Infrastructure, data, knowledge and services provided by the ten Core Projects of the Biodiversity Exploratories

Content

Introduction

Currently there are ten core projects in the Biodiversity Exploratories (BE). They provide infrastructure, coordination and essential basic data and knowledge on land use, biodiversity and ecosystem processes for all BE-projects, including longer-term monitoring.

Core Projects 1 (Biodiversity Exploratories Office), and 2 (Local Management Teams) provide general and regional coordination, Core Project 4 provides central data management, and Core Project 10 (Synthesis) provides exemplary synthesis across projects according to the guiding questions of the Biodiversity Exploratories, organises courses and synthesis events and provides a helpdesk function on analysis and synthesis.

Below, we summarise the data, knowledge and services provided to the contributing projects by Core Projects 3 and 5-9. For each of these Core Projects we list services provided to contributing projects during the current phase of the BE (2020-2023). Furthermore, we give a short outlook on future services likely to be offered 2023-2026, of course pending projects will be granted.

Service Table Core Project 3: Instrumentation and Remote Sensing

<u>General information:</u> Core project 'Instrumentation and Remote Sensing' collects, prepares, analyses and provides data on the environment. It maintains the network of climate and environmental monitoring stations, covers the remote sensing–based collection of plot and Exploratory wide data (platforms so far: UAVs, airborne, satellite), and processes the data to provide datasets ready for further analyses (ADR) to all projects of the Exploratories. Using tailored analytical database modules which are developed and maintained by this project, and which are available through BExIS (Core 4), it provides on the fly visualization and processing functionality to all projects to support the individual research studies by deploying specifically tailored and spatially explicit variables for research into biodiversity ecosystem functioning and ecosystem services.

Furthermore, this project provides individual consultation and training workshops to help researchers to integrate climate and spatial data into their research.

Table 1: Services provided in the 6th phase (2020 – 2023).

This table provides an overview of services offered by the core project Instrumentation and Remote Sensing in the 6th phase of the Biodiversity Exploratories and whether it is planned to continue these in the next phase.

Land use type	Data set	Main information	Method	ID	Complemented in the new phase
	Analysis ready satellite data	Continuous and regular time series of Copernicus and Landsat satellite images are acquired, pre-processed and provided via RSDB	Data pre-processing and time series interpolation is done using the FORCE processor	30969	Planned to continue
Full coverage of the three Exploratories	High resolution Digital Orthophotos (DOP)	The Digital Orthophotos (DOP) provide georeferenced aerial images including the blue, green, and red bands.	The images are processed by the federal survey administrations and provided by BKG.	30996	Will be updated

Selected grassland EPs and experiments	UAV image collection	RBG & multi-spectral high-resolution images are collected over grassland plots multiple times a year	Images are collected using a standardized workflows including geometric corrections and radiometric calibration	27730	Planned to continue
Selected forest EPs and FOX plots	UAV image collection	High resolution RGB images and point clouds are collected every three years	Images and point clouds are collected using a standardized worksflows	nn	Planned to continue
Full coverage of the three Exploratories	Digital Landscape Model (DLM)	Description of the topographic objects of the landscape in vector format based on the definitions of the ATKIS® object type catalog (ATKIS®-OK).	The DLM is generated by the federal administration surveys.	27728	Will be updated
Full coverage of the three Exploratories	Land cover data	Land cover information using the Corine Landcover classification (CLC) for the years 2021, 2015 and 2018	Land cover data is provided by the BKG	27727	Will be updated
Buffer of 500m around all EPs	Plot Surrounding Maps (PSM)	High resolution thematic maps of the landscape surrounding the EPs including single trees and hedges	Visual interpretation of high-resolution aerial images	nn	Will be updated and extended to larger buffers using deep learning image classification
All EPs of the three Exploratories plus the FOX plots	Plot-Level Climate Data	Climate measurements: – Temperature above and below ground	Climate-station measurements and interactive	19007	Planned to continue (and extended)

		– Radiation upward and downward, longwave and shortwave – Precipitation – Soil moisture – Barometric pressure – Wind direction, velocity, gust – Relative air humidity	processing software ("TubeDB")		
All plots of the three Exploratories	Plot-Level Climate Data	Climate data for public audience: – Temperature above and below ground – Sunshine duration – Precipitation – Soil moisture – Wind direction, velocity, gust	Derived from dataset 19007	24766	Planned to continue
	Management of remote sensing data	Types of managed data: (multiband) (time series) raster, point clouds, vector features, voxels	Software for management, visualization and processing ("RSDB")		Planned to continue and extended
	Processed camera-trap images	Processing of camera-traps image collections with box positions of animal occurrence.	ML based detection, management with software "PhotoDB"		Planned to continue and extended
	Management of large audio data archives		Developed Software "AudioDB"		

In case of application approval, Core project 3 intends to continue several services (as shown in the table 1) and plans to add new or update existing services that have not been offered yet.

Core 3 intents to provide the following services in the 7th phase (2023–2026) of the Biodiversity Exploratories:

- Gigapixel 360° panoramic images and tree crown characteristics for selected forest EPs
- Spectral temporal metrics (STM) for all EPs
- Trees, shrubs and hedges outside forest, crop type maps and grassland moving events of all three Exploratories in full coverage
- Soundscape and bird and bat species occurrence over time for selected forest EPs of all three Exploratories

A detailed description of the research intention and the methods can be found in the Appendix.

Service Table Core Project 5: Plants

General Information: Since the beginning of the Biodiversity Exploratories, the core project Plants addresses the diversity of vascular plants, lichens and mosses in both grassland and forests and so provides long-term data on these diversities. It estimates intraspecific variation of selected functional traits of plants in order to provide an additional level of diversity and provides, as a major ecosystem process, the above-ground productivity of grasslands and understorey vegetation in forests. It furthermore supports the grassland experiments REX & LUX and forest experiments FOX.

Table 2: Services provided in the 6th phase (2020 – 2023). This table provides an overview of all serviced offered in the 6th phase of the Biodiversity Exploratories and whether it is planned to continue these in the next phase. See also https://www.biodiversity-exploratories.de/en/projects/plant-diversity-and-plant-related-processes.

Land use type	Data set	Main information	ID	Complemented in the new phase
Grassland EPs	Vegetation Records for Grassland EPs, 2008 – 2020	Cover of all plants in spring	27386	Planned to continue
Forest EPs	Vegetation Records for 151 Forest EPs, 2009 – 2019	Cover of all plants in spring and summer	26746	Planned to continue
Grassland	Vegetation Records 2020 for new grassland experiment REX and LUX	Cover of all plants in spring	27871	Planned to continue
Forest	Vegetation Records 2020 for new forest experiment FOX	Cover of all plants in spring and summer	Up-coming	Planned to continue
Grassland EPs	Biomass data (all grassland EPs, 2009-2020)	Plant aboveground biomass	26466	Planned to continue
Forest EPs	Understorey biomass	Biomass of all plants in the understorey	Up-coming	

It is planned to continue these services for the upcoming 7th phase (2023–2026).

Service Table Core Project 6: Forest structures

General information: Core project 'Forest structure' focuses on the repeated inventory (every 5-6 years) of all forest plots and provides detailed data on all forest stands. Coordinates for each tree > 7 cm at breast height and its diameter and species identity is available. Aggregated information on the stand level such as stand volume, basal area, stand growth, amount of deadwood, tree species composition is provided as well as specific stand structural attributes. For trees < 7 cm at breast height the core-project provides densities and species identities using size classes. Additional information for EPs includes data on forest management intensity (ForMI and SMI indices), tree harvests, tree mortality, and type and density of tree related microhabitats. Core forest structure also contributed significantly to design, planning and implementation of the FOX gap and deadwood experiment. We developed guidelines for plot selection, inventoried the trees on FOX plots, planned the gap cutting and worked out the procedure for allocating deadwood items. Coordinates, dimensions and species identity of living trees as well as deadwood stem sections is available. Currently, the core-project works on quantifying above- and belowground gap closure in FOX.

Table 3: Services provided in the 6th phase (2020 – 2023). This table provides an overview of all serviced offered in the 6th phase of the Biodiversity Exploratories and whether it is planned to continue these in the next phase. See also https://www.biodiversity-exploratories.de/en/projects/kernprojekt-6-waldstruktur-eigenschaften-struktur-und-bewirtschaftung-der-wald-experimentierplots/

Land use type	Data set	Main information	Complemented in the new phase
Forest EPs	Forest management	Annually resolved harvest quantities for all forest EPs starting from 2009/10.	Planned to continue
Forest EPs	Forest management intensity	Annually resolved management intensity SMI for all forest EPs starting from 2009/10	Planned to continue
Forest EPs	Forest inventory of living trees	Complete list of all single trees (> 7 cm DBH) with their coordinates, sizes and species identities. 3rd forest inventory.	Planned to continue
Forest EPs	Stand properties and stand structure	Stand characteristics, forest structure measures and tree	Planned to continue

		species composition based on the 3rd forest inventory.	
Forest EPs	Forest inventory of dead standing trees	Complete list of trees that died between the 2nd an 3rd forest inventory (> 7 cm DBH) with their coordinates, sizes and species identities.	Planned to continue
Forest EPs	Growth, harvest and natural mortality	Forest growth, harvest and natural mortality for the period between 2nd and 3rd forest inventory	Planned to continue
Forest EPs	Forest inventory of small trees	Density and species identity of small trees (< 7 cm DBH) for diameter classes.	Planned to continue
Forest EPs	Forest inventory of tree regeneration	Density and species identity of tree regeneration < 1.30 m in height for height classes in years 2014/15.	Planned to continue
FOX experiment	Forest inventory of living trees	Complete list of all single trees (> 7 cm DBH) with their coordinates, sizes and species identities.	
FOX experiment	Gap cut trees	Complete list of experimentally logged trees (> 7 cm DBH) with their coordinates, sizes and species identities.	
FOX experiment	Stand properties and stand structure	Stand characteristics, forest structure measures and tree species composition for all FOX plots	
FOX experiment	Experiment factor: Gap size	Size of the gap from terrestrial laser scanning for FOX G and GD plots	Planned to continue
FOX experiment	Experiment factor: Deadwood	Origin and location of deadwood logs for FOX D and GD plots	
FOX experiment	Experiment factor: Deadwood	Volume of deadwood logs placed on FOX D and GD plots	

FOX experiment	Gap closure	Density and composition of tree regeneration for all FOX plots	Planned to continue
FOX experiment	Gap closure	Biomass and composition of roots up to 30 cm depth	Planned to continue

In case of application approval, Core project 6 intends to continue several services (see table 3) and plans to offer some new services.

Core 6 would like to provide the following services in the 7th phase (2023–2026) of the Biodiversity Exploratories for all forest EPs:

- Forest types, stand age, forest management intensity, deadwood properties, microhabitats
- Forest Inventory of living and dead standing trees
- Stand properties and stand structure and stand composition
- Growth harvest and natural mortality
- Forest productivity
- Tree diameter distribution
- Forest inventory of small trees and tree regeneration
- Airborn lidar stand properties: Horizontal heterogeneity, canopy height and canopy cover and summary of high-resolution forest structure parameters
- Terrestrial lidar stand property: Canopy closure in 2014 and 2019, Effective number of layers ENL, Stand structural complexity SSCI
- Abundance of browsed/not browsed of tree seedlings in fenced/unfenced subplots for height classes and tree species identities
- Browsing percentage of tree seedlings and saplings by animals

Further details about the research intention and the methods can be found in the Appendix.

Service Table Core Project 7: Arthropods

General information: Core project 'Arthropods' focuses on the yearly monitoring of arthropod species and ecological processes. We deliver species-level data time series for all grassland EPs. In forests, data are available yearly for VIPs and triennially for all EPs. Ecological processes (seed depletion, dung decomposition, predation) are assessed yearly. The core project also provides data on arthropods in the FOX and the grassland experiments.

We also provide a functional trait database of arthropod specimen collected in the Exploratories.

Furthermore, we have been coordinating the BELongDead wood decomposition experiment and monitor the insects emerging from the logs every year since the beginning.

Table 4: Services provided in the 6th phase (2020 – 2023). This table provides an overview of all serviced offered in the 6th phase of the Biodiversity Exploratories and whether it is planned to continue these in the next phase. See also https://www.biodiversity-exploratories.de/en/projects/core-project-7-land-use-above-ground-arthropod-diversity-and-arthropod-affected-processes/

Land use type	Data set	Main information	Method	ID	Complemented in the new phase
All VIPs	Arthropod mediated processes on VIPs	Ecological processes (seed depletion, dung decomposition, predation) measured annually since 2015	Seed trays, dung packages, dummy caterpillars	e.g. 31114, 31112	Planned to continue
Forest VIPs	Window traps on forest VIPs	Flying insects have been sampled annually since 2008; abundance information on many taxa, species-level data on various taxa, including Coleoptera and Hemiptera	Flight interception traps	22007	Planned to continue
Forest EPs	Window traps on forest EPs	Flying insects have been sampled triennially in 2008, 2011, 2014, 2017, 2020; abundance information on many taxa, species-level data on various taxa, including	Flight interception traps	22008	Planned to continue triennially

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		Coleoptera and Hemiptera			
FOX experiment	Window traps on FOX	Flying insects have been sampled in all FOX plots (including controls) since 2020	Flight interception traps	No data yet	Planned to continue
FOX experiment	Arthropod mediated processes on FOX	Ecological processes (seed depletion, dung decomposition, predation), measured in all FOX plots (including controls) in 2020	Seed trays, dung packages, dummy caterpillars	30904, 30938	Planned to continue triennially
Grassland EPs	Sweep-net samples	Arthropods sampled with sweep-nets since 2008; abundance information on many taxa, species-level data on various taxa, including Araneae, Coleoptera, Hemiptera, Orthoptera	Sweep-net transects	21969	Planned to continue
Grassland experiments	Suction sampling on RPs/UPs	Arthropods sampled with suction sampling in all RPs/UPs (including controls) in 2021; identification by meta-barcoding	Biocoenometer	No data yet	Planned to continue biannually
Grassland experiments	Arthropod mediated processes on RPs/UPs	Ecological processes (seed depletion, dung decomposition, predation), measured in all RPs/UPs (including controls) in 2021	Seed trays, dung packages, dummy caterpillars	31115, 31113	Planned to continue biannually
All plots	Arthropod trait data	Traits have been measured and collated from literature for almost all collected species	Morphological measurement; life-history from literature	e.g. 31122, 1870, https://datadryad.org/stash/dataset/doi:10.5061/dryad.2fqz612p3	Planned to continue
Belong-dead	Saproxylic beetles and other taxa	Specimens collected with deadwood eclectors from 2010-2021	Deadwood eclectors	31123, 31124	Planned to continue until logs are decayed

Belong–dead	Coordination	Information on who did what when and where on the log, since 2010 BELongDead maintenance	Information compiled through questionnaires and in 2 meetings per year, photos of logs, marking of logs	e.g. 18726, 16429, 16386	Planned to continue
Belong–dead	Wood decay	Weight loss of 1140 BELongDead logs since 2010 in 29 VIPs	Sampling and measurements every 3 years (last: 2021)	e.g. 27126	Planned to continue
Grassland EPs	LUI	Land–use intensity index and components, LUI niche for species	Development and enhancement of methods and tools to analyse land–use intensity and effects	e.g. 25086	Planned to continue

It is planned to continue these services for the upcoming 7ᵗʰ phase (2023–2026).

Service Table Core Project 8: Microorganisms

General Information: Core project Microorganisms is in charge of long-term monitoring of the biodiversity of soil microorganisms for all plots and large-scale experiments (in the current phase FOX, REX I + II and LUX). Inventories based on high-throughput amplicon sequencing are available for fungi (based on ITS2 gene marker), arbuscular mycorrhiza fungi (based on 18S rRNA marker gene) and bacteria (V3 region of the 16S rRNA gene marker). Archaeal inventory is based on shotgun metagenomics sequencing for selected plots. Metagenomes also provide inventories of functional genes as well as reconstructed MAGs (metagenome assembled genomes) of highly abundant taxa. Apart from the provided data, Core project Microorganisms is responsible for long term storage of soil samples and extracted nucleic acids (DNA and RNA) for future work. Facilitating access to sequencing (Illumina, Pacbio) and assisting with molecular work and bioinformatics after next generation sequencing are also services provided.

Table 5: Services provided in the 6th phase (2020 – 2023). This table provides an overview of all serviced offered in the 6th phase of the Biodiversity Exploratories and whether it is planned to continue these in the next phase. See also https://www.biodiversity-exploratories.de/en/projects/species-diversity-and-community-composition-of-soil-microorganisms-in-grassland-and-forest-ecosystems-along-land-use-gradients-3/

Land use type	Data set	Main information	Method	ID	Complemented in the new phase
EPs	Soil Fungi	List of ASVs present in all samples from 2021 soil sampling campaign.	Sequencing of ITS2 (DNA-based)	In progress	Planned to continue
	Soil arbuscular mycorrhiza Fungi	List of ASVs present in all samples from 2021 soil sampling campaign.	Sequencing 18S rRNA (DNA-based)	In progress	Planned to continue
	Soil Bacteria	List of ASVs present in all samples from 2021 soil sampling campaign.	Sequencing of V3 region of 16S rRNA (RNA-based)	In progress	Planned to continue
	Metagenomes/ soil archaea (selected EPs)	List of functions present in a subset of samples from 2017 and 2021	Shotgun sequencing of DNA	In progress	Planned to continue

		soil sampling campaign			
	Soil samples	Storage and provision of all samples from 2021 soil sampling campaign	Freezing at – 80°C	Done	Planned to continue
	Nucleic acid extracts	Extraction, storage and provision of extracted nucleic acids from all samples of the 2021 soil sampling campaign	Phenol–chlorophorm based RNA and DNA extraction	Done	Planned to continue
FOX	Soil Fungi	List of ASVs present in all samples from 3 sampling points: Jan 2020, Nov 2020 and May 2021	Sequencing of ITS2 (DNA–based)	In progress	Planned to continue
	Soil arbuscular mycorrhiza Fungi	List of ASVs present in all samples from 3 sampling points: Jan 2020, Nov 2020 and May 2021	Sequencing 18S rRNA (DNA–based)	In progress	Planned to continue
	Soil Bacteria	List of ASVs present in all from 3 sampling points: Jan 2020, Nov 2020 and May 2021	Sequencing of V3 region of 16S rRNA (DNA–based)	In progress	Planned to continue
	Metagenomes/ soil archaea (selected plots)	List of functions present in a subset of samples from May 2021	Shot gun sequencing of DNA	In progress	Planned to continue
	Soil samples	Storage and provision of all samples from 3 sampling points: Jan 2020, Nov 2020 and May 2021	Freezing at – 80°C	Done	Planned to continue
	DNA extracts	Extraction, storage and provision of extracted nucleic acids from all samples	Phenol–chlorophorm based DNA extraction	Done	Planned to continue

		from 3 sampling points: Jan 2020, Nov 2020 and May 2021			
REX I+II / LUX	Soil Fungi	List of ASVs present in all samples taken in May 2021	Sequencing of ITS2 (DNA–based)	In progress	Planned to continue
	Soil arbuscular mycorrhiza Fungi	List of ASVs present in all samples taken in May 2021	Sequencing 18S rRNA (DNA–based)	In progress	Planned to continue
	Soil Bacteria	List of ASVs present in all samples taken in May 2021	Sequencing of V3 region of 16S rRNA (DNA–based)	In progress	Planned to continue
	Metagenomes/ soil archaea (selected plots)	List of functions present in a subset of samples from May 2021	Shot gun sequencing of DNA	In progress	Planned to continue
	Soil samples	Storage and provision of all samples from May 2021	Freezing at –80°C	Done	Planned to continue
	DNA extracts	Extraction, storage and provision of extracted nucleic acids from all samples from May 2021	Phenol–chlorophorm based DNA extraction	Done	Planned to continue

In case of application approval, Core project 8 intends to continue several services (as shown in Table 5) and plans to add new services that have not been offered yet.

Core 6 intents to provide the following additional services in the 7th phase (2023–2026) of the Biodiversity Exploratories:

- EPs: Soil fungi, Soil arbuscular mycorrhiza Fungi, soil Bacteria, Metagenomes, Soil samples and nucleic acid extracts from all samples of the 2023 soil sampling campaign
- FOX: Soil fungi, Soil arbuscular mycorrhiza Fungi, soil Bacteria, Soil samples and DNA extracts in all samples from May 2023
- REX/LUX: Soil fungi, Soil arbuscular mycorrhiza Fungi, soil Bacteria, Soil samples and DNA extracts from May 2023

A detailed description of the research intention and the especially of the methods can be found in the Appendix.

Service Table Core Project 9: Soil

<u>General information:</u> The Core project 'Soils' focuses on (1) the provision of basic information on soil properties and functions at all experimental plots (EPs) and common experimental platforms (FOX, REX, LUX); (2) monitoring of aboveground litter fall in forests and of organic carbon and extracellular enzyme activities in soils; (3) coordinating joint activities of soil groups including the joint soil sampling campaign at the beginning of each phase (see below) to facilitate logistics and to maximize synergies and comparability of results; (4) maintaining a central archive with air dried samples of all aboveground litter and soil samples from previous sampling campaigns.

Table 6: Services provided in the 6th phase (2020 – 2023). This table provides an overview of all services offered in the 6th phase of the Biodiversity Exploratories and whether it is planned to continue these in the next phase. See also https://www.biodiversity-exploratories.de/en/projects/linking-biodiversity-and-land-use-to-soil-functions

CR: will be continued but in reduced form with focus on FOX plots and EP controls
C: will be continued as part of the joint soil sampling campaign;
NC: one-time analysis; will probably not be directly repeated in next phase

Land use type	Main information	Data set	Method	ID BEXIS	new phase
Aboveground litter fall					
Forest EPs and FOX plots	Aboveground litter fall is collected three times per year (early spring, summer, late autumn) with litter traps; samples are separated into leaves, twigs, fruits and leaves	Aboveground litter fall: total mass per plot and sampling time; C, N and S contents	gravimetric elemental analyses	20126 (EPs since 2015) 20127 (EPs since 2015)	CR CR
Mineral soil 0–10 cm, samples collected during joint sampling campaign in Mai 2021					
EPs forest, grassland	Soil characterization	Field protocols pH water content bulk density	Description 0.01 M CaCl$_2$ gravimetric	ongoing 31074 31075	C C C C

EP	Category	Parameter	Method	Status	Code
		total C, N, S	elemental analyses	ongoing	C
		organic C	elemental analyses	ongoing	
		OC stocks		ongoing	C
				ongoing	
		clay content	estimated from residual water		C
				ongoing	C
		Olson P	Olson extraction		NC
				ongoing	
FOX	Soil characterization	Field protocols	Description	ongoing	C
		pH	0.01 M CaCl$_2$	ongoing	C
		water content	gravimetric	ongoing	C
		bulk density		ongoing	C
		total C, N, S	elemental analyses	ongoing	C
		organic C	elemental analyses	ongoing	C
			estimated from residual water	ongoing	C
		clay content			
		Olson P	Olson extraction	ongoing	NC
REX, LUX grassland	Soil characterization	Field protocols	Description	ongoing	C
		pH	0.01 M CaCl$_2$	ongoing	C
		water content	gravimetric	ongoing	C
		bulk density		ongoing	C
		total C, N, S	elemental analyses	ongoing	C
		organic C	elemental analyses	ongoing	C
		OC stocks		ongoing	C
		clay content	estimated from residual water	ongoing	C
				ongoing	
		Olson P	Olson extraction		NC
EPs forest and FOX	Soil functions	Extracellular enzyme analyses (acid Phosphatase, beta-glucosidase, sulfatase, N-acetyl-	Fluorescent substrates	ongoing	C

		glucosminidas)			
		Cmic, Nmic	Chloroform fumigation extraction	ongoing	C

Special contributions to FOX experiment in forest

FOX	Soil sampling and characterization before harvest of trees in winter 2019/20	Field protocols pH total C, N, S organic C OC stocks clay content (est.)	as above	ongoing	NC
FOX	Soil sampling and characterization in autumn 2020	Field protocols pH total C, N, S organic C OC stocks	as above	ongoing	NC
FOX	Soil function Decomposition	Teabag decomposition	Teabags with rooibos and green tea below litter layer and 5 cm into mineral soil; 3 months field incubation in summer/autumn 2021	ongoing	NC

Sampling of the litter layer in forests during all sampling campaigns

Forest EPs, FOX	Characterization of litter layer	Total mass total C, N, S	elemental analyses	ongoing	C

Description of the general joint soil sampling campaign:

The sampling campaign is traditionally performed in May of the first year of a new funding period (had to be postponed in the ongoing phase due to Covid 19 restrictions). It takes about three weeks and is done in parallel in all three Exploratory regions and covering all EPs and (unless there is no demand) also the experimental plots of FOX, REX and LUX. It is coordinated by the core projects Soil, Microbiology and BEO but requires

active contributions from many soil related contributing projects so that we get enough people for this large endeavour. Thus, every project requiring soil samples should contribute 3 team members for the time of sample collection. Soils will be collected following the same protocol as in previous years to enable monitoring activities (data set 31037).

Briefly, the focus is on the biologically most active top 10 cm of the mineral soil. In forests also samples of the litter layer are collected. Typically on all EPs one mixed sample per plot is obtained based on samples taken with a corer (5 cm diameter) from 14 locations along two transects (20 m in grasslands/ 40 m in forests) on the plots. Samples are directly mixed in the field and roots and stones sorted/sieved out (and collected for contributing projects on demand) directly in the field laboratory. Subsamples for each project will be separated, and stored as required at 4°C or –20°C before being shipped to individual institutions. Freezing samples in liquid N_2 is possible but requires separate planning.

For the experimental plots also mixed samples from topsoils are obtained and processed but with a reduced number of samples due to smaller plot sizes.

Details and individual demands and requirements of each project will be discussed during the general assembly before (typically in February).

In case of application approval, Core project 9 intends to continue several services and plans to offer two new services.

Core 9 would like to offer the analysis of microbial biomass (Cmic) in the REX, LUX plots as an additional service in the 7th phase (2023–2026) of the Biodiversity Exploratories. In addition to the general joint soil sampling campaign, Core 9 intends to complement this by additionally examining the entire soil profile to a maximum depth of 1m.

Description of the planned total soil profile sampling campaign:

While the topsoil is the biologically most active zone of the soil, rooting depth goes in forests and grasslands reaches much deeper, so that also subsoils need to be considered for example for ecosystem nutrition or soil carbon sequestration. Therefore, we aim at complementing the traditional soil sampling campaign on the EPs, which is restricted to topsoils, by an additional sampling campaign where samples down to a maximum of 1m will be collected. The idea is to take larger soil cores (around 10 cm diameter) and produce mixed samples of five cores per plot for several depth increments (suggestion for now: 0–10 cm, 10–30 cm, 20–40 cm, 40–60 cm, 60+ cm). Depending on the number of contributing projects and the personal we will be able to get, sampling will take several weeks, probably months. Therefore, details on sampling time, priorities and procedures will be discussed during the general assembly and as far as possible adjusted to the demands of contributing projects.

Appendix

Table A1: Detailed description of the additional services that Core 3 intents to provide in the upcoming 7th phase (2023–2026).

Land use type	Data set	Main information	Methods
Selected Forest EPs	Gigapixel 360° panoramic images	We will collect gigapixel 360° panoramic images to document the forest structure and plant phenological dynamics	Data is collected using an automatic panorama head piXplorer from Clauss
Selected Forest EPs	Tree crown characteristics	Detailed information of the tree crown shape and size will be provided at the single tree level for the selected EP	We will use Airborne Laser Scanning (ALS), Terrestrial Laser Scanning (TLS), UAV images and field observations to observe the tree crown characteristics.
All EPs	Spectral Temporal Metrics (STM)	Remote sensing based Spectral Temporal Metrics (STM) to characterize the phenological developments	STMS will be derived from the Sentinel-2 time series using the FORCE processor.
Full coverage of the three Exploratories	Trees, shrubs and hedges outside forest	We will provide maps with single trees, shrubs and hedges for the entire area of the Exploratories	Based on the existing landscape maps of the plot surroundings we will train deep neutral networks to classify high resolution digital Orthophotos (DOP)
Full coverage of the three Exploratories	Crop type maps	Annual maps with information on the crop types will be provided	In cooperation with the Johann Heinrich v. Thünen-Institut (TI)
Full coverage of the three Exploratories	Grassland moving events	Annual maps showing the timing and number of moving events will be provided as an indicator of land use intensity	In cooperation with the Johann Heinrich v. Thünen-Institut (TI)

Selected forest EPs of all three Exploratories	Soundscape	High dimensional numeric vectors characterize content of audio samples. Building up on this basic product concrete characteristics can be derived, e.g. non natural disturbance levels created by machine learning approaches.	(Ultra-)sonic recorders "AudioMoths" and software to create "fingerprints" of the sound environment
Selected forest EPs of all three Exploratories	Bird and bat Species occurrence over time	The species occurrence over time allows to observe shifts of species activity over the years, e.g. breeding season.	(Ultra-)sonic recorders "AudioMoths" and ML for automatic species detection
Tests plots on cropland land use	Climate measurements: - Temperature above and below ground - Radiation upward and downward, longwave and shortwave - Precipitation - Soil moisture - Barometric pressure - Wind direction, velocity, gust - Relative air humidity	Climate-station measurements and interactive processing software ("TubeDB")	Temporary nstrumentation and added information from satellite data.

Table A2: Detailed description of the additional services that Core 6 intents to provide in the upcoming 7th phase (2023–2026).

Land use type	Data set	Main information	ID
Forest EPs	Forest types	Harmonised forest types	17706
Forest EPs	Stand age	Stand age of all forest Eps	17486
Forest EPs	Forest management intensity	Forest management intensity measured by the SMI and ForMI indices and their dynamics for all forest Eps. Two points in time.	SMI: 25046 ForMI: 24646
Forest EPs	Deadwood properties	Deadwood items including item volumes, deadwood type, decomposition stage and item source from two deadwood inventories for all forest Eps	2012: 24546 2017/18: 24526
Forest EPs	Microhabitats	Microhabitat abundance and diversity for all forest EPs based on a microhabitat inventory.	2017/18: 23646
Forest EPs	Forest inventory of living trees	Complete list of all single trees (> 7 cm DBH) with their coordinates, sizes and species identities. Years 2009/10 and 2014/15.	2009/10: 18268 2014/15: 21426
Forest EPs	Forest inventory of dead standing trees	Complete list of trees that died between the 1st and the 2nd forest inventory (> 7 cm DBH) with their coordinates, sizes and species identities.	23368
Forest EPs	Stand properties and stand structure	Stand characteristics, forest structure measures and tree species composition based on the 1st and 2nd forest inventories in the 2nd and 4th phases of the exploratories, respectively. Years 2009/10 and 2014/15.	2009/10: 22786 2014/15: 22766
Forest EPs	Stand composition	Stand composition from forest inventories (abundance, basal area, crown projection area and volume). Years 2009/10 and 2014/15	2009/10: 18269, 18270,18271, 2014/15: 22907

Forest EPs	Growth, harvest and natural mortality	Forest growth, harvest and natural mortality for the period between 1st and 2nd forest inventory	22846
Forest EPs	Forest productivity	Volume productivity of all forest Eps	22868
Forest EPs	Tree diameter distribution	Tree diameter distribution of the forest EPs for 4 cm diameter classes	19106
Forest EPs	Forest inventory of small trees	Density and species identity of small trees (< 7 cm DBH) for diameter classes in years 2014/15.	26806
Forest EPs	Forest inventory of tree regeneration	Density and species identity of tree regeneration < 1.30 m in height for height classes in years 2014/15.	26787
Forest EPs	Airborn lidar stand properties	Horizontal heterogeneity, canopy height and canopy cover from airborne LIDAR for all forest EPs	22927
Forest EPs	Airborn lidar stand properties	Summary of high resolution forest structure parameters from airborne lidar LIDAR for all forest EPs	17066
Forest EPs	Terrestrial lidar stand property	Canopy closure and of all forest EPs in 2014 and 2019.	27828
Forest EPs	Terrestrial lidar stand property	Effective number of layers ENL of all forest EPs in 2014 and 2019	27826
Forest EPs	Terrestrial lidar stand property	Stand structural complexity SSCI of all forest EPs in 2014 and 2019	27827
Forest EPs	Browsing	Abundance of browsed/not browsed of tree seedlings in fenced/unfenced subplots for height classes and tree species identities.	20039
Forest EPs	Browsing percentage	Browsing percentage of tree seedlings and saplings by animals (mostly ungulates)	20347
Forest EPs	Synthesis dataset	Assembled species and forest management information from Hainich forest EPs (2008–2011), used for syntheses project #8	21526

Table A3: Description of additional services that Core 8 intends to provide for the upcoming 7th phase (2023–2026).

Land use type	Data set	Main information	Method
EPs	Soil Fungi	List of ASVs present in all samples from 2023 soil sampling campaign.	Sequencing of ITS2 (DNA-based)
	Soil arbuscular mycorrhiza Fungi	List of ASVs present in all samples from 2023 soil sampling campaign.	Sequencing 18S rRNA (DNA-based)
	Soil Bacteria	List of ASVs present in all samples from 2023 soil sampling campaign.	Sequencing of V3 region of 16S rRNA (RNA-based)
	Metagenomes	List of Viruses and Phages present in all samples from 2023 soil sampling campaign.	Shotgun sequencing of DNA
	Soil samples	Storage and provision of all samples from 2023 soil sampling campaign	Freezing at –80°C
	Nucleic acid extracts	Extraction, storage and provision of extracted nucleic acids from all samples of the 2023 soil sampling campaign	Phenol-chlorophorm based RNA and DNA extraction
FOX	Soil Fungi	List of ASVs present in all samples from May 2023	Sequencing of ITS2 (DNA-based)
	Soil arbuscular mycorrhiza Fungi	List of ASVs present in all samples from May 2023	Sequencing 18S rRNA (DNA-based)
	Soil Bacteria	List of ASVs present in all samples from May 2023	Sequencing of V3 region of 16S rRNA (DNA-based)
	Soil samples	Storage and provision of all samples from May 2023	Freezing at –80°C
	DNA extracts	Extraction, storage and provision of extracted nucleic acids from May 2023	Phenol-chlorophorm based DNA extraction
REX I+II / LUX	Soil Fungi	List of ASVs present in all samples all samples from May 2023	Sequencing of ITS2 (DNA-based)
	Soil arbuscular mycorrhiza Fungi	List of ASVs present in all samples from May 2023	Sequencing 18S rRNA (DNA-based)
	Soil Bacteria	List of ASVs present in all samples from May 2023	Sequencing of V3 region of 16S rRNA (DNA-based)
	Soil samples	Storage and provision of all samples from May 2023	Freezing at –80°C
	DNA extracts	Extraction, storage and provision of extracted nucleic acids from all samples from May 2023	Phenol-chlorophorm based DNA extraction