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**Copernicus Tools for Monitoring Global Change  
Effects in Rivers and Riparian Zones  
(Cop.RIVER)**

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**Deliverable 7: Workshop opened at EU level 1**

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## 1 BACKGROUND

Cop.RIVER aims to promote the use of Earth Observation (EO) in applications and services related to the ecological status of riverscapes (*i.e.*, rivers and their associated alluvial plains, floodplains and riparian forests). The action will strengthen the Copernicus user uptake by supporting regional and national authorities in the implementation of the EU Biodiversity Strategy to 2020, the Habitats and Birds Directives and the Water Framework Directive by applying GAP analysis, to complement available Copernicus information on the state and characteristics of rivers and riparian zones.

The expert workshop ‘Needs and methodologies for riparian vegetation characterisation’, arises in the context of the European project Copernicus Tools for Monitoring Global Change Effects in Rivers and Riparian Zones (Cop.RIVER). The Cop.RIVER project, developed by IHCantabria, is aimed at evaluating the applicability of the remote sensing tools provided by the COPERNICUS programme (European Space Agency) for monitoring the effects of global change in rivers and riparian zones. For this purpose, key actors in the implementation of regulations such as the Habitats Directive, the Water Framework Directive and the Biodiversity Strategy 2030 (among others) have been identified, as well as experts in the characterisation of river landscape components in Spain and other European countries (*e.g.*, identification of riparian species, remote sensing experts).

The specific objectives of this workshop were:

- i) To identify the needs of the public administration for the management, monitoring and assessment of the state of riparian vegetation.
- ii) To review existing methodologies to characterise riparian vegetation at multiple spatio-temporal scales.
- iii) To detect methodological or knowledge gaps and possible improvements, identifying the main challenges and opportunities facing the study of riparian ecosystems and their application to management at a European level.

## 2 WORKSHOP OPENED AT EU LEVEL 1

This workshop, held on 19 September, brought together more than 25 participants from public organizations (General Directorate of Water, Biodiversity Foundation, Catalan Water Agency, TRAGSA Group) and academic institutions (Agronomy Superior Institute of the University of Lisbon, Autonomous University of Madrid - UAM, University of Valencia - UV, Institute of Environmental Hydraulics of the University of Cantabria - IHCantabria).

After a brief welcome and the presentation of the workshop in the context of the Cop.RIVER project, the presentation session was opened. Firstly, Javier Monte Morgado, representing the General Sub-Directorate for Water Protection and Risk Management (General Directorate for Water - DGA, MITECO), presented the needs of the DGA regarding the assessment and monitoring of fluvial ecosystems. The application of directives such as the Water Framework Directive or restoration actions and the development of strategies against climate change require the characterization of different components and processes of the fluvial space and their monitoring over time, highlighting the interest

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of the administration in incorporating new tools related to remote sensing in its work methodologies and the need to have knowledge about and access to them. Specifically, the DGA applies remote sensing for the characterization of variables associated with river hydromorphology (*e.g.*, delimitation of the active channel, prior identification of transversal barriers and longitudinal works, characterization of the morphological conditions of the channel), for the early detection of exotic aquatic plants and as a tool to improve the mapping of flood zones. The needs and opportunities for improvement expressed by the DGA were:

- Identification of both native and alien plant species
- Early warning indicators of aquatic invasive alien plant species
- Monitoring of restoration actions (*i.e.*, status of plantations, control of resprouting of invasive alien species).
- Detection of diseases by assessing the phytosanitary status of the vegetation.
- Extension of specific sampling to the rest of the reach or body of water.

Afterwards, the working group led by Rafael Hidalgo (General Directorate of Biodiversity, Forests and Desertification - MITECO), which brings together experts in riparian areas (Juan Antonio Calleja and Francisco Lara - UAM, Ricardo Garilleti - UV, François Tapia - TRAGSATEC), presented the official procedures for the monitoring and assessment of the conservation status of riparian forests and shrublands in Spain. In this intervention, the regulatory and technical framework for the monitoring and assessment of riparian habitats was presented, pointing out that photo-interpretation, based on satellite images, is useful as a first approximation for the recognition of different physiological units, which must subsequently be visited in the field for the identification of species and the delimitation of habitats. In addition, satellite information facilitates the calculation of the parameter 'Future prospects', as tools such as LiDAR allow the characterization of variables used in the evaluation of the degree of alteration of the natural system (*e.g.*, surface occupied by the water surface, depth and sinuosity of the riverbed, sediment dynamics). The main development proposal expressed by this working group was:

- Determination of the spectral signature of species and habitats, and characterization of their variability at species level and between species, as well as their spatial and temporal variability, with the aim of improving the spatial demarcation and recognition of communities in the areas where this is possible, and limiting or eventually avoiding direct field studies.
- Delimitation of the Riparian Reference Area
- Improve or make more efficient the tools for assessing the intensity of the impact of pressures and threats on the habitat type.

Patricia Rodríguez González, representing the Centre for Forestry Studies and Associated Laboratory TERRA (Superior Institute of Agronomy - University of Lisbon), then identified the main challenges and opportunities facing the study of riparian ecosystems and their application to management, presenting different research projects. The projects featured show, on the one hand, the usefulness of remote sensing to identify biotic and abiotic aspects that characterize and determine the functioning of riparian ecosystems, and on the other, the challenge posed by the fact that fundamental attributes

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and processes of riparian ecosystems occur at very different scales. Specifically, this working group highlighted the following opportunities for improvement in the characterization and management of riparian ecosystems through the use of remote sensing:

- Improve tools to quantify and prioritise ecosystem services associated with riverbanks.
- Improve numerical models and simulation tools.
- Calibrate methods and manage data availability to improve indicators and monitoring strategies.

In the second session, Álvaro Fernández Menéndez, PhD student at the Continental Ecosystems Group (IHCantabria), presented the possibilities offered by remote sensing to characterize different components of the fluvial landscape (*i.e.*, active riverbed, vegetation patches and sediments) and to understand their temporal dynamics. In particular, it showed that by combining field data, time series of spectral indices and other environmental variables (*e.g.*, topography, climate) it is possible to predict, with some degree of accuracy, the presence of water, vegetation or sediment in riparian zones on a spatial continuum. The study of the temporal patterns of the spectral signal of vegetation formations (*i.e.*, spectrophenology) also allows the prediction of the occurrence of certain riparian species and habitats, facilitating the monitoring of the conservation status of riparian ecosystems at a regional scale. The main need expressed in this paper was:

- The availability of field data for the training and subsequent validation of remotely sensed models to identify and characterize the components of the river landscape (*i.e.*, active channel, permanent and dynamic vegetation, sediments) and to develop the technique of spectrophenology of riverbank vegetation.

The last presentation was given by Laura Concostrina, researcher of the Continental Ecosystems Group (IHCantabria), presenting the development of a tool for the selection and application of indicators of the state of conservation of the components that make up the fluvial landscape through the use of remote sensing, the main objective of the Cop.RIVER project. This open access tool is aimed, firstly, at facilitating the selection of remote sensing indicators that allow the characterization of biotic and abiotic attributes, as well as some processes and functions, presented by riparian ecosystems and rivers at the scale of the river network. Secondly, this tool will provide a guide for the calculation of these indicators, including the methodology to be followed and the resources available for their application. The opportunity for improvement shown during this presentation was:

- The use of remotely sensed indicators will improve the ability to monitor the state of riparian habitats and ecosystems by providing information on a time-space continuum.

To conclude, a space was opened for discussion on the key issues presented at the workshop.

The following is a synthesis of the content presented by the workshop speakers, the conclusions of the roundtable and the results of a short survey of the participants.

## 2.1 Remote sensing applications for the characterization of fluvial landscape components and processes

- Remote sensing enables the identification and characterisation of habitats at different levels of aggregation.
- Multiple remote sensing tools exist for different scales: satellites vs. drones vs. handheld equipment (*e.g.*, spectroradiometer) that allow to complete spatially or temporally the characterisation of riparian zones at the catchment or regional scale.
- Remote sensing provides spectral, climatic, topographic and environmental (*e.g.*, soil-related) information, as well as information related to pressures and threats.
- The availability of time series of spectral images allows the identification of seasonal patterns of vegetation (intra- and inter-annual), from which multiple indices can be derived to assist in the identification and characterisation of riparian species and habitats (*e.g.*, spectrophenology).

## 2.2 Main needs identified

For managers and technicians:

- Improve knowledge and access to sources of remote sensing resources and available application methodologies.
- Improve habitat delimitation, identification and characterization, or, if the matter is sufficiently mature, establish standardized protocols (defined and adapted to different circumstances), for habitat delimitation, identification and characterization, also at the lowest levels of disaggregation, as far as possible, to optimize the use of fieldwork.
- Improve or make more efficient the tools for characterizing variables used in the assessment of the degree of alteration of the natural system and for assessing the intensity of the impact of pressures and threats on the ecosystem (*e.g.*, presence of alien and invasive species and detection of diseases of riparian vegetation).
- Extend the information obtained in the field at a sampling point to the river reach or water body. Follow-up of restoration actions.

For the research groups:

- It is necessary to have information obtained through field work carried out by experts that allows the identification of riparian vegetation at species level and in the different strata. This information is the basis for the development of models to predict the presence of species, plant formations and/or habitats.
- The structural complexity of riparian habitats requires that remote sensing is combined with upstream (*i.e.*, model training) and downstream (*i.e.*, model validation) fieldwork to maximize its applicability ('upscaling').

## 2.3 Challenges identified and future developments

For managers and technicians:

- Remote sensing has great potential to improve spatio-temporal continuity in data sets (*i.e.*, from patches to reaches and river networks) but entails the loss of resolution of detail in some variables (*e.g.*, species composition).
- The characterization of headwater reaches (*e.g.*, steep relief, riverbank vegetation replaced or masked by slope vegetation) and urban reaches or areas with intensive livestock or agricultural use (*i.e.*, row of trees) requires a specific approach.
- It would be interesting to include the characterization of soil attributes and processes (*e.g.*, subsurface flow, soil moisture in the riparian zone), as well as sediment dynamics in the channel, using remote sensing.

For the research groups:

- Riverbank habitats have high spatial and temporal dynamics, which must be taken into account when selecting and processing remotely sensed information.
- Development of a freely accessible online tool, updated and maintained over time, including:
  - A guide for the selection of indicators
  - The methodologies to be followed for the calculation of the indicators
  - The remote sensing products to apply the proposed methodologies
  - Other applications, such as the quantification of ecosystem services (*e.g.*, temperature regulation by riparian forest) from remotely sensed indicators.

## 2.4 Results of the survey on the application of remote sensing in riparian vegetation characterization

The participants of workshop were mainly from the technical, management and scientific fields, and to a lesser extent from the educational field. The vast majority of them work in the riparian zone, but also in other terrestrial and aquatic habitats. Approximately half of the participants use field data as a source of information, while the other half combine field work and the use of remote sensing. The vast majority of participants work at various temporal scales, although some of them focus on conservation status reporting periods (*i.e.*, every 6 years).

Some examples of how participants make use of remote sensing are:

- The delimitation of the active channel and the floodplain.
- Characterization of the riparian zone and fluvial geomorphology.
- Identification of species and habitats (as a first approach)
- Characterization of attributes such as vegetation cover, composition and structure, surface heterogeneity and connectivity of habitats and vegetation formations.
- The identification of impacts such as the presence of artificial structures, modifications of the natural channel and others.

The developments suggested by the participants were:

- Characterization of subsurface flow
- Mapping of native and invasive species
- Determination of the age of riparian vegetation
- Assessment of vegetation patch advancement
- Assessment of sediment transport processes (erosion/sedimentation)
- Indicators of the physiological state of riparian vegetation, phytosanitary status and early warning indicators.

### 3 CONCLUSIONS

The expert workshop allowed to share needs, interests and future developments related to the use of remote sensing in the characterisation of riparian vegetation, as well as in the monitoring of components, processes and conservation status occurring in riparian ecosystems. The most relevant conclusions of the workshop were i) remote sensing is a useful tool to characterise the river landscape and its different components at the reach and catchment scale and with a short temporal frequency, ii) remote sensing has limitations for certain types of river reaches (*e.g.*, headwater reaches, urban) and variables (*e.g.*, species richness), and iii) it is crucial to select the appropriate remote sensing indicators according to the object of study, the spatial scale at which it can be assessed and the needs for reporting or modelling. Interaction between technicians and managers of natural areas and research groups is essential to advance in the development of tools that provide accurate and useful information for the management and conservation of river landscapes, such as those based on remote sensing.

### 4 ACKNOWLEDGMENTS

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