SPOKE 5 - ACTIVITY 5: PROJECT DEVELOPMENT

Impacts of land use and forestry actions (in urban contexts) on supporting/regulating ecosystem services: biological level

Abstract (from the submitted general NBFC proposal) - Impact of urban forestry on supporting and regulating ecosystem services (biological level). The aim is the assessment of the effects of different NBS and urban biodiversity management strategies on plant and animal functional diversity and of its mediated ecosystem services (i.e., pollination, seed dispersal, and pest control). A multidisciplinary and ecosystem multilevel approach, based on innovative technologies (e.g., DNA/RNA-based, smart sensors), will permit the development of efficient and scalable tools for monitoring the effectiveness of urban green restoration actions in shaping biodiversity and its functional interactions. Specific research on the environmental and biotic urban factors influencing plant reproduction, animal biodiversity, population connectivity, functional traits, and trophic interactions will be used to obtain suitable predictive and risk management models to provide the guidelines for the design and management of sustainable and resilient NBS in different urban contexts.

Task 5.1 Plant Reproduction in the urban environment

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Partners' institutions

University of Naples Federico II, University of Milan Bicocca

Short background [max 500 words]

The maintenance of urban biodiversity is based on the presence of a complex plant community that supports trophic and functional relationships among organisms. The composition of this urban plant community is affected by environmental changes occurring in urban environments that can be seen as series of selection filters affecting the distribution of plant species and functional traits. Nature Based Solutions (NBS) might potentially increase the diversity of urban plant communities by relaxing these ecological filters. Advanced Floristic surveys of urban flora employing recently developing technologies may allow to correlate biotic and abiotic factors driving the distribution of urban plant species and reproductive traits and the extent to which NBS are able to modify them.

However, in order for NBS to guarantee the persistence and resilience of a complex plant community, native and introduced plant species must attain reproductive success (in terms of growth, mating dispersal, germination).

Plants reproductive success depends on their genetic and phenotypic diversity and on their interactions with biotic and abiotic environmental variables. Many of these environmental variables that shape selection on plant reproductive traits, e.g. temperature, water availability, length of the growing-season, nutrient availability, and composition of the pollinator/disperser/herbivore communities, differ in urban *versus* natural environments, as well as within different urban contexts. In front of a predictable reduction of plant reproductive success in urban environments, plants might evolve fitness related reproductive traits in order to recover their reproductive functions, hence leading to local adaptation towards an urban phenotype/genotype. Although evidence for genetic adaptation to urban context are recently emerging, still scarce is the knowledge on evolutionary changes affecting reproductive traits and how these changes follow a convergent pattern across urban environments. Finally, a continuous monitoring of reproductive success and adaptation dynamics of plant species in urban environment is needed. This is an emerging aim of conservation authorities interested in understanding biodiversity of the managed areas and the potential corrective actions to be adopted in order to ensure the complexity and the resilience of plant communities and the inherent ecosystem services (e.g., carbon sequestration, pollination). Nonetheless, traditional monitoring strategies are still highly expensive in terms of human and time resources and are therefore often conducted on a reduced spatial and temporal scale. Many recent technological advances in remote and proximate sensing and in image processing strategies allow nowadays to develop easy-to-apply and automatized tools for monitoring of plant reproduction that might represent a great advance to increase spatial and temporal scale and reduce the related costs.

General objectives of the task (theoretical & applicative) [max 250 words]

- Understanding if and how urban environments filter plant reproductive traits and species presence/absence
- Setting up innovative strategies for monitoring the plant reproduction in the urban context
- Understanding the factors limiting the reproduction of urban plants
- Identifying signatures of plant adaptation to urban environments in reproductive traits
- Identifying the mitigating effects of NBS on plant reproduction and consequently on species abundance

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Impact (in the context of the activity 5 and of the whole spoke) [max 250 words]

- Support for the introduction in NBS practices of approaches for increasing and maintaining the specific and functional biodiversity of native plants by assuring their reproduction
- Support for the identification of plants better adapted to urban environments
- Improvement of the management of urban plant diversity
- Improvement of ecosystem services provided by urban plants
- Improvement of the resilience of urban flora

Task experimental development [max 2500 words]

WP 5.1.1 Urban filter on plant reproductive traits and the mitigating effect of NBS

- ***WP description:***

Urban ecosystems are characterized by striking biotic and abiotic environmental changes compared to surrounding natural areas. These environmental changes shape an ecological filter for reproductive traits that is likely to deeply modify the composition of urban plant communities. Understanding how this filter acts along natural-urban gradients and whether NBS are able to reduce its strength can be of primary importance for developing new approaches for increasing and maintaining the specific and functional biodiversity of native plants in NBS.

- ***Aim/s:***

- Understanding which reproductive traits are over or underrepresented in urban environments compared to surrounding natural vegetation
- Detecting target iconic species that even showing suitable reproductive traits are absent in urban environments and could be reintroduced
- Disentangling the drivers for over or underrepresentation of different reproductive traits in the urban environments and in NBS
- Understanding whether NBS mitigate the urban filter, hence increasing plant biodiversity

- ***Activities:***

- **WP 5.1.1 Act. 1 (creation of a database of urban flora)**: We will create a database including floristic information from the different Italian urban areas. This database will include available data as well as additional data that will be collected/integrated. For each urban area, floristic data of the surrounding natural areas will also be collected. For all the species, either present in the urban or in the natural areas, we will infer the reproductive traits (e.g., dispersion strategy, type of fruit, seed traits, pollination type, phenology, breeding system, polyploidy). With these data, we will compare the occurrence of species with different reproductive traits in urban *versus* natural areas and will identify traits that are over or underrepresented in the urban context and that determine the composition of the urban plant communities as consequence of urban filtering. In the second year, we will experimentally test these reproductive filters by evaluating reproductive success of potted clonal flowering plants cultivated along an urban gradient (citizen science). This activity will also allow to identify target rare or iconic species that even showing suitable reproductive functional traits are absent in urban environments (these species will be used in **WP 5.1.2 Act. 4**) and could be introduced if the limiting factors explaining their absence are understood.

- **WP 5.1.1 Act. 2 (mitigating effects of NBS on plant community composition)**: The above-described comparative analyses will also be conducted using floristic data from NBS areas (connection with **Task 1.2**). These analyses will allow to understand whether the urban filter might be relaxed by NBS, hence producing an increasing in the diversity of plant species in urban environments.

- **WP 5.1.1 Act. 3 (abiotic drivers for urban plant distribution)**: The database established in **WP 5.1.1 Act. 1** will also be fed by an easy-to-use app for urban plant identification (described in **WP 5.1.4**) specifically developed in this project. This app will employ a proximate sensing approach and will increase the amount of georeferenced data for plant presence in the urban areas. With these data we expect to identify a gradient of plant occurrence/reproduction in urban context and to gather a more accurate correlation of presence/absence of plant species with abiotic parameters (e.g., humidity, temperature, soil type, land use, urbanization degree) identified through a remote sensing approach by using freely available mid-resolution radar and multispectral data and purchasable high resolution multispectral data (see **WP 5.1.4 Act. 3**). Overall, this action will allow to understand the main abiotic drivers of plant species distribution in urban areas.

- ***Location:***

This WP will be developed at all the urban centers selected by the spoke 5 coordinators and potentially in other urban areas where floristic data are available.

- ***Outputs:***

  - Definition of urban filters
  - Catalogs of urban flora
  - Identification of urban drivers for plant distribution and reproduction
  - Identification of the effects of NBS on urban plant biodiversity
  - A national database for the urban flora

- ***strategic tools/instruments/databases to be adopted - specify if external service/consulence is required:***

A server for processing the remote sensing data

A storage system for the data archive

- ***involved researchers/institutions and their role)***

  - Lorenzo Boccia (UNINA) will be in charge in the development of the app
  - Salvatore Cozzolino will contribute to the description of the reproductive traits
  - Antonino De Natale (UNINA) will be in charge of the floristic survey of the area of Naples
  - Gerardo Di Martino will access and process the remote sensing data and of the organization of the database.
  - Giovanni Scopece (UNINA) will contribute to the description of the reproductive traits

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WP 5.1.2 Limiting factors for plant reproduction in urban environments and mitigating effects of NBS

- ***WP description:***

NBS persistence stands on assuring an efficient reproduction to urban plant species. Only reproducing plants can persist over generations and maintain long term diversity in naturalized areas, reducing management efforts and costs. Plant reproduction is a complex process that requires the sequential accomplishment of different stages: mating, seed formation, seed dispersal, germination, and seedling establishment. Plants are fully adapted to accomplish these stages in their native environment. However, urban environment is characterized by different biotic and abiotic conditions compared to the natural habitat of plant species. In front of these changes, plants might 1) suffer of a reduced reproductive success, 2) adapt their reproductive traits to better cope in urban environment.

- ***Aim/s:***
    - Understanding whether urban plants have a low reproductive success
    - Detecting the limiting factors to plant reproduction in urban areas
    - Understanding the limiting factors for plant colonization of urban context
    - Understanding whether NBS mitigate these limiting factors
    - Understanding whether plants that reproduce efficiently in urban environments rely on local genetic adaptation or phenotypic plasticity
    - Understanding whether adaptation to the urban environment shows a convergent adaptive pattern across cities.

- ***Activities***
    -

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- **WP 5.1.2 Act. 1 (survey of urban plant reproductive success)**: During the first year we will survey reproductive success of plant species found in selected urban areas by estimating flowers, fruits and seed traits. The reproductive success in natural areas of the same species will be also recorded. From these species we will perform genetic analyses for estimating level of genetic diversity, connectivity and inbreeding in urban areas compared to natural areas. From all the plants sampled in this activity we will collect seeds to be used in **WP 5.1.2 Act. 2 and 3, 4 and 5**. With these data, we expect to identify those plant species that have a lower reproductive success in urban compared to natural areas and a reduced genetic connectivity.

- **WP 5.1.2 Act. 2 (transplanting urban and natural genotypes)**: During the second year, we will focus on these latter species (Task 5.1.2 Act. 1). Using seeds collected in urban (hereafter urban genotypes) and natural environments (hereafter natural genotypes), we will establish experimental plots in three "common garden" conditions: 1) urban, 2) natural, and 3) NBS. All genotypes included in the experimental plots will be phenotyped for reproductive traits (e.g., odour, colour, flower size, phenology, nectar, pollen) and their reproductive success will be estimated by recording flowers, fruits and seed traits. The combination of these parameters will constitute the basis for the definition of indicators for the monitoring of reproductive success. On a subset of genotypes included in the experimental plots, we will perform pollinator exclusion and pollen saturation experiments to understand whether the limiting factor for their reproduction in urban environments is pollination or resources. In all the plot areas abiotic factors will be estimated through an integrated network of proximal and remote sensors and biotic factors will be estimated in collaboration with **Task 5.4**. From this experimental activity, we expect that both urban and natural genotypes reproduce less efficiently in urban than in natural environments and that NBS might mitigate the differences. We also expect that urban genotypes perform better than natural genotypes in urban environments, as an indication of some recover strategy for plant reproduction in urban genotypes either based on adaptation or plasticity. If yes, a positive/negative correlation of some phenotypic trait with reproductive success will be an indication that these traits are under positive/negative selection in urban or in natural environments. Finally, the comparison of phenotypic traits of urban and natural genotypes will allow understanding whether some traits are already differentiated as consequence of selection in urban context.

- **WP 5.1.2 Act. 3 (transplanting of urban genotypes in different urban areas)**: During the third year, we will select target species that showed potential evidence of

- genetic adaptation (results from **WP 5.1.2 Act. 1 and 2**) and we will perform transplanting in the different cities involved in the project. With this experiment we test whether: 1) local urban genotype always performs better that local natural genotype i.e., local (city) adaptation, 2) the different urban genotypes show evidence of convergent adaptation towards a common urban phenotype (parallel adaptation) or 3) some (foreign) urban genotypes outperform (local) urban and natural genotypes in the different contexts.

Both urban and natural genotypes will be sequenced (see **Task 5.1.3**).

- **WP 5.1.2 Act. 4 (identification of potential new urban plant species)**: we will use a list of iconic species that have not colonized the urban environment despite having functional traits suitable as identified in **WP 5.1.1 Act. 1**. We will grow them in urban environments and in NBS to understand the reasons for their absence (e.g. germination, pollination, dispersion) and identify possible management strategies to overtake these limitations.

- ***Location:***

Act. 1, 2 and 4 will be conducted in two target cities with the highest Italian population density (Naples and Milan). Act. 3 will be conducted at all the urban centers selected by the spoke 5 coordinators.

- ***Outputs:***

- Survey of plant reproductive success in urban and natural habitat
- Identification of factors limiting plant reproductive success in urban environments
- Identification of mitigating effects of NBS
- Identification of patterns of selection and adaptation in urban environments
- Definition of indicators for the monitoring of plant reproduction in NBS

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- ***Strategic tools/instruments/databases to be adopted - specify if external service/consulence is required.***

- ***Involved researchers/institutions and their role):***
  - Serena Aceto (UNINA) will be involved in genetic analyses
  - Giovanna Aronne (UNINA) will be involved in the transplanting and plant phenotyping (nectar and pollen)
  - Salvatore Cozzolino (UNINA) will be involved in the experimental design
  - Antonino De Natale (UNINA) will be involved in the transplanting, in plant phenotyping (floral traits) and in reproductive success estimation
  - Francesco Loreto (UNINA) will be involved in in plant phenotyping (volatile organic compounds)
  - Giovanni Scopece (UNINA) will be involved in experimental design and in plant phenotyping (floral traits, colour and phenology) and in reproductive success estimation
  - Giuseppe Ruello UNINA will be involved in the identification of abiotic factors through the development of ad hoc remote sensing algorithms
  - Fabrizio Grassi (UNIMIB) will be involved in genetic analyses
  - Lorenzo Guzzetti (UNIMIB) will be involved in experimental design and in plant phenotyping
  - Massimo Labra (UNIMIB)
  - Emiliano Pioltello (UNIMIB)

WP 5.1.3 Genomic signature of urban plant adaptation

- ***WP Description:***

Local adaptation is a fundamental prediction arising from the theory of natural selection. It states that organisms in a particular environment tend to evolve fitness-related traits towards local optima. Bottom-up population and landscape genomic approaches seek to link genetic signatures of local adaption with environmental variables. Here we propose a "bottom up" investigation of the genomic basis for local adaptation in urban plants. Candidate locally adaptive loci will be detected by association between allele frequencies and a suite of environmental variables from urban locations. Despite different urban environments differ for many parameters, the urban context is expected to impose similar selective pressures on plant reproduction. Therefore, it is likely that reproductive traits of plant species show convergent adaptations in different cities determining a common "urban genotype".

- ***Aim/s:***

The aim of this WP is to test the hypothesis that urban environments determine local adaptation and eventually parallel convergent adaptation shaping a "urban genotype".

- ***Activities***:

  - **Task 5.1.3 Act. 1 (detection of urban candidate loci by WGS)**: During the third year, the same species used in Task 5.1.4 Act. 3 will be sequenced (link to Molecular Biodiversity Platform). This will allow to identify the genomic regions that are responsible for the adaptation to urban environments. Population pairs (urban and natural) will be subject to whole genome sequencing (WGS) and genomic variants (polymorphic SNPs) identified by mapping sequence reads against the reference genome. Candidate locally adaptive loci will be detected in a population genomic framework to account for neutral population structure, by association between allele frequencies and environmental data variables (as identified in ***WP 5.1.1***) in a genome environment association (GEA). Sample from historical herbaria for the target species, where available, will be collected in order to perform the same genomic analyses. This will allow to understand whether adaptation to urban habitats was already present within natural populations as standing genetic variation of whether it evolved as consequence of recent mutation/genomic rearrangements eventually driven by the urban stress (urban-induced mutation load)

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- **Task 5.1.3 Act. 2 (definition of the urban transcriptome)**: we will sequence transcriptomes of originally urban and natural populations of the target species grown in natural versus urban environment. To further validate the adaptive potential of detected loci, we will test for links between trait variance and locally adapted genomic loci by comparative analysis of gene expression and functional variation in molecular phenotype between populations pairs, and their association with genomic SNPs revealed by GEA (i.e., we will analyze individual gene expression profiles to identify expression variants (eQTLs) linked with genomic variants associated with population differences. Then, through annotation and expression analysis we expect to identify key locally adapted functional traits. We expect to detect whether local adaptation follows parallel or independent trajectories and whether how ecotypic variation (e.g., urban versus natural) maps onto genome variation. Finally, we will build a gene co-expression network and infer connectivity values within and between modules for each gene. Gene co-expression networks are available for some model species. Here we will generate networks by using expression differences between genetically distinct individuals, as these patterns better reflect regulatory variation existing in natural and urban populations and use them as proxies for convergent evolution to the urban environment.
- **Task 5.1.3 Act. 3 (a transnational urban syndrome)**: The same species will be finally collected in different euro-mediterranean urban and natural areas and will be trait-phenotypized in a common garden and genotyped. This action will allow to understand whether the same plant trait and genetic regions are involved on urban adaptation on a larger scale (for example across Mediterranean cities).

- ***Location:***

This WP will be conducted at all the urban centers selected by the spoke 5 coordinators. Activity 4 will also be conducted in different euro-mediterranean urban areas

- ***Outputs:***

  - Identification of genomic signature of urban adaptation
  - Definition of urban genotype

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- Improvement of the resilience of urban flora

- ***strategic tools/instruments/databases to be adopted - specify if external service/consulence is required.***

- ***involved researchers/institutions and their role)***
    - *Serena Aceto (UNINA) will be involved in genomic and transcriptomic analyses*
    - *Salvatore Cozzolino (UNINA) will be involved in genotyping and gene network*
    - *Antonino De Natale will be involved in the collection of herbarium specimens*
    - *Lorenzo Guzzetti UNIMIB*
    - *Emiliano Pioltello UNIMIB*
    - *Fabrizio Grassi UNIMIB*
    - *Massimo Labra UNIMIB*

- ***WP5.1.4 Innovative approaches for the monitoring of plant reproduction in urban contexts***

- ***WP description:***

Plant reproduction is crucial for the establishment of complex plant communities, but its monitoring has been overlooked. Establishing easy to use and automatized tools for monitoring of plant reproduction might be of interest for conservation authorities also because of the high costs (human resources) usually associated to the monitoring programs. Automatized monitoring also allows to overcome the typical discontinuity of traditional monitoring activities.

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- ***aim/s:***
    - Creating innovative tools for the continuous monitoring of plant reproduction in urban environments
    - Developing indirect tools for estimation of pollination ecosystem service
    - Improving the performance of plant reproduction monitoring strategies in in NBS and urban areas
    - Developing predictive tool for plant phenology in the city
    - Identifying abiotic drivers of plant phenology

- ***activities:***
    - **WP 5.1.4 Act. 1 (App for urban plants and their flowers)**: An app will be developed to monitor plant presence and reproduction in urban environments. The App will be designed for devices equipped with a LIDAR sensor (i.e. top-of-range Apple devices). This app will allow to identify urban plant species (from the database established in **WP 5.1.1 Act. 1**) using a machine learning approach based on the use of convolutional neural networks on collected georeferenced images. Using the same machine learning approach, the App will also record phenological phases (e.g. vegetative, flowering, fruiting) and, for selected species, the number of flowers and/or fruits. These georeferenced data will feed the database established in **WP 5.1.1 Act. 1**. The App might include a questionnaire for the collection of other info. In order to have a well-distributed sampling, the app will create Vegetation Control Points based on the abundance of already available data that will appear as flags in the urban map. These flags will disappear once pictures from the area have been received. To boost users to collect data, the App will employ a rewarding system for trained explorer that will confer a score. In the second year of the project, this app will be tested with Natural Science and Biology students of Naples University (and other Universities) and collected data will contribute to the development of **Task 5.1.1 Act. 3**.
    - **WP 5.1.4 Act. 2 (Portable monitoring station for plant reproductive success):**

A portable monitoring station will be designed and implemented to detect the reproductive indicators established in **WP 5.1.4** in order to estimate the plant reproductive success. This station will be equipped with ultra high-resolution cameras, LIDAR sensors and environmental sensors. A dedicated software tool will manage the scansion of an area of about 400 m2 every week producing high resolution 3D images. Using the same machine learning approach implemented in **WP 5.1.4 Act. 1**, this station will identify the plant species and will record: 1) plant phenology, 2) number/dimension of flowers, 3) number/dimension of fruits.

- **WP 5.1.4 Act. 3 (Urban clock)**: Using the app developed in **WP 5.1.4 Act. 1** we expect to collect a great number of ground truth on plant phenology (e.g., flowering, fruiting, leaves abscission) for urban plant species. These data will be analyzed to establish correlations among the phenological stages of different urban species. From these analyses we will extract indicator species whose phenology can be predictive of phenology of other species. Among these species, we will select those that are visible using a remote sensing approach. This activity will allow to set up an efficient monitoring strategy for urban plant phenology. After having tested and validated this tool, we will employ it with two main purposes: 1) to observe whether plant phenology in urban areas differs from that of natural surrounding areas, and 2) to observe whether plant phenology in urban areas changed over the last 30 years using the available historical series of satellite images acquired by the Landsat and Sentinel missions, integrated (when available) with high resolution Synthetic Aperture Radar data provided by Cosmo Skymed and TerraSAR-X missions and very high resolution multispectral data acquired by Geoeye, WorldView and analogous sensors.

- ***Location:***

This WP is independent of the urban areas. Two heterogeneous case studies will be selected

- ***Outputs:***
  - Creation of the App
  - Design and implementation of a monitoring station for urban plant reproduction

- Implementation of a tool for urban phenology monitoring

- ***strategic tools/instruments/databases to be adopted - specify if external service/consulence is required.***

- *involved researchers/institutions and their role*

  - Lorenzo Boccia (UNINA) will work on the App development
  - Giuseppe Ruello (UNINA) will work on App implementation, portable monitoring station for plant reproductive success and urban clock
  - Daniele Riccio (UNINA) will work on portable monitoring station for plant reproductive success and urban clock
  - Gerardo Di Martino (UNINA) will work on plant scanner and urban clock
  - Giovanni Scopece (UNINA) will work on the correlation of phenological data and will furnish the botanical support for the development of the portable monitoring station for plant reproductive success
  - Antonino De Natale (UNINA) Will furnish the botanical information for the development of the App

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Gantt chart of the task (table)

	I ANNO						II ANNO						III ANNO					
WP 5.1.1 Act. 1 (creation of a database of urban flora)	■	■	■	■	■	■	■	■	■	■	■	■						
WP 5.1.1 Act. 2 (mitigating effects of NBS on plant community composition)	■	■	■	■	■	■	■	■	■	■	■	■						
WP 5.1.1 Act. 3 (abiotic drivers for urban plant distribution)							■	■	■	■	■	■	■	■	■	■	■	■
WP 5.1.2 Act. 1 (survey of urban plant reproductive success)	■	■	■	■	■	■												
WP 5.1.2 Act. 2 (transplanting urban and natural genotypes)							■	■	■	■	■	■						
WP 5.1.2 Act. 3 (transplantings of urban genotypes in different urban areas)													■	■	■	■	■	■
WP 5.1.2 Act. 4 (identification of potential new urban plant species)	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
WP 5.1.3 Act. 1 (detection of urban candidate loci by WGS)												■	■	■	■			
WP 5.1.3 Act. 2 (definition of the urban transcriptome)												■	■	■	■	■	■	■
WP 5.1.3 Act. 3 (a transnational urban syndrome)															■	■	■	■

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WP 5.1.4 Act. 1 (App for urban plants and their flowers)																		
WP 5.1.4 Act. 2 (Portable monitoring station for plant reproductive success)																		
WP 5.1.4 Act. 3 (Urban clock)																		

Expected criticalities and Possible contingency (table)

RISK ELEMENT	**WP**	**LIKELIHOOD** (high-moderate-low)	**IMPACT** (high-moderate-low)	**MITIGATION STRATEGIES**
Database of urban flora	1	Very low	Very low	Most of the data are already available
The schedule of experiments is dense and ambitious, and experiments have a sequential organization	2-3	moderate	moderate	We will increase the number of replicates for each experiment.

Connections within and outside Activity 5 [max 250 words]

Connections within Activity 5:

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Characterization of biotic factors to be correlated with plant reproductive performances will be done in collaboration with Task 5.2 and 5.4 in particular with the activities on entomological surveys and pollination interactions.

Connections within spoke 5:

WP 5.1.1 will establish connections with Task 1.2 and 1.5 for the survey of floristic data in NBS.

WP 5.1.4 will establish connection with Task 7.1 and 7.3 for the innovative monitoring and management of urban forestry.

Other potential connections within spoke 5 are:

WP 5.1.1 with Task 2.1

WP 5.1.2 with Task 3.2

WP 5.1.3 with Task 6.3 and 6.4

Connections with other Spokes:

The actions to be developed in natural areas for comparison with urban environments, i.e. WP5.1.1, WP5.1.2 and WP5.1.3 will establish a connection with Spoke 3 and 4 that will investigate plant distribution and traits in natural areas. A connection with these spokes will also be established for the collection of data from the historical herbaria.

WP 5.1.4 will establish connections with Spoke 8 for technology transfer of devices for advanced monitoring.

WP 5.1.4 Act. 1 will establish a connection with Spoke 7 for the potential use of the App in citizen science programs.

Connections with the NBFC platforms [max 250 words]

WP 5.1.2 and 5.1.3 will establish connections with Molecular Biodiversity Platform and with Natural History collections

Outputs and deliverables of the task (divided by Year 1, Year 2 and Year 3) [max 250 words]

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Outputs Year 1

Catalogs of urban flora (WP5.1.1)

Survey of plant reproductive success in urban and natural habitat (WP5.1.1 Act. 2)

Creation of the App (WP5.1.4)

Definition of urban filters (WP5.1.1)

Outputs Year 2

Identification of the effects of NBS on urban plant biodiversity (WP5.1.1)

A national database for the urban flora (WP5.1.1)

Identification of factors limiting plant reproductive success in urban environments (WP5.1.2)

Identification of mitigating effects of NBS (WP5.1.2)

Identification of patterns of selection and adaptation in urban environments (WP5.1.2)

Definition of indicators for the monitoring of plant reproduction in NBS (WP5.1.2)

Outputs Year 3

Identification of urban drivers for plant distribution and reproduction (WP5.1.1)

Identification of genomic signature of urban adaptation (WP5.1.3)

Definition of urban genotype (WP5.1.3)

Improvement of the resilience of urban flora (WP5.1.3)

Design and implementation of a monitoring station for urban plant reproduction (WP5.1.4)

Implementation of a tool for urban phenology monitoring (WP5.1.4)

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