

Extracto del proyecto Thematic Center on Mountain Ecosystem & Remote sensing, Deep learning-AI e-Services University of Granada-Sierra Nevada.

N/REF.: LifeWatch-2019-10-UGR-01

Objectives of the project

Our proposal raises the study, conservation, and provision of ecosystem services that derive from biodiversity. Our Center on Mountain Ecosystems aims to be a prototype node for LifeWatch ERIC so that they can later be replicated in other nodes. We have taken into account that all the objectives and actions set out in the proposal are addressed to the different user profiles of the proposal: Researchers, Managers and Citizens in general.

Scientific side: Both the monitoring plan proposed in the WPs of the proposal and the management protocols and analysis of the information generated will contribute decisively to improving the knowledge of the functioning of the Sierra Nevada ecosystems in global change scenarios. These objectives will be addressed by multidisciplinary teams formed by researchers from the University of Granada belonging to different scientific disciplines related to biodiversity, global change, big data and artificial intelligence and sustainable development in direct contact with decision makers and citizens in general.

Environmental Management side: The knowledge generated in the scientific field has allowed us to design management procedures for the adaptation of Sierra Nevada ecosystems in the face of the impacts of global change, ensuring the provision of ecosystem services.

Citizen Participation side: In a permanent forum for dissemination to society using the tools available, from participatory activities to social networks.

Sustainable Development side: Within the conceptual framework of sustainable development (Agenda 2030 of UN), we are working in collaboration with the Provincial Council of Granada (Diputación de Granada), which guarantees the projection of knowledge scientific generated by UGR on the anthropized territory. Thanks to the collaboration with Diputación de Granada we also developed an ambitious plan of participatory activities based on the Citizen Science model and environmental education.

Our proposal incorporates the implementation of a general data management plan, based on the principles of FAIR, creating an harmonized digital information base, which integrates both presence / absence data of species and environmental layers.

In accordance with the philosophy of a European ERIC, we have proposed a realistic internationalization plan, without forgetting the national and autonomic dimension, through JRU-LifeWatch Spain. The developments of LifeWatch-ERIC will also be integrated in the developments of the EOSC, IBERGRID, IBERLIFE and COPERNICUS initiatives.

Rationale of the Project

Many of the world's mountain ecosystems are undergoing important global change, in particular climate change, which may affect the ability of mountain regions to provide critical goods and services to both mountain inhabitants and lowland communities. It is urgent, therefore, to combine and coordinate efforts between the scientific world, the public administrations responsible for management, and society in general to obtain the best possible information to curb and manage this loss of biodiversity. We need new conceptual and multidisciplinary approaches that can work on a large scale using the most recent information and communication technologies to address new challenges that contemplate both the conservation of biodiversity and its sustainable use.

In a global change scenario, biodiversity is both a natural heritage that must be preserved, and a natural, renewable resource providing provisioning, regulating and cultural ecosystem services. Both concepts (conservation vs. utilitarianism) have traditionally been considered as antagonistic, and so have been raised and developed during the last century. Our central tenet (Biodiversity is **both** a problem and a solution) embraces the concept of Nature-based Solutions (NbS) defined by IUCN (2017) as actions to protect, sustainably manage and restore natural or modified ecosystems. Our proposal represents a change in the way of understanding nature, deepening an ecosystemic and socio-ecological approach as a line of analysis and action in the research, monitoring and management of the natural environment. Our approach will provide a set of biodiversity-related variables that will provide a unique opportunity for the general public, students, managers and scientists to understand how nature works, how humans depend on it, and what threats we face as a result of global change. An important aspect of this objective is to further develop and consolidate a network of observation sites in mountains around the world to serve as an 'early warning' system for assessing global change impacts.

The long-term evaluation of ecosystems function and services in a context of global change is a major aim of our approach. Long-term series collected in our programme will help us to forecast the evolution of our ecosystems under new scenarios, with the use of modelling tools. The variables that are proposed to be measured in the present project ensure the continuity of the time series initiated long time ago by the research teams of the University of Granada, variables which we consider essential for the diagnosis of the health status of the ecosystem, its capacity for adaptation, and the provision of ecosystem services. The creation of the LifeWatch Thematic Center on Mountain Ecosystem (University of Granada-Sierra Nevada) will allow the incorporation of all existing sources of information (including all scientific and technical data) in the field of biodiversity and global change in the Sierra Nevada for their analysis and interpretation in a scientific context. Our challenge now is to create a long-term physical and virtual European e-infrastructure for research and monitoring (including analysis, modelling and synthesis) that will optimize the adaptive conservation and ecosystems service provisioning of mountain ecosystems.

Our proposal also contemplates the human dimension of biodiversity in global change scenarios, setting realistic goals of sustainable development aligned with the "Agenda 2030"

of UN (<https://www.un.org/sustainabledevelopment/es/objetivos-de-desarrollo-sostenible/>). The objectives of the Provincial Council of Granada (Diputación de Granada) within the framework of this proposal is to complement and accompany the proposed scientific, innovative and technological actions within the framework of LifeWatch for the UGR from the perspective of socio-economic development and the social dynamization given by the presence in the territory of the Provincial Council of Granada (Diputación de Granada).

Sierra Nevada Global Change Observatory: the starting experience

Since 2007, Sierra Nevada Global Change Observatory (OBSNEV) has undergone an ambitious project promoted by the Regional Government of Andalusia (Junta de Andalucía) with scientific coordination by UGR, aiming to develop a monitoring and information management programme. The design of the OBSNEV monitoring program has been inspired by the conceptual framework and the thematic areas proposed by the [GLOCHAMORE](#) initiative (Global Change in Mountain Regions) (Bjørnsen 2005). The architecture of the OBSNEV monitoring programme is based on evaluating, by standardized methodological protocols, the functioning of the ecosystems of the Sierra Nevada Natural Area, its natural processes, and its dynamics over the middle to long term. OBSNEV compiled an enormous amount of environmental information and mobilized the scientists and managers working in Sierra Nevada, establishing linkages with similar projects at national and international scales. [OBSNEV](#) has identified the main global change impacts and has analyzed the biophysical and socioeconomic data available to assess exposure, sensitivity, and adaptive capacity of Sierra Nevada ecosystems to future scenarios http://sl.ugr.es/results_obsnev_en (Zamora et al. 2016).

The *Thematic Center on Mountain Ecosystems (UGR-Sierra Nevada)* as a proof of concept for LifeWatch ERIC: demonstration of our capabilities

The continuation of the work previously described requires evolving from the project stage to being considered as a long-term infrastructure of international relevance. Now, with the support and commitment of the public administrations, academic institutions, and LifeWatch ERIC it is our opportunity to make it real. LifeWatch is an e-science and technology infrastructure for biodiversity and ecosystem research to support the scientific community and other users. LifeWatch is putting in place the infrastructure and information systems necessary to provide an analytical platform for the modelling and simulation of both existing and new data on biodiversity to enhance the knowledge of biodiversity functioning and sustainable management.

The main goal of LifeWatch ERIC is to advance biodiversity and ecosystem services research and to provide major contributions to addressing the big environmental challenges facing the Earth, including knowledge-based solutions to environmental managers and stakeholders for its preservation. To this end, LifeWatch ERIC provides access through a pan-European distributed e-Infrastructure to a multitude of sets of data, services and tools enabling the construction and operation of Virtual Research Environments (Virtual

Laboratories & Decision-support Applications) where specific issues related with biodiversity research and preservation are addressed through the execution of integrated models.

The University of Granada-Sierra Nevada has all the ingredients to develop the proof of concept for LifeWatch ERIC:

1. Huge **biodiversity** and good information about this biodiversity.
2. A **strong scientific institution**, the University of Granada, providing a very good level of scientific knowledge on broad topics related to biodiversity and global change, computing
3. A long and very **professional record of collaborations** with the National Park managers and the Andalusian government.
4. A great **scientific knowledge** about the anthropogenic impacts (particularly climate change, but also environmental pollution, land use changes, forest fires, invasions, etc.) on biodiversity and the ecosystem services in Mediterranean mountain areas.
5. An **humanized territory**, where there are 60 municipalities, ideal to consider the human, socioeconomic dimension of biodiversity under a global change scenario.

*Our conceptual proposal: **Biodiversity is both a problem and a solution***

Nature plays a critical role in providing food, energy, medicines and genetic resources and materials fundamental for people's physical well-being and culture (IPBES report 2019). Nature underpins all dimensions of human health and contributes to non-material aspects of quality of life and cultural integrity. However, human actions are threatening more species to global extinction than ever before. An average of around 25 per cent of species in assessed animal and plant groups are threatened, resulting in biological communities which are becoming more similar to each other in both managed and unmanaged systems within and across regions. This loss of biodiversity poses a serious risk to global food security by undermining the resilience of many natural and agricultural systems to threats such as pests, pathogens and climate change (IPBES report 2019). Our knowledge about biodiversity is still very limited, and in fact, we still do not know how many species are there. It is estimated that there are 9 million species, 85% is still not described (Mora et al 2011). So we really need to continue the collection of information about biodiversity in nature. We have a second problem: Much of the existing information on biodiversity is still invisible and what is not known is not valued nor used. In a global change scenario, biodiversity is both a natural heritage that must be preserved, and a natural, renewable resource providing provisioning, regulating and cultural ecosystem services. Both concepts (conservation vs. utilitarianism) have traditionally been considered as antagonistic, and so have been raised and developed during the last century. However, biodiversity is still perceived as an obstacle or at most an appendage to the development process when, in fact, they form the basis of gaining competitiveness in a global environment, the form of governance over land directly affects biodiversity and ecosystems with consequences for the well-being of citizens. In the



Anthropocene, we must have to look for the complementarity between both concepts, and recognize that, here and now, ***biodiversity is both a concern and a source of solutions to environmental and socioeconomic problems.*** In this context, our general hypothesis is: ***The most biodiverse and multifunctional ecosystems offer a wider range of ecosystem services, and have a greater capacity of resistance and resilience in the face of disturbances.***

Questions associated with the approach: ***Biodiversity as a problem*** in a scenario of global change: 1) How do global change (climate change, land use change, pollution, over-exploitation, invasive alien species) affect biodiversity and ecological processes in mountain ecosystems? 2) Predictions: The combination of increase in temperature, reduction of rainfall, increase of extreme events, less snow fall and duration imply less flow in rivers, more vegetation stress, forest decay, fires, etc.

Questions associated with the approach: ***Biodiversity as a solution*** in a scenario of global change: 1) How can biodiversity (compositional, structural, and functional) favor the resistance and resilience of mountain ecosystems in the face of global change, ensuring the provisioning of ecosystem services? 2) Predictions: More biodiverse ecosystems (natural and agrosystems) will be more resistant to disturbances arising from global change, and will be more resilient to them, so they will self-organize and adapt better.

Our proposal represents a change in the way of understanding nature, deepening an ecosystemic and socio-ecological approach as a line of analysis and action in the research, monitoring and management of the natural environment. The work packages included in this proposal are categorized into thematic and transversal ones (Figure 1):

Thematic Work Packages:

WP-1) Biological collections

WP-2) Comprehensive monitoring of watersheds

WP-3) Comprehensive monitoring and adaptive management of mountain forests

WP-4) Evaluation of ecosystems structure, function and services

WP-5) Climate modelling

WP-6) Sustainable development

Cross-cutting Work Packages:

WP-7) VRE (Data Management Plan, Services, Artificial Intelligence, Social Participation)

WP-8) Remote sensing

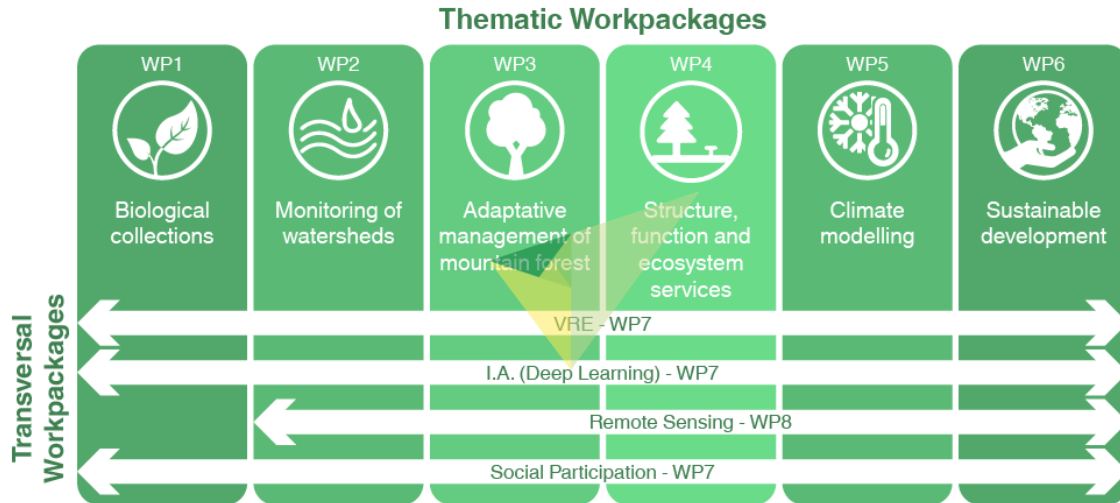


Figure 1. Workpackages

Brief explanation of WP goals:

WP-1) BIOLOGICAL COLLECTIONS (digitalization of Herbarium and Zoological collections of UGR):

The objective is to create a repository of high quality images of the specimens in different formats/elements (sheets, three-dimensional samples, microscopic images for microorganisms, pollen, etc.). This task would be transversal to many other actions of the project, according to the main objectives of LifeWatch ERIC program. We will implement an online tool for different queries (i.e. different levels of access and complexity) regarding de audience (general public, managers, researchers, etc.).

WP-2) COMPREHENSIVE MONITORING OF WATERSHEDS

The infrastructure design in our WP-2 and WP-3 Thematic work packages is inspired by the successful model of Hubbard Brooks (<https://hubbardbrook.org>) (Likens, 2013) where, for the first time, long-term ecological experiments were carried out at basin scale that have meant a before and after in the study about the impact of natural and anthropic disturbances on the natural environment. The projected permanent infrastructure and associated monitoring program will work under the following philosophy: 1) Carefully formulated questions by researchers and managers, 2) Maintaining time series of essential variables 3) Using the new technological tools at the service of 1 and 2.

This WP-2 includes an Intensive Monitoring Program where the hydrographic basin constitutes the principal integral unit of study. Different lentic and lotic waterbodies of the hydrographic network will be selected. This study constitutes the main core of the Long-term Monitoring Program, where the already existing weather stations will be complemented with new equipment. At a second level, an Extensive Monitoring Program that will address the limnological study of a selection of 30 lagoons of the Sierra Nevada and the satellite tracking

of the complete set of surface water bodies (from lagoons to peat bogs). This study will seek to calibrate field and remote sensing measurements, for the purpose of studying the natural evolution of lakes and lagoons from aquatic to terrestrial sites due to siltation, or the generality of the effects of global change between systems.

WP-3) COMPREHENSIVE MONITORING AND ADAPTIVE MANAGEMENT OF MOUNTAIN FORESTS

Inspired in the ecosystem-approach previously described (<https://hubbardbrook.org>, Likens, 2013), our proposal intends to evaluate the response of ecosystem structure, composition and function to disturbances (mostly droughts, fires and pest). Predicting the future mountain ecosystems requires a comprehensive understanding of multiple disturbances and their interactions. Fires, severe droughts and pests are the main disturbances for Mediterranean forests. On the other hand, a long-term perspective is needed to evaluate the impacts of these threats. For this reason, the proposal is focused on the temporal continuity of previously long-term research, taking advantage of the long-tradition research activity of several research groups of UGR, particularly on mountain forests.

WP-4) EVALUATION OF ECOSYSTEMS STRUCTURE, FUNCTION AND SERVICES

Ecosystem services are assessed both from the supply side (e.g. biophysical evaluations) and from the demand side (e.g. socio-cultural evaluations). In addition, revealing the links between ecosystem structure and functions and multiple supporting, provisioning, regulating and cultural services can guide management. We will identify, evaluate and map the biophysical aspects of ecosystem services relevant for the scientific, manager and public communities of Sierra Nevada. For that, we will identify key biophysical aspects and ecosystem services most relevant for Sierra Nevada from a multi-actor perspective (Figure 2). We will also evaluate and map the biophysical aspects of ecosystems services considering their spatially-explicit dimensions of ecological supply and potential demand. Finally, we will predict the supply and demand of biophysical based ecosystem services as a helping decision-making tool over scenarios of management and environmental change.

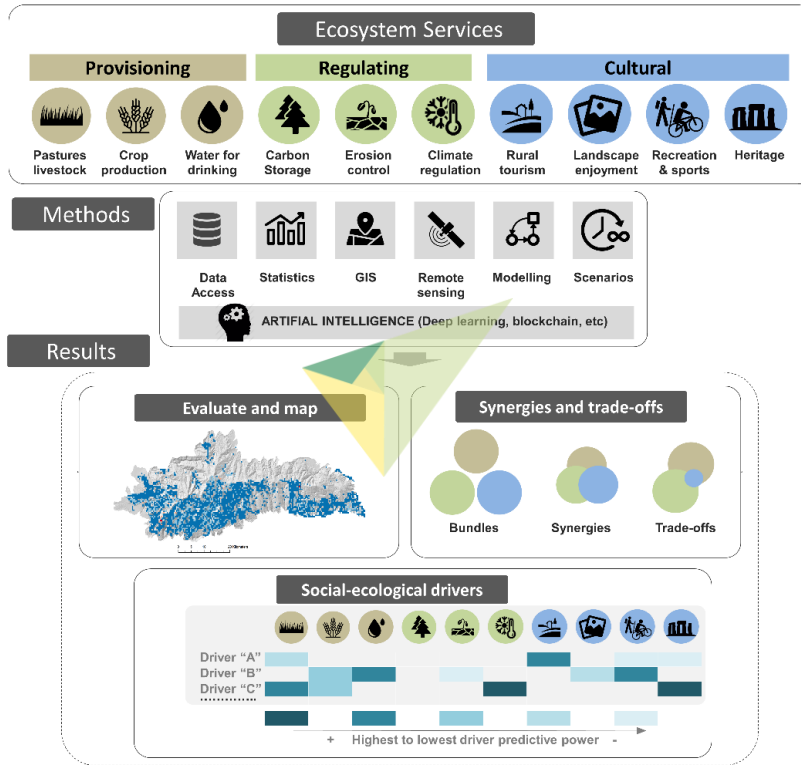


Figure. 2 Workflow proposed to monitor the supply and demand of ecosystem services and disservices in Sierra Nevada

WP-5) CLIMATE MODELLING

This WP intends to establish a climatic database of high quality for Sierra Nevada (SN) and the climate modelling for this area at present and future from the climate change projections at high resolution generated by dynamical downscaling of the general circulation models (GCMs), which serve as climate reference frame for other studies.

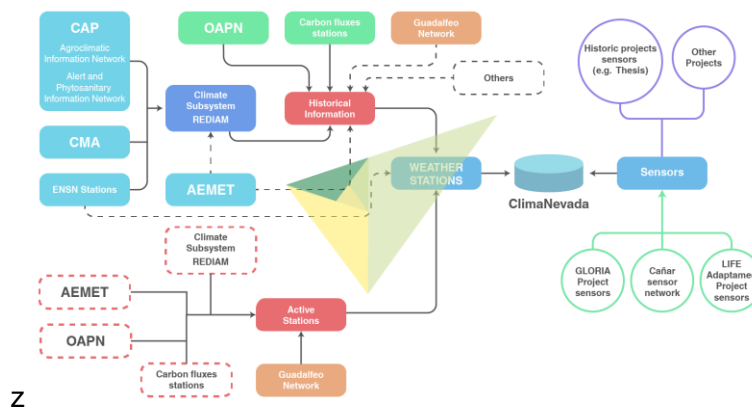


Figure 3: Scheme of the climatic data and their sources to be included in the observational climate data base.

WP-6) SUSTAINABLE DEVELOPMENT

The role of the Diputación de Granada within the framework of this proposal is to complement and accompany the proposed scientific, innovative and technological actions. within the framework of Life Watch for the UGR from the perspective of socio-economic development and the social dynamization. In this sense, this Action Plan has been prepared starting from the following intervention perspective: On the one hand, both the socioeconomic challenges of the Spanish Science and Technology Strategy and the proposals proposed by the UGR's scientific community to the Life Watch Eric project have been taken into account and, on the other, the identification and analysis of those instruments/strategic plans in force, institutionally adopted and elaborated with the participation of the social and economic agents of the territory. Thus, our proposal contemplates the human dimension of biodiversity in global change scenarios, setting realistic goals of sustainable development aligned with the "Agenda 2030" of UN (<https://www.un.org/sustainabledevelopment/es/objetivos-de-desarrollo-sostenible/>).

Specific objectives in WP6 included:

- WP 6.1. Historical systems of water management in Sierra Nevada: governance, local ecological knowledge and ecosystem services
- WP 6.2. Agrobiodiversity and social and technological innovation for the local communities of the mountain: the case of Sierra Nevada
- WP 6.3. Sustainable tourism management in Sierra Nevada
- WP 6.4. Monitoring of atmospheric pollution in Sierra Nevada.
- WP 6.5. Awareness of climate change in Sierra Nevada
- WP 6.6. Scientific dissemination

WP-7) VRE (DATA MANAGEMENT PLAN, SERVICES, ARTIFICIAL INTELLIGENCE)

The LifeWatch ERIC project aims to create an electronic infrastructure (e-Infrastructure) aimed at strengthening scientific, technological and innovation capacity in the field of biodiversity. In particular, its objective is to establish a large data, information and knowledge network based on a powerful e-Infrastructure of communications, supercomputing and distributed 'cloud'. This e-infrastructure will have as users the scientific community, environmental managers and citizens. It will allow, among many other things, access to large volumes of data related to biodiversity (biotic: fauna, flora, abiotic: atmospheric, terrestrial, oceanic and fluvial / freshwater) and will allow to work on them with analysis tools, available in a series of virtual research environments such as, for example, virtual laboratories (VRE), or with support tools for decision making by environmental managers, as well as access to data and social science tools by the general public.

I. Virtual Laboratories

As working tools to answer the questions and provide the information required by the different users of the system, we have identified 3 lines of development for virtual

laboratories, which are easily extrapolated to all areas of existing biodiversity. We propose the creation of these virtual laboratories: Ecosystems, Species and Climate.

These laboratories will have a specific part (associated with their subject matter) and another transversal part that can be extended to any laboratory of the same type. Laboratories will emerge from the scientific proposal resulting from the use of e-infrastructure. The following have initially been identified as examples:

- Ecosystems: Sierra Nevada high-mountain lakes - **VRE MountainLakes**
- Species: Iberian ibex (*Capra pyrenaica*) - **VRE Capra**
- Climate: Climate in the Sierra Nevada environment - **VRE ClimaNevada**

All laboratories will have tools that can be structured in the following hierarchical levels, interdependent, and with IA and GIS as a transversal element (although we mention it in the hierarchical breakdown): Access to data, Statistics, GIS & AI, Modelling and Simulation.



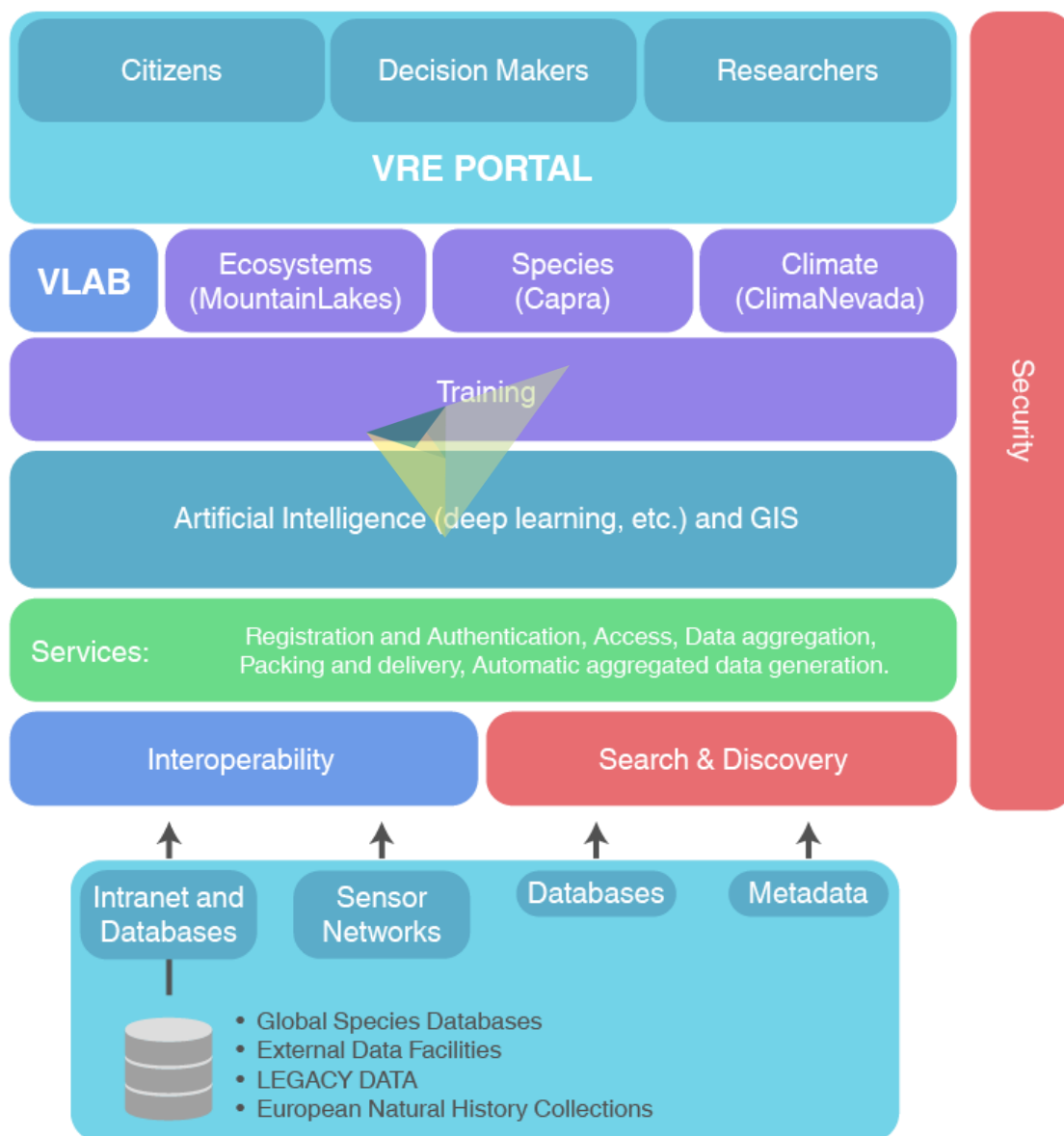


Figure 4. VRE Layers

WP-8) REMOTE SENSING

This work package aims to monitor the ecosystems of Sierra Nevada at two scales: 1) regional: using free, high resolution satellite images, to assess changes occurring in the regional context, and 2) site: using very high spatial and spectral resolution satellite imagery, in support to the field monitoring of other LifeWatch initiatives to assess changes in ecosystems in reference sites. Monitoring at both scales will allow not only to resolve scientific and management issues relevant to these scales separately but also to establish relationships between changes observed at the regional scale with remote sensing and at the plot or site scale through field monitoring in the rest of work packages. The system final

goal is to erase the barriers that researchers (within and outside LifeWatch), managers and stakeholders frequently find when trying to make use of satellite information.

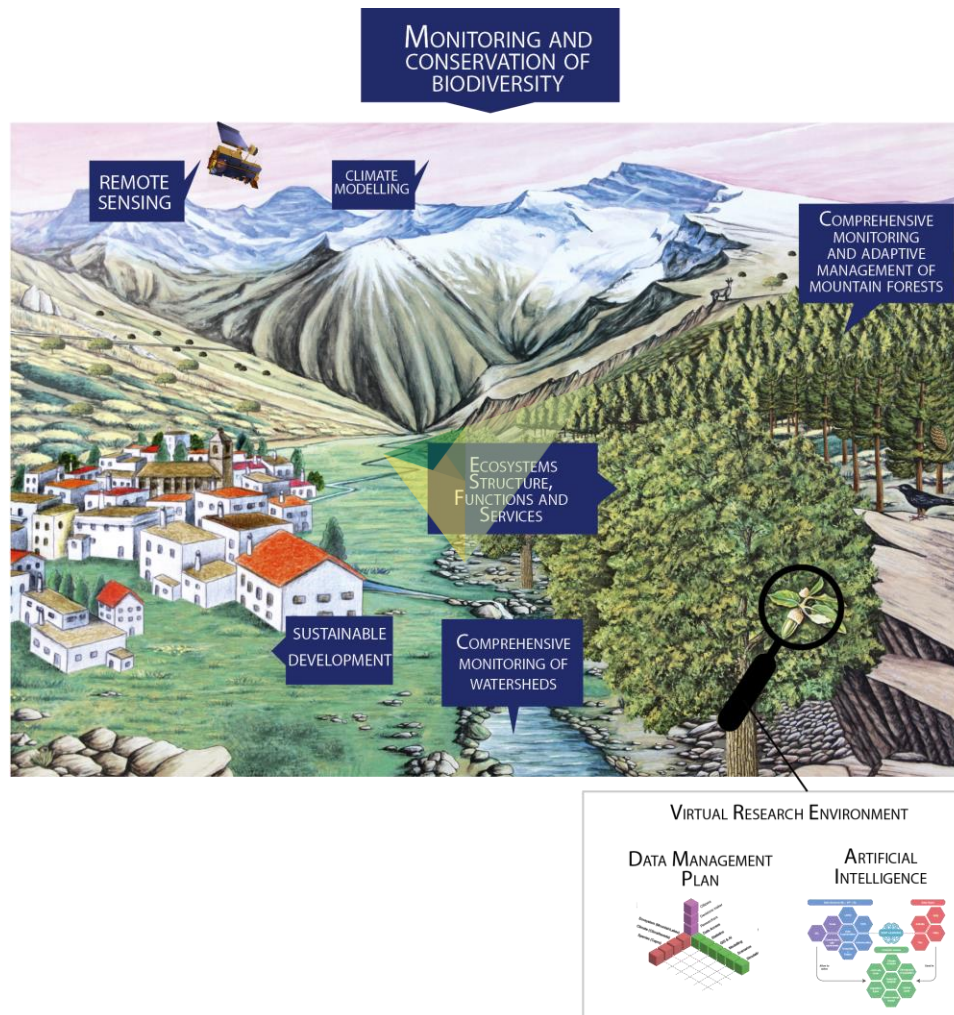


Figure 5. Idealized projection of work packages in Sierra Nevada ecosystems

Expected results of the project

1. Digitalization of raw data and non-processed data (paper, articles, files...) to enable processing with new computing tools.

- I. Digitalization of biological collections.
- II. Scientific studies.
- III. Grey literature.

2. Development of a Data Management Plan (DMP) oriented to provide useful tools to manage the data life cycle and F.A.I.R. principles.

3. Creation of a metadata catalogue with basic information about data packages of the project. Integration of metadata and/or data in international repositories

4. Create user friendly prototypes of e-infrastructure (VREs) for collect and catalogue existing biodiversity data of Sierra Nevada regardless of its provenance, integrate data (according FAIR principles) and allow used them into developed services and tools.

5. Development of interdisciplinary strategies for the transfer of scientific knowledge for decision making and adaptive management.

6. Creation of citizen science projects in various fields.

7. Implementation of decision-making tools enabling natural resource managers to foster the functional diversity of ecosystem under a global change/climatic change scenario.

8. Creation, validation and exploitation of a monitoring and remote sensing infrastructure in terrestrial and aquatic systems.

9. Identification of the environmental and socio-economic benefits of biodiversity-based ecosystems (ecosystem services).

10. Internationalization: Creation of forums facilitating the experience and knowledge exchange.

- I. Thematic Center on Mountain Ecosystems. Collaboration with institutions, universities and research centers working on mountains of Spain (e. g. Ordesa y Monte Perdido, Aigüestortes, Picos de Europa), Europe (Italy: e. g. Grand Paradiso National Park; Grecia, Eslovenia, etc) and world-wide, particularly Ibero-American and african mountainous areas.
- II. International collaboration with others institutions (GBIF, LTER, etc). Our Mountain Center will integrate and federate LifeWatch ERIC developments into the EOSC, IBERGRID, IBERLIFE and COPERNICUS initiative developments.
- III. National projects (JRU-LifeWatch Spain, IEPNB)
- IV. Regional projects. Junta de Andalucía, REDIAM.

11. Development of advanced Artificial Intelligence models for the analysis and prediction of biodiversity scenarios.

12. Development of a distributed information system for monitoring and traceability in biodiversity based on blockchain (LIFEBLOCK).