TITOLO DI DOTTORATO:
BIODIVERSITY

PH.D. TITLE:
BIODIVERSITY

COORDINATORE / *COORDINATOR*
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TEMATICHE DI RICERCA / *RESEARCH TOPICS*

Biodiversity Loss: A Global Problem - Biodiversity, the diversity of life on Earth, is an essential contributor to human life such as crop pollination, climate regulation, water and air filtration, and disaster-risk mitigation. However, biodiversity is declining more and more rapidly, mainly due to the pressure of human activity on ecosystems. According to recent data, human activities might be responsible for a significant alteration of biodiversity quantifiable in about 70% of the biodiversity loss in terrestrial, freshwater and marine ecosystems. The main human-caused drivers of biodiversity erosion, land and sea use, overexploitation of natural resources, pollution, and sudden dispersal of alien species, are believed to be the main causes for the extinction of several thousands of plant and animal species. Based on scientific evidence, IPBES (2022) shows that this situation is further exacerbated due to the temperature increase (IPCC 2022) caused by climate change which could threaten over 20% of species globally, thereby claiming for decisive political actions aimed at contrasting this erosion. The loss of biodiversity is also affecting Italy and the entire Mediterranean area. The risk of extinction in Mediterranean biodiversity is estimated by a WWF report (2020) at about 50% for vertebrates, 20% for mammals, 25% for birds, 64% for amphibians, 40% for of aquatic plant species. The evidence of the problem is now widely perceived as urgent to such an extent that even the Italian Parliament has recently (2022) approved two articles (9 & 41) of the Constitutional Chart with which the environment and biodiversity assume a constitutional value and consequently must be protected as an asset of public interest and "in the interest of future generations". The scientific community, therefore, must address the problem of biodiversity erosion, ecosystem functioning and the effects on ecosystem services and human well-being and consequently there is an urgent need to increase both the degree of knowledge and to develop innovative methodologies in the study of the causes, also exploiting new enabling technologies. A new generation of researchers will form the basis, the fulcrum at a national level, to face the challenges and to respect the foundations laid down in our Constitution. In this context, it therefore makes sense to tackle the problem of biodiversity loss "at the country level" in a systemic way, even more so if we think of Italy's central role in the Mediterranean basin, its wider coastal extension, its latitudinal, altitudinal and ecological diversity and in the presence of the intellectual, social, legislative and economic resources to guide the other coastal countries towards a common strategy.

The National PhD School in Biodiversity, for which the University of Palermo plays the role of coordination, arises from a joint action of universities, public research bodies and private companies, most being part of the National Biodiversity Future Center (NBFC). The actions of the NBFC will work to align the Italian policy on biodiversity, reaching the objectives of the "European Strategy for Biodiversity to 2030" in three years and among the objectives there is also the transfer of all the research and knowledge produced into training actions. The present proposal of a National PhD School in Biodiversity stems from this objective. The 2030 strategy aims to protect at least 30% of marine and terrestrial ecosystems in Europe and promote the restoration of at least 15% of habitats and related ecosystem processes, in order to reverse ecosystem degradation and biodiversity loss. The vision of the biodiversity community is based on the most modern socio-ecological vision: healthy and functioning ecosystems - thanks to the role played by biodiversity - represent the fundamental property for sustaining life on our planet. If the ecological functions and the underlying processes normally expressed in conditions of absence of human disturbance are eroded or lost due to human

stressors, it is possible to observe measurable cascading effects that influence the supply of ecosystem goods and services with severe impairment of human well-being. Such a scientific and ecological vision does not exclude the human species a priori from ecosystem processes but explores the sustainability of possible solutions to admit the human presence in ecosystems, and to manage the effects of human action in line with the UN SDG Goals for 2030. Thus, biodiversity is not only seen as a further source of business opportunities according to the linear extractive logic that characterizes the capitalism of our time, but it is thought of as a value in itself, generating well-being through its ability to provide ecosystem goods and services. PhD students in Biodiversity will be protagonists of future achievements in the study of the role of biodiversity on ecosystem functioning in all habitats, from deep sea to upper mountains, and on the quality of human life.

The National PhD program in "Biodiversity" will be divided into 6 curricula; common elements among them will be: i) a strong (trans)interdisciplinary footprint in devising innovative solutions to assess, monitor, conserve, protect and restore marine, terrestrial and urban biodiversity across all national sites; ii) the conceiving and the application of highly innovative technological and digital solutions in the field of biodiversity and for the estimation of ecosystem vulnerability, supported by Key Enabling Technologies (KET), which stimulates the Italian scientific and industrial leadership in this field; iii) the adoption of new predictive modelling strategies, new early warning technologies, tools suitable for supporting functional biodiversity and ecosystem resilience; iv) the development of digital platforms to acquire new knowledge on biodiversity, making it available to a large community of male and female researchers, and to provide conservation solutions that pass through the digitization of naturalistic museum collections, the development of national archives of molecular information, etc.; v) innovative monitoring tools based on robotics, artificial intelligence, IoT and ICT; vi) the analysis and understanding of strategies for the enhancement of intellectual property, open innovation and technology transfer, entrepreneurial experiences that contribute to economic sustainability in the field of monitoring, conservation, restoration and enhancement of biodiversity.

CURRICULA (Italiano / *English*):

Curriculum 1 - *Marine biodiversity and innovative technological solutions; ;* The CV aims at studying the Italian marine systems characterized by a combination of biodiversity hotspots integrated into a "human marine landscape" to provide innovative strategies for transboundary cooperation in the Mediterranean for biodiversity conservation and the development of international protocols for exporting monitoring and conservation practices in line with the EU 2030 plan. The CV combines observational, descriptive, and manipulative research to harmonize and integrate databases on coastal-marine biodiversity, monitor marine biodiversity at various levels of the ecological hierarchy, experimentally assess the vulnerability of Mediterranean habitats to global and local environmental change drivers, and build future scenarios of species distribution, ecosystem structure, composition, and functioning to define conservation scenarios for achieving EU objectives. The projects may involve concrete actions to reduce human pressures (e.g., tourism, fishing, and aquaculture, etc.) on marine biodiversity by experimenting innovative solutions to mitigate biodiversity loss. Studies will focus on the relationships between biodiversity, ecosystem processes, and functioning, natural capital formation, and the provision of ecosystem goods and services. The application of new KET (e.g., AI/ML methodologies to enhance current limitations in detecting human impacts on marine ecosystems), strengthening the protection and management of marine biodiversity with new methodologies and strategies, blue biotechnologies to support the sustainable valorization of marine biomass following a circular approach, and the development and experimentation of restoration actions in critical marine habitats, from intertidal zones to the deep sea, are also previsioned. The activities should generate scientific research to support the achievement of SDG 14.

Curriculum 2 - *Terrestrial and freshwater biodiversity and innovative technological solutions;* The CV aims at addressing issues concerning terrestrial and freshwater ecosystems, the geographic distribution of communities in various Italian habitats, and the effect of human and environmental stressors. The main goal is to define appropriate strategies for the conservation and monitoring of terrestrial biodiversity and inland waters by adopting innovative transdisciplinary approaches and combining scientific methodologies with innovative KET such as genetics, molecular biology, electron microscopy, and digital tools (e.g., AI/ML). This will involve building databases and implementing biodiversity collections and multilevel data-driven modeling approaches using comprehensive field data collection and multi-omics data. The approach used should involve interdisciplinary and multidisciplinary research to elucidate functional relationships within biodiversity

and ecological responses to changing environmental conditions in representative natural habitats of terrestrial and freshwater ecosystems. The studies should consider different eco-regions such as forests, grasslands, mountain habitats, river basins, and lakes. The proposed projects should consider innovative technologies to integrate data from various sources into a "data lake" used for a wide range of activities, including visualization, advanced analysis, modeling strategies, ML, Digital Twins, and monitoring technologies. The projects should: i) contribute to achieving the goals of the 2030 Agenda (SDG 15) by halting biodiversity loss; and ii) provide knowledge to improve services and policies for a circular economy with low carbon emissions, such as net carbon emission certificates, economic quantification of ecosystem services, productive value chains, environmental insurance, and payment for ecosystem services; iii) the development of theoretical synthesis approaches on the organization and maintenance of biodiversity, ecosystem services, and the socio-economic impacts associated with them.

Curriculum 3 - *Urban biodiversity and innovative technological solutions;* This CV aims at delving into the issues of urban biodiversity from a multidisciplinary and transdisciplinary perspective, devising solutions to promote human well-being and quality of life in urban contexts. Urban areas cover approximately 7% of the national territory, with less than 10% consisting of green spaces. In this context, the curriculum is dedicated to developing strategies for implementing Nature-Based Solutions (NBS) to restore and/or enhance functional urban biodiversity while also mitigating key abiotic and biotic stress factors. It aims to define integrative design strategies to maximize ecosystem services and the long-term resilience of interventions. Product and process technological innovations will be a valuable element in implementing projects based on monitoring solutions and ensuring effective evaluation and management of interventions. The projects may encompass topics related to urban regeneration programs, biodiversity, the effects of climate change, and quality of life. They aim at providing urban planners and other stakeholders with adequate scientific support. The projects also aim at creating economic and social value by promoting new professional activities dedicated to the sustainable supply chain of biological resources. They involve the design of ecological restoration and recovery of marginal areas, along with the development of innovative activities for monitoring, management, and promotion of the cultural heritage of urban biodiversity.

Curriculum 4 – *Translate scientific evidence on biodiversity into social awareness and economic value;* The CV will implement new solutions to communicate, enhance, and share the value of biodiversity with the Italian and international mass audience. The aim is to raise awareness about the intrinsic value of biodiversity and the need for collective behavioral changes to promote and preserve Italy's and the Mediterranean's natural, biological, and ecological resources. The projects will consider strategic aspects of biodiversity, both as an inherent value and as a guarantee of human well-being, ecosystem resilience, and economic recovery. The objectives of the projects in this curriculum are as follows: i) Develop new languages and communication formats for science that reach all Italian audiences through a multi-channel and cross-media perspective, engaging a mass audience beyond the environmentally motivated minority. ii) Find new educational solutions to translate scientific evidence into effective language to reach schools, universities, and other educational institutions. iii) Devise new behavioral models and increase awareness in the whole society to enhance the value of research outcomes with public administrations, institutions, national networks involved in biodiversity conservation and enhancement, as well as the industrial and economic sectors. iv) Design strategies to implement mass cataloging and digitalization of Italian naturalistic collections as research, training, and communication tools, contributing to the networking of the Italian distributed museum system. v) Define new business models and forms of intellectual property valorization generated within the research field. vi) Study the evolution of corporate and institutional strategies in parallel with the adaptation of regulatory frameworks and industrial dynamics to achieve the SDG.

Curriculum 5 – *Biodiversity and the one health approach;* The CV aims at studying the beneficial effects of biodiversity and ecosystem functioning on environmental quality and human well-being, with the goal of promoting ecologically and socially sustainable economic growth. In a 'One Health' context, the strategic framework of the European Union, which recognizes how human health, animal and plant health, and ecosystem health are inseparably interconnected, this curriculum includes research projects aimed at studying and deepening the risks to health and the importance of the human-biodiversity-ecosystem interface in the evolution and emergence of pathogens; the study of the causes and consequences of certain human activities, lifestyles, and behaviors in ecosystems; studies concerning health security from a global perspective and across local scales, integrating human health, animal health, plant health, ecosystem health, and the role of biodiversity in functioning; studies on the applicability of the 'One Health' framework in order to reduce the barriers that still separate the disciplines of medicine and veterinary science from biology, conservation, ecology, and environmental sciences; the development of integrative approaches that connect the study of the underlying factors of stress responses to their consequences on ecosystem functioning and evolution.

Curriculum 6 - *Biodiversity & innovation: business, policy, systemic logic and regenerative economy;* The CV aims at analyzing the relationship between the business world and the impact and dependence on biodiversity with a cross-cutting perspective. It aims at developing interdisciplinary skills to understand the potential offered by KETs for new approaches to monitoring, restoration, conservation, and enhancement of biodiversity. The CV proposes the examination of the systemic relationship between business organizations and biodiversity to understand the complexity of this relationship and the importance of the role of different actors. The objectives include: a) The role of policies and models of public governance at the national, international, and community levels that stimulate innovative processes for the conservation and regeneration of natural capital in marine, terrestrial, freshwater, and urban systems. b) The coordination mechanisms and relationships among the different actors in the value chain and how such mechanisms can reduce the business impact on biodiversity loss and ecosystem functioning. c) The role of technological and organizational innovation in stimulating an economy that can effectively regenerate the natural capital it utilizes. d) The underlying dynamics of the relationship between businesses and ecosystem services and how new business models and strategic and organizational approaches can lead to a development model in balance with the natural system. e) The challenges that businesses face, the tools and capabilities they need to develop to address the complexity of the challenge of a regenerative economy. f) The critical analysis of existing models to assess the impact of investments and human activities on biodiversity, and vice versa, through the analysis of indicators, best practices, and international comparisons. g) The potential offered by the progress of KETs that facilitate new approaches to monitoring, conservation, restoration, and valorization of biodiversity.

TITOLI DI ACCESSO / *MASTERS REQUIRED*
(Commission evaluates the eligibility for foreign master degrees)

Classi di Laurea Specialistica o Magistrale / *Master Degree Classes:*
All master degree classes

Lauree V.O. (only for Italian system):
Tutti il Diplomi di Laurea (V.O.) equiparati ai suddetti titoli di accesso giusto il Decreto Interministeriale n. 233 del 9 luglio 2009

PAGINA WEB DEL DOTTORATO / *PH.D. WEB PAGE*
https://www.unipa.it/dipartimenti/distem/dottorati/biodiversity

POSTI DISPONIBILI / *AVAILABLE POSITIONS*

Posti con borsa di studio *Positions with scholarship*	**41**

DETTAGLIO FINANZIAMENTO BORSE / *SCHOLARSHIPS FINANCING DETAILS*

Codice / *Code*	**Tematica/ *Topic***	**Soggetto finanziatore / *Funder***	**Fondi/ *Funds***	**Posizioni/ *Positions***
[UNIPA]	Libera/ *Free*	Università degli Studi di Palermo + NBFC Tematiche/Topics: CV 1: Interactions in complex predator communities and their implications for marine biodiversity conservation and management CV 1: Upscaling mechanisms driving biodiversity and ecosystem functioning (BEF) relationship under human-caused stressors in marine habitats CV 1: Studying the resilience of seagrass marine habitats by Earth Observation systems monitoring and assessment of goods and services through innovative biodiversity LCA methods CV 1: Development of methods for the analysis of emerging contaminants on Italian coastal marine organisms, aimed at the creation of devices for continuous monitoring and the analytical treatment of experimental data through early warning system models CV 2: Monitoring strategies to disentangle the interaction between hydrodynamic factors and animal and vegetal communities CV 5: Bioprospecting in a one-health context: integrative approaches for the study of stress responses effectors and their role on ecosystem evolution CV 5: Data integration of human, animal, and environmental health components and multivariate statistical models to improve	PROPRI	7

		prediction of certain health diseases related to these components		
[UNISI]	Vincolata/ *Fixed*	Università degli Studi di SIENA CV 2: Monitoring fungal diversity in biancana badlands in Italy (FUDIBA) CV 2: Monitoring invasive alien plants in Italy: effects on diversity in Nature 2000 habitats	PROPRI	2
[UNIPD]	Vincolata/ *Fixed*	Università degli Studi di PADOVA CV 1: Integration of biodiversity and environmental data across multiple scales to understand the structure and functioning of coastal ecosystems CV 4: Meta-analysis of biodiversity trends in Italy	PROPRI	2
[UNISALENTO]	Vincolata/ *Fixed*	Università degli Studi del SALENTO CV 1: A multi-species approach to marine habitat restoration to promote species combinations and interactions, emergent properties, and community recovery CV 2: Ecological responses to climate change: organization and maintenance of biological diversity	PROPRI	2
[UNIFI]	Vincolata/ *Fixed*	Università degli Studi di FIRENZE CV 1: Genomic approaches to study connectivity and local adaptations of animal marine species: an efficient tool to enhance conservation strategies under a climate change scenario CV 2: Genomic approaches to study the impact of global warming on population dynamics and range expansion of Italian terrestrial vertebrate species	PROPRI	2
[UNIGE]	Vincolata/ *Fixed*	Università degli Studi di GENOVA CV 1: Taxonomy and ecology of shallow and deep-water Mediterranean scleractinians	PROPRI	1
[UNIMIB]	Vincolata/ *Fixed*	Università degli Studi di MILANO-BICOCCA CV 3: Development and validation of innovative systems for the monitoring of functional biodiversity in urban areas CV 5: Development of highly flexible descriptive tools as platform for in silico	PROPRI	2

		(Q)SAR studies on natural polyphenols		
[UNIMOL]	Vincolata/ *Fixed*	Università degli Studi del MOLISE CV 3: Advanced techniques for long term monitoring of mammals in urban landascapes	PROPRI	1
[UNIMORE]	Vincolata/ *Fixed*	Università degli Studi di MODENA e REGGIO EMILIA CV 2: Biodiversity, biogeography and evolution of freshwater Gastrotricha	PROPRI	1
[UNISA]	Vincolata/ *Fixed*	Università degli Studi di SALERNO CV 5: Development and optimization of innovative technologies for the extraction, characterization and biological evaluation of healthy ingredients from natural sources	PROPRI	1
[UNINA]	Vincolata/ *Fixed*	Università degli Studi di NAPOLI Federico II CV 1: Innovative approaches for biodiversity monitoring and mapping	PROPRI	1
[UNIROMA3]	Vincolata/ *Fixed*	Università degli Studi ROMA TRE CV 2: Integrative Taxonomy and Biogeography of Halictidae and Megachilidae (Apoidea) of Italian fauna	PROPRI	1
[UNIUD]	Vincolata/ *Fixed*	Università degli Studi di UDINE CV 2: Population genomic analyses of endangered and endemic plant species CV 2: Upscaling the effects of global changes on plant diversity at different ecological scales CV 2: Exploring microbial diversity following rewilding in mountain areas	PROPRI	3
[SSSUP]	Vincolata/ *Fixed*	Scuola Superiore di Studi Universitari e Perfezionamento Sant'Anna CV 2: Scaling up functional biodiversity in agroecosystems to support the agroecological transformation of farms and landscapes CV 6: Management of innovation and sustainability, analysis of firms and public organizations	PROPRI	2
[SZN]	Vincolata/ *Fixed*	Stazione Zoologica Anton Dohrn – SZN	PROPRI	3

		CV 1: Importance of seamounts and upwelling systems for mesopelagic biodiversity and related trophic web in sustaining pelagic top predators CV 1: Ecological role of microbial communities around the seamount systems: study of biodiversity of prokaryotic communities through multi-omics approaches and bioinformatic tools CV 1: Long-term analysis of protection effectiveness within the Italian marine Protected Areas and assessment of potential relationships between the ecological status of main benthic habitats and the cumulative impact of human pressures on coastal environments		
[OGS]	Vincolata/ *Fixed*	Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS CV 1: Plankton biodiversity, environmental variability and system resilience in lagoon ecosystems: modelling and assessing system response to climate change and multiple pressures CV 1: Eco-evolutionary dynamics in marine plankton communities CV 1: Ocean life and plankton biodiversity in polar: modelling and assessing microbial ecosystem functioning CV 1: Advancing ex-situ restoration and ecosystem functioning assessment for Mediterranean marine forest recovery	PROPRI	4
[CNR.IAS]	Vincolata/ *Fixed*	Istituto per lo Studio degli Impatti Antropici e Sostenibilità in Ambiente Marino CV 1: Spatial variability of the species-specific environmental "optimums" for pelagic fish species allowing a comparison between the current and future scenarious	PROPRI	1
[118.PNRR.UNIVPM]	Vincolata/ *Fixed*	Università Politecnica delle MARCHE CV 1: Biodiversity interactions between micro- and macro-organisms in marine ecosystems	DM118	2

		CV 1: Study of planktonic communities and their long term interannual variability through traditional and innovative tools		
[118.PNRR.UNIFI]	Vincolata/ *Fixed*	Università degli Studi di FIRENZE CV 3: Apoidea (Hymenoptera: Apoidea: Anthophila) as biodiversity indicators in urban environments and environmental ameliorations for the wild bee community	DM118	1
[118.PNRR.UNIMORE]	Vincolata/ *Fixed*	Università degli Studi di MODENA e REGGIO EMILIA CV 2: A Citizen Science approach to study the biodiversity of Italian tardigrades in terrestrial environments, to promote the dissemination of knowledge of tardigrades and to raise the awareness on the value of biodiversity and its conservation.	DM118	1
[117.ARPA]	Vincolata/ *Fixed*	Agenzia regionale per la protezione ambientale (ARPA) CV 5: Bioprospecting in a one-health context: integrative approaches for the study of stress responses effectors and their role on ecosystem evolution	DM117	1

PA: Pubblica Amministrazione / Public Administration
PC: Patrimonio Culturale / Cultural heritage
TDA: Transizione digitale ed Ambientale / Digital and environmental transition
PNRR: Tematica prevista dal PNRR / Research Topic of the PNRR