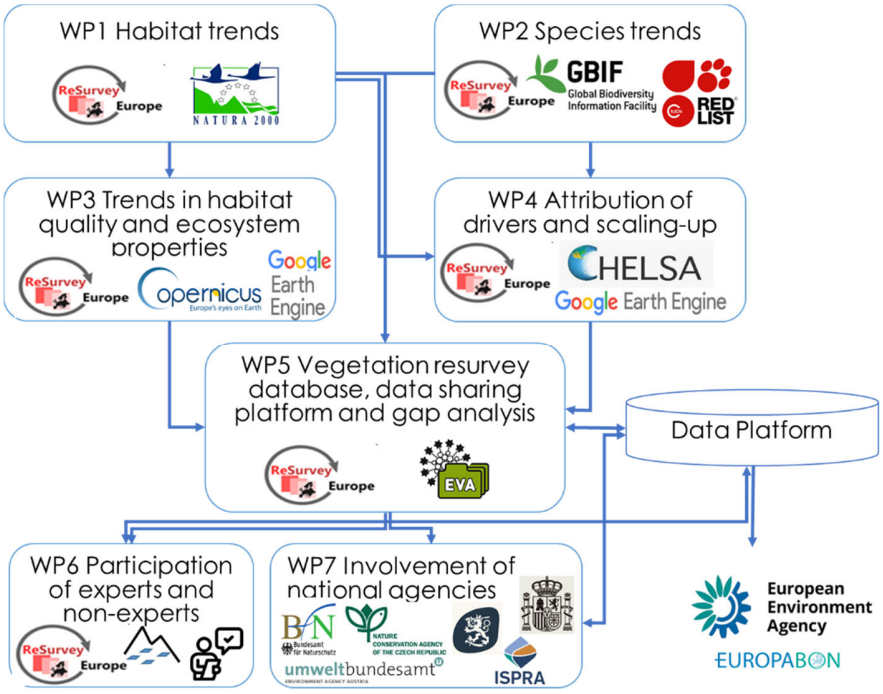


Figure 3: Workflow between the workpackages iof MOTIVATE

Work packages and research plan

WP1. Habitat trend analyses using vegetation-plot time series

Ute Jandt, Helge Bruelheide (both partner 1, MLU) Florian Jansen (partner 2, Uni Rostock)

Rationale

Although the global loss of biodiversity is well documented[22], previous analyses of vegetation-plot time series often found no trend in species richness[23,24]. This is referred to as the "biodiversity conservation paradox"[25]. Most time series, however, have revealed strong temporal turnover[26,27], suggesting that change in species composition is the main component of biodiversity change, rather than species loss[13]. Resurveyed vegetation plots provide information on change in community structure (reflected in rank abundance curves[28]), habitat quality (reflected in conservation status, such as the A, B, C scheme of the EU Habitats Directive[29]), ecosystem properties (reflected in community mean indicator values, which were recently compiled for whole Europe[30]) or provision of ecosystem services (such as the provision of nectar for insect pollinators[31,32]). While vegetation-plot resurveys have become important elements in the Swiss monitoring programme for vascular plants[33], they have yet to be implemented in most EU countries. While many member states collect repeated vegetation records in the context of monitoring Annex I habitats, and the vast majority of monitoring programmes in forests are also carried out on permanent plots[7,34], these vegetation-plot data are seldom open-access. In summary, there is a huge untapped potential for using vegetation plot resurveys to support European biodiversity monitoring.

Objectives

The objectives of WP1 are to: 1) Analyse vegetation change by habitats. A major drawback of previous analyses is that they were done without differentiating habitats, although biodiversity trends are clearly habitat-specific[35]. 2) Complement summary metrics of plot-level biodiversity (e.g., species richness, Shannon diversity and evenness) with metrics that capture changes in community structure, habitat quality, ecosystem properties and ecosystem functions[36]. 3) Link habitat-specific time series to the Habitats Directive (HD) reports and integrate the results of 1-3 to provide EBVs for biodiversity monitoring[21]. Our overarching hypothesis is that the information that can be derived from long-term vegetation plot resurvey data differs from that of current monitoring programmes.

Interrelationships between work packages and synergies within MOTIVATE

The information on habitat change will be fed into WP3 and WP4. Together with WP5 and WP7, we will mobilize the underlying raw data of the HD reports, high nature value (HNV) farmland, and national habitat monitoring programmes[32,35] to both boost our time series and allow using the pipelines developed in task 1.1 and 1.2 to facilitate future reports. Together with WP2 and WP3, the habitats' extent and condition will be

assessed throughout their full European range. Together with WP5 and WP7, we will mobilize the underlying raw data of EU monitoring programmes.

Expected results and relevance

WP1 will supplement the trends obtained from more recent national monitoring programmes, in particular with respect to long-term trends, and thus, will increase our knowledge on habitat change. Not only do the current monitoring programmes provide shorter and more recent observations of change, they also lack the details of vegetation resurvey data.

Task 1.1 Analyse vegetation change trends by habitat type (D7, D=Deliverable, in temporal sequence)

Hypothesis: Biodiversity trends are habitat-specific

Approach and methodology: We recently developed an expert system to automatically classify large batches of vegetation plots to habitat types[37,38]. Using this tool, the ReSurveyEurope time series will be matched with EUNIS habitat types and included in the database (see WP5). In addition, information on habitat- and status-specific characteristic species groups from national variants of the Interpretation Manual of European Union Habitats[39] will be harmonized across Europe to develop universal formulas to define the habitats and their respective conservation status. Assessment of habitat quality will follow the established Article 17 reporting scheme but generate standardized habitat designation and quality definitions across Europe.

Task 1.2 Trends in habitat quality, conservation status and functions (D11)

Hypothesis: Changes in habitat quality, conservation status, as well as ecosystem properties and functions, differ from changes obtained from traditional taxonomic biodiversity metrics.

Approach and methodology: Complement taxonomic summary metrics of plot-level biodiversity (e.g., species richness, Shannon diversity and evenness) with metrics that capture changes in community structure (e.g., species' mean ranks of abundance, turnover and nestedness in temporal beta diversity[40]). Applying these metrics to the habitat- and status-specific characteristic species groups of task 1.1, we will be able to derive trends in habitat quality and conservation status. We will also analyse trends in functional diversity to derive information on temporal trends in ecosystem properties and functions[41].

Task 1.3 Link vegetation resurvey data to reporting schemes (D16)

Hypothesis: Vegetation resurvey data provide relevant information not contained in reports of other EU monitoring programmes, and thus, are an important complement to those programmes.

Approach and methodology: We will link habitat-specific time series information from Task 1.1. to the Habitats Directive (HD) Article 17 reports of the EU member states and provide details for future reports which cannot be derived from the current reporting schemes[7,29]. Together with WP5 and WP7, we will mobilize the underlying raw data of the HD reports, HNV farmland, and national habitat monitoring programmes[32,35], using the pipelines developed in 1.1 and 1.2. By integrating the results of tasks 1.1-1.3, we will expand the EBV on "Ecosystem distribution of terrestrial EUNIS habitats".

WP2. Native, neonative and alien species trends

Franz Essl, Stefan Dullinger, Michael Glaser, Bernd Lenzner (all partner 3, Uni Vienna)

Rationale

As a consequence of accelerating environmental change, species' populations are changing in size and geographical distribution[42], while numbers and range sizes of alien species are increasing rapidly[43]. In addition, some native species are expanding their ranges to track environmental change (i.e. neonatives[44]). Yet, little is known about how these trends vary across Europe, and how they correlate with the current distribution of species. It is also little explored to what degree expert assessments of species' threat are reflected in local-scale trends of abundance, occurrence and range size.

Objectives

WP2 aims to evaluate spatiotemporal changes of plant species occurrence and abundance based on the ReSurveyEurope data set. The objectives are to: 1) assess abundance and distribution changes of species with different biogeographic origins, 2) study the abundance changes of species within their native range, 3) investigate how these changes differ between threatened and not threatened species, 4) determine how abundance changes differ between species of different ecological preferences and of different habitats, 5) link the observed changes to drivers (delivered by WP4), and 6) explore land-use and climate change scenarios to compare possible future biodiversity change under a business-as-usual scenario vs. scenarios of ambitious EU biodiversity policies based on the goals of the Post 2020-Global Biodiversity Framework. The analysis will focus on three complementary facets - i.e. abundance in plots, occurrences in plots, and spatial extent of occurrences / area of occupancy[45]. We will study these phenomena across habitats and environmental settings, and

separately for species of different biogeographic origin (natives, neonatives, aliens) and for native species of different conservation status (i.e. threatened versus non threatened species). The spatial analysis in WP2 will generate deeper insight into hotspots and coldspots of biodiversity change in Europe. Thus, this WP will contribute to the EBV on "Species distributions of terrestrial plants".

Interrelationships between work packages and synergies within MOTIVATE

The information on species spatiotemporal changes will be fed into WP 7. Together with WP1 and WP3, the habitats' extent, condition and trends will be assessed throughout their full European range, also outside the Natura 2000 network.

Expected results and relevance

WP2 will provide an assessment of the trajectories of local plant abundance and regional distribution changes in Europe from 1950 onwards. It will also explore how observed changes are modulated by species and region characteristics. This data will allow inferring future plant species abundance and distribution changes, which will inform analyses in WP1, WP3 and WP4.

Task 2.1 Analysing historic species' abundance changes and range extensions (D5)

Hypothesis: Changes in abundance and distribution are linked to the biogeographic status of plants.

Approach and methodology: We will assess historic abundance changes and range extensions in native, neonative[44], alien and invasive (=the subset of alien species with detrimental impacts on biodiversity) species. We will focus on the time period from 1950 onwards, i.e. the phase of rapid and accelerating environmental changes in Europe. To robustly assess these trends, we will investigate individual/total species' losses and gains. Trajectories of species' distribution changes will be explored by using mixed effects regression models with autocorrelation structures[14] and occupancy models[46].

Task 2.2 Investigating changes in historical abundance and distribution of threatened species (D9)

Hypothesis: Non-threatened native species, compared to threatened species, historically had higher abundances and larger range extents in Europe.

Approach and methodology: Threatened species are assumed to be habitat specialists or have restricted ranges, given their affinity to specific environmental conditions[47,48]. Additionally, it has been shown that the threat status of a species can also be explained by its sensitivity or resilience to disturbances, with more sensitive species generally more likely to be in higher threat categories[49,50]. We will use mixed-effect models to relate species national threat status (e.g., using national Red Lists of plants like ref.[51] for Germany) to their degree of specialisation (using Ellenberg Indicator Values[30]) and affinity to disturbance (using Disturbance Indicator Values[52]), as well as changes in abundance and range extent. For analysing how species of different habitats (e.g. grasslands, forests, arable fields) have changed in abundance and range over time, we will group species according to their phytosociological preferences and analyse differences among habitats using mixed models[53].

Task 2.3 Projecting historical changes in plant species abundance and range extent into the future (D14)

Hypothesis: Species of different habitats and ecological preferences respond differently to future environmental change scenarios.

Approach and methodology: Linking species responses to drivers (delivered by WP4), we will explore land-use and climate change scenarios to compare possible future biodiversity change until 2050 under business-as-usual vs. scenarios of ambitious EU biodiversity policies based on the goals of the Post 2020-Global Biodiversity Framework. We will correlate the temporal trends of species incidence and abundance identified in 2.1 to the spatio-temporal patterns of drivers in WP4. Subsequently, we will use these fitted models and scenarios of future development of these drivers to predict how abundance and range of different groups of species (native, neonative, alien; habitat- and conservation status-specific characteristic species, see WP1) will likely develop until 2050.

WP3. Trends in habitat quality and ecosystem properties

Borja Jiménez-Alfaro, Susana Suárez-Seoane, José Manuel Álvarez Martínez (all partner 4, UNIOVI)

Rationale

Biodiversity changes at both the species and community levels are partially linked to the disruption of ecosystem functionalities[54]. In recent years, new efforts have focused on evaluating ecosystem properties[55,56], but these efforts have not yet been implemented in habitat-level monitoring systems that combine ground-based and remote-sensing observations[57]. To advance this field, we still need to develop automatized approaches for habitat mapping and monitoring, integrating ground data information on vegetation and COPERNICUS data. These approaches should explore the potential of remote sensing for ecosystem mapping at high spatial resolution[18,58] and further applications of these maps to detect temporal trends across multiple EBVs.

Objectives

The aim of WP3 is to evaluate spatio-temporal trends of European habitat types at the ecosystem level using COPERNICUS data sets in the areas sampled by ReSurveyEurope. The evaluation of trends will focus on three ecosystem-level EBVs: geographic extent, primary productivity and phenology. The main objectives are: 1) to quantify changes in the extent of the resurveyed habitats at the landscape scale; 2) to calculate trends in the ecosystem productivity of the resurveyed habitats; and 3) to develop and test a protocol for monitoring phenological changes of habitat types based on time series of remote sensing imagery. In all cases, we will quantify habitat trends for the specific time lags covered in each resurvey data point to test how the changes observed with remote sensing can be compared with the changes observed at the plot level.

Interrelationships between work packages and synergies within MOTIVATE

This WP will provide key information about ecosystem-level changes that occurred in European habitats, and how they relate to the results of WP1 (e.g., changes in habitat quality) and WP2 (e.g., changes in species ranges), complementing the information needed in WP7. We will produce new information on landscape units to be used as response variables in WP4 and to contribute the surveys and analyses in WP6.

Expected results and relevance

WP3 will produce information about temporal trends in the area of occupancy and the productivity of European habitats, and the links between these trends and the observed changes in vegetation resurveys. This information is crucial for understanding changes at different spatial scales that are compatible with EBVs at species, community, and ecosystem level. The overall results of WP3 are expected to develop tools for monitoring ecosystem based EBVs comprehensively, and to motivate the integration of remote-sensing indicators in the future monitoring systems of European habitats.

Task 3.1 Mapping the geographic extent of resurveyed habitats with remote sensing (D2)

Hypothesis: Biodiversity changes measured in local plant communities are related to the variation in the extent of the studied habitat, especially when drastic changes occurred at the landscape scale.

Approach and methodology: All analyses will be programmed in Google Earth Engine using either JAVA, PYTHON or R platforms. We will use the coordinates of the resurveyed plots as central points to define areas of interest (AOI) as landscape units of ca. 1 km^2 to track ecosystem EBVs. First, we will sample replicates of the same habitat type (EUNIS level 3 or similar) within each AOI. These replicates will be created by algorithms based on unsupervised classification and multispectral similarities of satellite images (e.g., seeded region growing algorithms [59,60]) to map the extent of the resurveyed habitats in the years of sampling. The calibration of these algorithms with Landsat (or Sentinel) will be optimized to reach the maximum level of comparability among time data points. If possible, we will use Natura 2000 habitat maps available for specific study regions to validate the classifiers and to extend habitat occupancy to larger areas. The trends in habitat extent (i.e., number and spatial aggregation of pixels represented in each AOI) will be compared with the vegetation changes measured in the resurveyed plots.

Task 3.2 Evaluating temporal trends in the productivity of resurveyed habitats (D6)

Hypothesis: Changes in ecosystem productivity can inform about subtle changes measured in vegetation, even when drastic changes were not apparent at the local scale.

Approach and methodology: The AOI defined in task 3.1 will be used to track changes in the productivity of the resurveyed habitats. These changes will be based on spectral indices such as NDVI and SAVI (as surrogates of vegetation productivity) and will be calculated mainly on the temporal lag between available sampling periods. In addition, we will calculate within-year rates of the same indices to evaluate phenological trends in the focal habitats between the survey(s) and resurveys. The expected pixel resolution will change according to the source images, but we expect most calculations to be based on Landsat 5 TM, 8OLI and 9OLI (30 m) for tracking surveys since middle 1980s. Changes in productivity for each focal point and habitat type will be correlated with observed changes in vegetation obtained from WP1 and WP2.

Task 3.3 Developing a remote-sensing framework for monitoring phenological changes (D17)

Hypothesis: Spectro-phenological signatures can provide habitat-specific tools for monitoring the phenology of ecosystems and to anticipate changes at the species and community levels.

Approach and methodology: We will focus on Sentinel 2 data (available since ca. 2017) to create inter-annual phenological curves with high temporal resolution (e.g., monthly) for each habitat type sampled in the resurveyed plots. We will design a comprehensive analytical framework (temporal coherence, gap filling, smoothing, etc.) to create representative spectro-phenological signatures and specific functional metrics for each habitat type in the last five years to define a set of EBVs. This information is expected to improve the resolution and quality of within-year trends calculated in task 3.2 with Landsat. We will test the capability of this information to provide high quality information by selecting a subset of AOI for which we can obtain additional information on recent

changes with known drivers (e.g. drought, forest fires, or succession). We will track disturbances identified in the resurveyed data by combining and harmonizing Landsat and Sentinel time series databases [61,62]. By reviewing the most recent approaches used for similar aims in the literature, we will propose a framework useful for monitoring current to future temporal trends in EU habitats.

WP4. Attribution of drivers and extrapolating to the regional scale with remote sensing

Francesco Maria Sabatini, Alessandro Chiarucci, Duccio Rocchini (all partner 5, UNIBO), Marta Carboni, Alicia Acosta (both partner 6, URoma3)

Rationale

The added value of integrating vegetation plot time-series in current monitoring schemes is undisputable. Yet, vegetation plot time-series represent spatially punctual observations, whose distribution is rarely representative of the geographic space and environmental conditions of the monitored area. To draw conclusive assessments of the biodiversity trends at play, there is the need of upscaling these point observations to the whole region of interest[63,64]. By providing repeated, consistent and comprehensive representations of the Earth surface, remote sensing has the potential to complement and enrich biodiversity monitoring based on vegetation plot time-series and to achieve the needed upscaling[65].

Objectives

WP4's primary objective is to identify the main global change drivers underlying trends observed in our time series, quantify biodiversity loss across Europe, and identify areas of maximum change. Specifically, WP4 will: 1) Gather a set of spatially explicit environmental predictors and land use/land cover proxies based on remote sensing, which relate to biodiversity change across Europe; 2) Calibrate and validate models of biodiversity change across Europe in a spatially explicit way, 3) Create time-resolved large-area maps of plant biodiversity change over the last 35 years, and 4) Identify global change drivers behind observed species and habitat changes, as derived from our time-series.

Interrelationships between work packages and synergies within MOTIVATE

WP4 will complement previous WPs, by linking spatially explicit potential drivers of vegetation change, to the biodiversity change observed at the level of habitats (WP1) and species (WP2). The biodiversity modelling performed in WP4 will also integrate the output of WP5, both by highlighting areas of insufficient sampling density and by pinpointing areas of expected large biodiversity loss. In addition, WP4 will provide and share baseline data with WP2, WP3 and WP5.

Expected results and relevance

WP4 will produce spatially-explicit, temporally-resolved maps of predicted compositional dissimilarity, which can be used to quantify regional biodiversity loss, and highlight areas of maximum biodiversity change. WP4 will also identify the main drivers of change behind the observed trends in habitat-level and species-level diversity. By pinpointing which species and habitats are most threatened by climate or land use change, or a combination of both, WP4 will provide insights on the best way to ensure their long-term conservation.

Task 4.1. Gathering spatial determinants of biodiversity change across Europe.

Hypothesis: Climate and land-use change are the main drivers of biodiversity loss in Europe

Approach and methodology: Task 4.1 will gather and harmonize current and past environmental and land-use spatial data sets related to potential drivers of vegetation changes. It will include both time-invariant environmental predictors (e.g., soil, topography) as well as predictors varying over time such as (a) climatic variables, (b) land-cover & land-use data, and (c) anthropogenic pressures. These datasets will be identified at the European scale, making use of available GIS products (such as SoilGrid[66], Chelsa[67], EarthEnv[68]), but also tracking historical land-use changes for particular time series and particular habitat types (WP3). The current and past layers will form the basis for Task 4.2 and also be made available to the other WPs and partners. Decadal collections of remote sensing imagery will also be assembled as spatially explicit proxies of biodiversity change (see Task 4.3) by the COPERNICUS and LANDSAT programmes (also see WP3).

Task 4.2. Calibrating and validating models for predicting potential biodiversity change (D8)

Hypothesis: Biodiversity change is unevenly distributed across European habitat types

Approach and methodology: Task 4.2 will match vegetation-plot time series to their corresponding pixel or set of pixels in decadal collections of remote sensing imagery in order to calculate their temporal change in the spectral response since 1984[69]. Spectral change trajectories will be used to predict the expected temporal turnover in species composition for other vegetation plots in the study area (obtained from the European Vegetation Archive, EVA[70], see WP5), for which ground-based time series are not available. Spatial predictors from Task 4.1 will be used as environmental covariates. The goal is to develop a three-step model linking

compositional turnover to spectral change where time-series are available (first step), predict compositional turnover based on the spectral change and environmental covariates for those additional vegetation plots for which time-series data are not available (second step), and predict species composition and compositional turnover for the remaining pixels in the study area without compositional data (third step), based on their environmental and spectral similarities to the pixels used in the first and second step. Generalized dissimilarity modelling[71] will be used to calibrate spatially explicit models predicting changes in species composition for every pixel of well-sampled study regions over the last 35 years, given the observed trajectories of spectral and climatic change, and the initial community composition and environmental conditions. Models will be cross-validated, after accounting for the biased distribution of plots[72], and after calculating their area of applicability[73]. Wall-to-wall maps of predicted compositional dissimilarity will finally be created for different time frames (e.g., 1990, 2000, 2010, 2020), and their results will be compared to pinpoint areas of maximum absolute change, and fastest rate of change.

Task 4.3. Identifying global change drivers behind observed biodiversity changes (D12, D17)

Hypothesis: Habitats and species respond differently to climate and land use change

Approach and methodology: Task 4.3 will identify the main global change drivers underlying the biodiversity trends observed in our time series across habitats (WP1) and species (WP2). Relevant drivers will be identified by modeling biodiversity changes as a function of the spatio-temporal changes in the data on drivers gathered in 4.1. We will fit generalized mixed effect models (GLMMs), considering each of the trends in the main metrics of habitats (e.g., richness, Shannon, evenness, see 1.2), and species (e.g., abundance and range extent, see 2.2) as dependent variables, and the trends in climate and land use as predictors. The models will also include interactions between the mean characteristics of the habitats (e.g., EUNIS level I or II) or species (e.g., threat level, native status) and the main drivers of change, to assess whether different categories of habitats or species respond differently to the same driver. Random effects will include the species or habitat identity and the biogeographical region these species or habitats occur in. By comparing the performance of GLMMs with alternative explanatory variables, we will highlight those drivers (e.g., annual evapotranspiration, land use intensity etc.) that have the most important effects on habitat and species temporal trends.

WP5. Vegetation resurvey database, data sharing platform and gap analysis

Milan Chytrý, Jan Divíšek, Klára Klinkovská, Ilona Knollová, Marcela Řezníčková, Lubomír Tichý, Martin Večeřa (all partner 7, MUNI)

Rationale

Europe has a more than 100-year-long tradition of plot sampling of vegetation. However, records from plot observations had been scattered in the literature, unpublished reports, field protocols and, multiple regional or national vegetation-plot databases. To make use of these data for international analyses, two PIs of this proposal (M. Chytrý and B. Jiménez-Alfaro), in collaboration with dozens of European vegetation scientists, started in 2014 the European Vegetation Archive (EVA)[70], and integrated a database of European vegetation plots. The database grew rapidly, and in March 2023, it contained more than 2 million vegetation-plot records from 106 partner databases. The EVA database provided data to 175 projects led by its partners or external researchers, which resulted in 158 publications focusing on both fundamental research (community ecology, biogeography and macroecology) and applications (conservation assessment of habitats). However, data from resurveys were either not included or not tagged consistently in EVA. This gap was closed by ReSurveyEurope. However, this database requires further development. First, more data from under-represented regions and habitat types have to be added. Second, as the data have been so far stored in an offline database using the Turboveg 2 program[74], the development of new online functions is needed to facilitate quick access to the data and analyses.

Objectives

The objectives of WP5 are to: 1) analyse the ReSurveyEurope database to highlight gaps in representativeness across regions and time of initial sampling and resampling; 2) extend ReSurveyEurope by including additional literature data, databases and unpublished records, as well as monitoring data from national conservation agencies; 3) develop an online platform of resurveyed vegetation plots, which will show the plot locations, vegetation or habitat type and survey and resurvey times in an interactive map.

Interrelationships between work packages and synergies within MOTIVATE

The extended and technically more advanced version of the ReSurveyEurope database, which we will prepare in WP5, will be the main source of data for analyses in WP1 and WP2. The data from ReSurveyEurope will also be used in WP3 and WP4. The gap analysis of the ReSurveyEurope database and information from the EVA database will be used in WP6 to define key regions for new resurvey work and specific activities of WP6.

The database platform will be co-designed with stakeholders (WP7) to meet the needs of national conservation agencies and the European Environmental Agency (EEA).

Expected results and relevance

WP5 will develop the largest database of resurveyed vegetation plots in Europe, including all European regions and habitat types. The database will have an online interface that will make it possible to filter data according to different selection criteria. This database will become the most important source of information on vegetation change in Europe, including fine-resolution data from specific locations and detailed information on plant species composition and abundances. It will be at the basis of most of MOTIVATE's analyses, and and also be made available to external users, for research and applications in conservation assessment and monitoring.

Task 5.1 Analysing gaps in the ReSurveyEurope database (D3)

Approach and methodology: The current version of the ReSurveyEurope database will be subject to detailed quality control. Consistency of information across datasets will be maximized by implementing standardized terms in respective database fields. Plot observations will be assigned to EUNIS habitat types at the hierarchical Level 3 using the EUNIS-ESy classification expert system[37,38]. A gap analysis will then be performed with a focus on geographic coverage, representation of different habitat types, environmental characteristics provided by 4.1, survey times and time spans between consecutive surveys. The results will be used in 5.2 and WP6.

Task 5.2 Extending the ReSurveyEurope database by additional data (D16)

Approach and methodology: First, we will use existing international collaborative networks of vegetation scientists who collect vegetation-plot data, particularly the Working Group European Vegetation Survey (EVS). Researchers in this network will be asked to provide data from their fieldwork, literature or unpublished materials. Second, in collaboration with WP7, we will contact national conservation agencies that run monitoring projects and negotiate the inclusion of monitoring data in the ReSurveyEurope database. Third, we will screen the EVA database to detect records from resurveyed plots that are not indicated as such. Fourth, the EVA database will be searched to identify historical plots with accurate coordinates in the areas of the largest data gaps. These plots will be indicated in an online map on the MOTIVATE data-sharing platform, and external collaborators from the EVS or recruited in WP6 will be invited to resurvey plots in their areas of interest and mark them permanently in the field. Resurveyors and data providers will be motivated by an option to participate in MOTIVATE's data analysis and publications. To prevent duplicated survey efforts, the MOTIVATE platform will allow users to register for resurveying particular sites. An online manual detailing best resurvey practices will assure standardization among surveyors.

Task 5.3 Developing an online platform for resurveyed vegetation plots (D4)

Approach and methodology: We will provide public information about the ReSurveyEurope database following the FAIR principles for scientific data management and stewardship while respecting the ownership rules of third-party data contributors according to the approved ReSurveyEurope Data Property and Governance Rules. Each new version of ReSurveyEurope and each data selection for research projects will be assigned a DOI to assure the findability and accessibility of the data and repeatability of the study. Experienced external programmers will be subcontracted to prepare the database structure. A public online platform will be developed that will make it possible to filter data from ReSurveyEurope by regions (using interactive maps), habitat types and time periods. It will be co-designed based on feedback from national conservation agencies to serve their needs.

WP6. Living archives: integrating expert opinions and local stakeholder perspectives

Roger Norum, Jonathan Carruthers-Jones (both partner 8, UOULU)

Rationale

The integration of participatory, citizen science approaches that merge natural and social sciences has been highlighted as key to the delivery of both international and EU biodiversity policy targets[2,75]. Such approaches have also been shown to be critical for carrying out impactful research and generating scientific excellence in biodiversity conservation[76]. Inclusive transdisciplinary research is thus necessary to provide the evidence base for EU policies which aim at achieving effective stakeholder participation in biodiversity conservation[1,77]. WP6 will develop and operationalise mixed methods from the social sciences[78] that capture qualitative expert knowledge and opinions on the accuracy and value of long-term vegetation surveys in a structured way, allowing for comparisons across sites and spatial scales[79]. These data will also be used to improve our understanding of MOTIVATE's quantitative datasets. Analysis of these distinct forms of data will enable more complete characterisations of surveyed habitats and associated biodiversity, and enrich the value of the long-term survey

data. WP6 will also reflect on how this participatory qualitative knowledge can be used to improve the effectiveness of long-term monitoring and how monitoring data are put into practice by decision-makers within and beyond protected area networks.

Objectives

WP6's primary objectives are: 1) capture personal insights of expert surveyors on the survey process and landscape change and how the survey process can be improved; 2) identify regions where resurvey capacity could be increased and build future survey capacity in these areas; 3) knowledge exchange between resurvey experts and the wider community of local stakeholders. WP6 will thus furnish MOTIVATE with insights to improve long-term monitoring and ensure fuller and more just community participation in biodiversity conservation, making it more efficient, inclusive, and generative.

Interrelationships between work packages and synergies within MOTIVATE

Surveyors to be contacted in WP6 will be triangulated from the EVA database addressed in WP5. WP6 also makes use of the gap analysis from WP5, complementing WP5's vegetation resurvey tasks. Data from WP1-4 will be collated and synthesized before being fed into the workshops run in WP6. Outcomes of the workshops and focus groups will be further analysed by WP5 in order to bring together all quantitative and quantitative data created by MOTIVATE.

Expected results and relevance

WP6 will result in: 1) analysis of questionnaire survey data from the experts who originally established the long-term monitoring; 2) in-depth analysis of expert opinion on the effectiveness of the survey methods and future directions to improve the survey process as well as how this information is used to improve the effectiveness of biodiversity conservation; 3) analysis of how the time series could be improved to reflect changes on the ground, as well as key landscape scale drivers of that change; 4) an increased sense of broad ownership (via participatory methods) of the final mapping output, as well as key steps towards building a common community vision for biodiversity conservation. In the broader sense, communication at the workshops of the insights generated by the vegetation time series and the expert questionnaires could potentially address aspects of the phenomenon of the shifting baseline syndrome[80], whereby local communities are not aware of how much species richness and abundance has been lost because impoverished landscapes are culturally normalised by successive generations. Participatory methods also address the contested nature of 'expert'-led conservation policies by creating broader ownership of the final mapping output, making biodiversity conservation more effective and efficient[81,82]. Additionally, in situ research with a broad community of participants compels people to interact with nature, bringing health and wellbeing benefits, and building positive attitudes towards the local environment and its conservation[83].

Task 6.1 Capturing expert surveyors' perspectives on vegetation change and conservation priorities (D3)

Approach and methodology: Human perceptions of habitat characteristics and attitudes to nature conservation will be collected at scale using questionnaires (see e.g. ref.[84]). We will deploy survey questionnaires in local languages to the surveyors who originally established the vegetation plots, as well as to current resurveyors (n= ~500 studies). Questionnaire participants will be determined based on the EVA database and on suggestions from project PIs. This survey will determine: key aspects of species and habitat change in the surveyors' study areas from their own viewpoints; key drivers of these changes; whether these changes are accurately represented in the database; and reflections on future scenarios and effective management strategies to protect and restore habitats. Time required for filling out the survey will be approx. 20 minutes, which, while slightly limiting the amount of detail, will ensure high levels of participation and make the exercise useful at the European scale and for enabling effective scientific comparison of data. Questionnaire translation, distribution and data analysis will be overseen by WP7 and managed locally in each site.

Task 6.2 Sharing expert knowledge and building future expert capacity (D10, D13)

Approach and methodology: Questionaires (6.1) will be complemented and enriched by situated research approaches which explore in depth the various details and nuances of human knowledge at the local scale. We will conduct interviews at the target areas with all available local surveyors along the same transects as used by the vegetation surveyors. This will allow analysis of the relationships between survey data and human insights on the same themes. Walking or 'go-along' methods will be used which generate deeper place-based narratives than sedentary research practices, particularly in terms of narrative 'quantity and spatial specificity to the study area'[85]. They enable comprehensive documentation of stakeholder experiences and their linked environmental narration[86]. This task will commence by identifying four key regions where resurvey capacity could be increased. As a qualitative complement to the quantitative vegetation resurvey tasks in WP5, in 6.2 for each of these new target regions, a local expert surveyor will be paired with a new research assistant (e.g., a local botany student, identified through the project team's broad academic networks) to conduct walking interviews. Via this go-along

method, we will gather from participants concrete information on regional changes during the lifetime of the surveyor. Pairing the local experts with the next generation of botanists will not just be a training opportunity for the students but will also encourage knowledge exchange and critical capacity building across generations.

Task 6.3 Outreach: community awareness and local building capacity (D15)

Approach and methodology: In order to actively include local actors in the research process, this task convenes a series of participatory workshops which will take place in the four key target locations, pinpointed by gap analysis for data coverage with the database. The goal is to build a qualitative complement to the new quantitative vegetation survey capacity. Participants in the workshops will comprise both surveyors and the wider community of stakeholders from both within and outside the target areas. Key local stakeholders will be identified using an initial consultation with local conservation experts followed by an iterative snowballing method[87]. The workshops serve multiple functions. Firstly, they are large meetings with the local community that facilitate sharing with relevant stakeholders both the long-term plot data from other project WPs (WP1-WP4), as well as the expert reflections on change from 6.1 and 6.2. Secondly, they will capture local feedback and reflections on both the findings from the local area and on some of the broader findings of the MOTIVATE project. This will be incorporated into WP4 as part of the wider process of intregating results from the various WPs to improve the survey process going forward. Thirdly, they serve as fieldwork campaigns, to which new potential surveyors will be invited.

WP7. Co-design by involving national conservation agencies

All (everybody responsible for his/her own country), overall coordination: Ute Jandt (partner 1, MLU)

Rationale

The MOTIVATE project is closely linked to the reporting obligations of the Habitats Directive (HD, Council Directive 92/43/EEC) in Europe[5]. The reports on the conservation status for habitats and species under the HD (Article 17[6]), suffer from several shortcomings. There is a lack of consistent and reliable raw data on which the conservation status of habitats and species is based[7]. While some Member States established a special standardised monitoring programme for Article 11 of the HD, others used data from already existing programmes (e.g. habitat mapping, large-scale forest inventories, landscape monitoring). This explains the discrepancies, which have been observed when the reports are compared with other assessments. Furthermore, there is a general lack of data integrating in European monitoring schemes[7].

Objectives

The overarching objective of WP7 is to support the biodiversity monitoring of the member states. WP7 is MOTIVATE's contact point for exchanging data with the national conservation agencies. On the one hand, WP7 will provide resurvey data and derived EBVs tailored to the needs and data formats required by the agencies. On the other hand, WP7 will ask the national agencies for additional vegetation-plot time-series data. Overall, the whole process will be co-designed with representatives of the national agencies and surveyors of the different countries. As a result, WP7 will provide an important component for the future biodiversity monitoring of the EU.

Interrelationships between work packages and synergies within MOTIVATE

WP7 will integrate all outputs of the previous WPs. The main link is to WP5, where the data-sharing platform is designed together with the national agencies (Fig. 3). Similarly, there is a close cooperation with WP6, which captures the human dimensions and aims at local capacity building. In particular, WP7 will benefit from the participatory approaches with experts and non-experts as implemented in WP6.

Expected results and relevance

Integrating trend information on the majority of habitats monitored under the HD with the regular reports of member states will reinforce the national biodiversity monitoring programmes and facilitate reporting of the member states under the HD. Thus, MOTIVATE will 1) improve the assessment of quality and conservation status of habitats, 2) provide quantitative information on trends of habitats and species in Europe and 3) will serve as a blueprint for the whole process of co-designing pipelines of integrating other data than vegetation-plot resurveys into the future European biodiversity monitoring. MOTIVATE will bring in the extremely valuable competences of hundreds of current and future resurveyors of vegetation-plot resurveys into the European monitoring under the HD, in a way that ensures their future engagement into monitoring, at no additional costs for the EU or member states.

Task 7.1 Establishing communications channels and exchange data with the national agencies (D3, D15, D16)

Approach and methodology: Accomplishing all WPs outlined above requires close collaboration with the national agencies responsible for the HD. We will jointly identify those habitat types that have a sufficient

coverage in the ReSurveyEurope database and at the same time are not yet well covered in the monitoring under the HD. We have already established contacts to most European national agencies in the current EuropaBON project (see V.D.). We will organise regular stakeholder meetings, country-wise, to avoid the language problem, and jointly, across countries. We will hold regular online workshops with representatives of the national agencies, the EEA, GeoBON and the European Topic Centre for Biological Diversity and Ecosystems (ETC-BE)(see V.C.). We plan a concluding international high-level workshop in Leipzig, making use of iDiv's facilities (see V.B.).

Task 7.2 Establishing and documenting the process of co-designing pipelines

Approach and methodology: Both the pipelines of how MOTIVATE will provide resurvey data and derived EBVs to the agencies and the process of how these pipelines are co-designed together with these agencies will be documented and published as methods paper in international journals. By integrating vegetation-plot resurveys into the monitoring, the MOTIVATE project will substantially enhance the quality of reporting the species and habitat conservation status for the entire EU. Our ultimate goal is to expand this approach to cover all habitat types, by combining so-far untapped data with remote sensing, modeling and extrapolation methods. This will improve the standardisation of reporting and support national conservation agencies and decision makers.

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V.B. Communication and outreach plan

There will be five different levels of engagement of stakeholders, resurvey scientists and the wider public, mirroring the different experiences, responsibilities and functions of stakeholders from the local to the EU level:

1. Development of an Online Platform for the Wider Public (see 5.3)*:* The MOTIVATE website will include educational elements for the public and give an overview of the project, the objectives, and the expected outcomes. We will make use of social media channels, blog posts, infographics and produce video clips to explain the project and its importance.

2. Questionnaires for Surveyors (see 6.1)*:* Questionnaires sent to the original surveyors will collect data on their experiences, challenges and opinions on key drivers. We will also make these questionnaires available online for easy access.

3. Walking Interviews (see 6.2)*:* A local expert surveyor will be paired with an early career research assistant to conduct walking interviews. This will improve our understanding of the surveyors' views on the observed vegetation changes. We will offer different options to the surveyors to make these interviews as pleasant as possible. We will use social media to also encourage exchange of personal experiences of resurveyors after the interviews.

4. Participatory Workshops (see 6.3)*:* The participatory workshops will serve as a means to share and discuss the results of the MOTIVATE project, and at the same time, will be combined with field work campaigns. The applicants already have close relationships with local stakeholders in many regions, which will be used to identify the locations where these workshops will be held.

5. Implementation of vegetation-plot time series in the monitoring programme under the EU Habitats Directive (see 7.2)*:* We will organise regular online stakeholder meetings with the national agencies of the MOTIVATE's PI countries. MOTIVATE's results will be presented on national conferences. Regular online meetings will be scheduled to discuss the project's findings with our Scientific Advisory Board, the EEA and the European Topic Centre on Biodiversity and Ecosystems (ETC-BE). There will be one concluding international high-level workshop, to which representatives from the EEA, ETC-BE, EuropaBON and GeoBON will be invited.

The societal and policy impact of MOTIVATE will result from these stakeholder interactions. Outcomes of all elements described above will be either summarized in scientific publications, reports on MOTIVATE's homepage, press releases and best practice high-level policy briefs targeted to national and EU agencies.

V.C. Description of project coordination and management

To achieve its objectives, MOTIVATE needs effective and adaptive management procedures (Fig. 4).

The Coordinator. The MOTIVATE consortium will be led by the Coordinator and his deputy. The Coordinator, Ute Jandt (MLU), has long experience with working in large collaborative projects. She had led several projects in the German DFG Priority programme "Biodiversity Exploratories". She coordinated the ReSurveyGermany project and was lead author of high-impact publications in Nature[13] and Scientific Data[12]. She also led WP on the showcases for the Habitat Directives in the EuropaBON project[7]. The position of the Deputy Coordinator will be given to Milan Chytrý (MUNI), ensuring that the EVA database and ReSurveyEurope is represented within the coordinating team. The Coordinator will identify risks, will draft contingency plans and will survey ethical and gender issues.

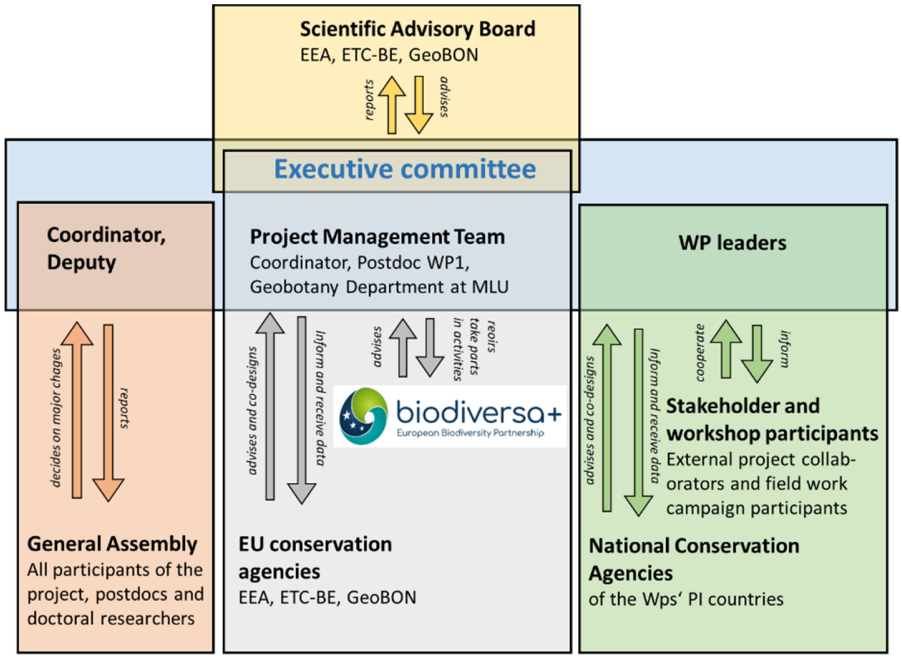


Figure 4: Management structure of MOTIVATE

The Project Management Team will be composed of the post-doc in WP1, who also supports the Coordinator by handling daily administrative and organisational issues, and Helge Bruelheide, full professor at MLU. The Project Management Team will also monitor the project progress, will supervise the preparation and transmission of deliverables and prepare the final report (Deliverable D18).

The Executive Committee is the decision-making body of the project. It is composed of all WP leaders and the members of the Project Management Team. The Executive Committee will steer the overall development of activities and make executive decisions on the direction of the locations of the workshops and field work campaigns.

The General Assembly is composed of all participants of the project, which includes the postdocs and doctoral researchers employed by the project. The General Assembly

will make decisions related to changes in the Consortium Agreement and, if necessary, will suggest expansions and major changes of the MOTIVATE project.

The Work Package Leaders will be responsible for the management of the respective WPs and the achievement of milestones.

The Scientific Advisory Board consists of international scientists who are also members of the main agencies and NGOs involved in biodiversity monitoring at the European level. It currently consists of H. Pereira (GeoBON), M. Watson (ETC/BD), J.-E. Peterson & M. Pallitzsch Lund (EEA).

Stakeholder and workshop participants will become external project collaborators.

Contact persons at the *National Conservation Agencies* of the PIs' countries as well as the *EU Conservation Agencies* will give advice on the project and contribute to co-designing the online platform.

V.D. Interconnection to national and transnational research projects and programmes

The focus of MOTIVATE is the entirety of the European continent, as the underlying ReSurveyEurope database of vegetation-plot resurveys covers all EU and non-EU countries. The project has close links to national activities such as ReSurveyGermany[12] or ReSurveyCzechia (in preparation).

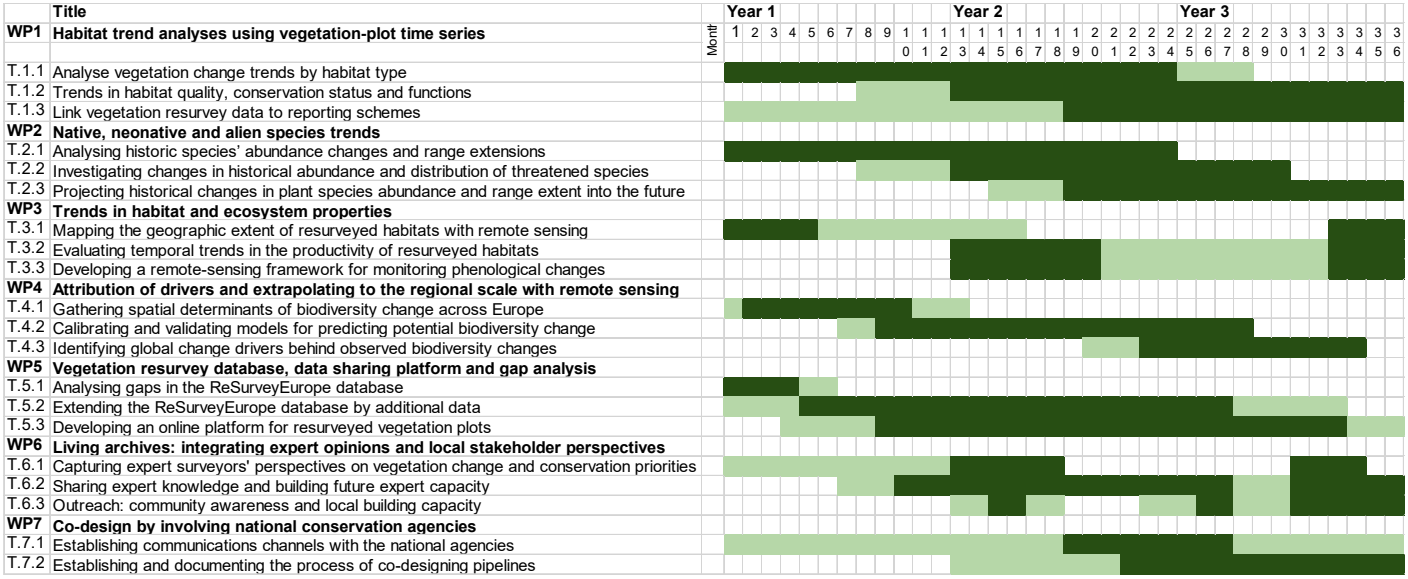
MOTIVATE also seeks integration with products that have been delivered by recent national and European projects, for instance EUMON and EU BON on European monitoring, DIARS on invasive species, GLOBIS-B on EBV workflows and GLOBDiversity on remote-sensing-enabled EBV case studies (see Appendix 5 in[7]). Similarly, results from previous Biodiversa projects as well as national and regional biodiversity monitoring assessments will be systematically compiled and searched for underlying raw biodiversity data. We will also make use of our networks, as the applicants are either principal investigators in key projects on monitoring or are part of scientific advisory boards. MOTIVATE is also linked to global initiatives, such as the global vegetation database initiative sPlot, one of iDiv's strategic projects.

Despite the pan-European focus (in particular of WP1, 2, 3, 5 and 6.1), we focus on certain EU member states in some of theWPs. We expect that we will work in our partners' six home countries because of our intimate knowledge in these regions and our national networks. Mobilising further time series will be done for all of Europe, including EU candidate and EFTA countries, based on the gap analysis in resurvey coverage carried out in WP5. Similarly, the gap analysis of WP5 will be used to identify key regions in which 6.2 will conduct walking interviews in the field. These will take place in the same regions in which we will hold participatory workshops (6.3).

ReSurveyEurope covers all habitat types in both terrestrial and aquatic environments. Therefore, we expect that our results will be relevant for the whole Habitats Directive, except for marine habitats.

V.E. Time schedule and working programme

Gantt chart: the approximate timing of activities. Light green: basic activities (e.g. data aquistion), dark greeen: augmented activities.



V.F. Proposed Data Management Approach

The project adheres fully to relevant standards and best practices in vegetation plot data management, following Data Property and Governance Rules of the EVA and ReSurveyEurope databases. All original raw data in ReSurveyEurope are either already open access or are contributed to the database by the data owners or custodians. In the latter case, the rights of individual data owners (or their representatives) are not affected by the inclusion of their data in the database. This ensures that 1) the exact locations of ongoing monitoring programmes are not made public, preventing external interference; 2) data owners can freely publish analyses of their own data; and 3) data owners are offered the possibility to contribute to joint analysis publication(s), provided they do so through writing, data, analysis, interpretations and conceptual contributions (see the IAVS Code of Professional Ethics). This ensures that the original data remains with the custodians, who further develop and curate national and regional databases.

Still, ReSurveyEurope aims to publish as much as possible of raw vegetation-plot resurvey data. This can be accomplished through major publications with data owners or by publishing only parts of the raw data. All derived products, such as EBVs that describe the temporal trend of time series, will be published open access. Both the publications of original data and of derived products follow the FAIR (findable, accessible, interoperable and reusable) principles. In particular, each version of the database and each data selection provided to a specific research project will be archived and assigned a DOI to guarantee findability and accessibility of the data and repeatability of studies. ReSurveyEurope makes use of the Turboveg platform, the most widespread computer program globally for storing, handling and harmonising vegetation data. The data structure is fully compatible with EVA and other large databases (sPlot) and allows easy export as .csv files.

Relevant project research data and outputs will be deposited and described in disciplinary/institutional/multi-disciplinary public data repositories (e.g. Zenodo, Figshare, iData) that guarantee long term preservation and can attribute persistent unique identifiers (such as DOI, HANDLE, etc.) to the deposited items. They all adopt standard descriptive metadata such as Dublin Core and DataCite Metadata Schema and provide OAI-PMH interoperability to ensure data sets indexing and discoverability. The data repositories are registered in re3data directory and they are harvested by OpenAIRE to guarantee full visibility to the project research outputs within the European Open Science Cloud. As a general rule, research data underlying public reports and scientific publications will be deposited and made openly available immediately at the time of publication of results. The other project data will be deposited by the end of the project.

In the Data Management Plan (DMP, Deliverable D1) we will specify the versions or parts of the data that cannot be openly shared. We will distribute the shareable data and research outputs by adopting licenses that allow full data re-use, such as Creative Commons licenses (CC0 or CC:BY) or OpenDatabaseLicense (OdbL) for data-sets. However, we will specify in the DMP if different re-use licenses need to be applied to specific data/research outputs upon motivations. We do not expect to create any sensitive or restricted data. Generated and used data in the project will be made available at the time of publication of the respective scientific output. We do not expect to create output that might claim any IPR.

The project complies with the EU's General Data Protection Regulation (GDPR) of 27 April 2016, reinforcing principles on the processing of personal individual data. Project researchers carrying out qualitative research on human subjects will abide by the guidelines of the American Anthropological Association Code of Ethics. Written, informed consent will be required of all research participants; information given to the subjects prior to receiving informed consent will describe MOTIVATE, its possible benefits and its possible drawbacks to the subjects, as well as the ability to opt out of participation at any time.