The Geomorphic Units survey and classification System (GUS)

Le Système de classification et analyse des Unités Géomorphologiques (*GUS*)

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RÉSUMÉ

Le Système de classification et analyse des Unités Géomorphologiques (GUS) a été développé afin d'intégrer l'évaluation des conditions hydromorphologiques à l'échelle d'un tronçon de rivière (ex. avec l'Indice de Qualité Morphologique, MQI) à travers l'analyse et la classification des unités géomorphologiques, et permettre de mieux établir le lien entre conditions morphologiques à l'échelle du tronçon, unités géomorphologiques caractéristiques et conditions biologiques. Le système inclut 3 échelles spatiales (Macro-unités, Unités, Sub-unités), organisées en 3 contextes spatiaux (Lit mineur, Unités marginales, Plaine alluviale) et est structuré selon 3 niveaux de description (Général, Basique, Détaillé). A chaque niveau, des informations spécifiques sont collectées: du simple recensement des unités et de leur nombre, à la mesure de leur taille ou de caractéristiques spécifiques (ex. type de sédiment, conditions hydrologiques, végétation, etc.). Le système est appliqué en combinant la télédétection et les relevés de terrain, selon l'échelle spatiale et le niveau d'analyse. Il est applicable à la plupart des contextes fluviaux (ex. petites rivières ou grandes fleuves), et a été développé pour être flexible et adaptable (sections obligatoires et/ou optionnelles) en fonctions des objectifs spécifiques (ex. caractérisation du tronçon, évaluation des conditions, suivi) et des données disponibles (ex. résolution des images).

ABSTRACT

The Geomorphic Units survey and classification System (GUS) has been developed for the survey and classification of geomorphic units in streams and rivers, suitable to integrate the hydromorphological assessment at the reach scale (e.g. the Morphological Quality Index, MQI), and therefore to better establish links between hydromorphological conditions at the reach scale, characteristic geomorphic units and related biological conditions. The system includes 3 different spatial scales (i.e. Macro-units, Units, Sub-units) organized in 3 spatial contexts (i.e. Instream, Marginal, Floodplain) and is structured in 3 levels of description (i.e. Broad, Base, Detailed). At each level, different specific information is collected: from the simple census of units and their number, to the measurement of units size and the survey of specific unit characteristics (e.g. sediment, hydrology, vegetation). The method is applied by combining remote sensing analysis and field survey, according to the spatial scale and the level of description. It is applicable to most of fluvial conditions (e.g. from small streams to large rivers), and has been designed to be flexible and adaptable (i.e. including mandatory and/or optional sections) on the basis of specific objectives (e.g. reach characterization, assessment, monitoring) and available data (e.g. image resolution).

KEYWORDS

Field survey, Geomorphic units, Hydromorphological conditions, Physical habitats, Remote sensing

1 INTRODUCTION

The assessment of stream hydromorphological conditions is required for the classification and monitoring of water bodies by the Water Framework Directive 2000/60, and is useful to establish links between physical and biological conditions. The scale of physical habitats is the most suitable in defining such links. Several physical habitat assessment methods have been developed worldwide since the 1980s. However most of the methods used across Europe are affected by a series of important limitations, including (Belletti et al. 2014): (i) the notable difference between the terminology used and the present state of the art in fluvial geomorphology; (ii) the spatial scale of investigation, that is in most cases not well framed within a multi-scale approach, being rather small ('site' scale) and of a fixed length; (iii) these methods often define high status/reference conditions on the basis of the presence and abundance of features, failing to recognize the 'natural' variability of geomorphic structures amongst different river types. In that context a new system for the survey and classification of geomorphic units (GUS) in streams and rivers has been developed. The spatial scales of Geomorphic Units (GU hereafter) and related smaller ones (hydraulic units and river elements) are the most appropriate to assess physical habitats in a geomorphologically meaningful context. This system is part of a wider set of novel tools for an overall hydromorphological assessment of European streams (see Rinaldi et al., 2015). More in detail, the system is suitable to integrate the Morphological Quality Index (MQI) developed in Italy (Rinaldi et al. 2013) and recently expanded to other European countries in the context of REFORM (REstoring rivers FOR effective catchment Management). It is also aimed at allowing the establishment of links between hydromorphological conditions at reach scale, characteristic morphological units and related biological conditions.

2 THE GEOMORPHIC UNITS SURVEY AND CLASSIFICATION SYSTEM

2.1 The main characteristics of the GUS

The main characteristics and innovative features of the GUS can be summarized as follows:

- It is designed to provide a general framework for the survey and classification of GU, while it does not aim to assess the deviation from given reference conditions and/or assess the status or quality of the stream by the use of quantitative indices.
- It is an open-ended, flexible framework, where the operator can set up the level of characterization and the specific focus of the survey, depending on the objectives and on available resources.
- The system is embedded in an appropriate spatial nested hierarchical framework.

2.2 The geomorphic units and the spatial nested hierarchical framework

The GU are organized in different levels within a nested hierarchical framework. The levels differ in terms of spatial extent and of detail of characterization, i.e. the larger scale means a greater level of generality, while the smaller scale means a greater detail. They are defined as follows (Figure 1):

- **Macro-unit:** This is an assemblage of units of the same type, e.g. aquatic portions, sediment, vegetation. The scale can be identified with the reach or a representative portion (sub-reach).
- **Unit:** This is the basic spatial unit, and corresponds to a feature with distinctive morphological characteristics and significant size, e.g. riffle, bar, island. The size is variable, in relation to the spatial setting and the type of unit. It generally corresponds to the scale of the 'mesohabitat'.
- **Sub-unit:** This corresponds to patches of relatively homogeneous characteristics in terms of vegetation, sediment and/or flow conditions. The size is smaller than the units, and can correspond to individual isolated elements or patches, e.g. logs, gravel patches. The scale can vary from that just below the 'mesohabitat' to the scale of 'microhabitats'. Sub-units are ecologically relevant.

2.3 Spatial settings

Three spatial settings and relative units are distinguished: (1) bankfull channel, i.e. all the GU located within the bankfull channel (e.g. bed configuration, bars, islands); (2) marginal zone, i.e. those features located at the interface between bankfull channel and floodplain (e.g. banks, berms); (3) floodplain, i.e. all the units occupying the remaining floodplain external to the bankfull channel and the marginal zone (e.g. recent terraces, wetlands, oxbow lakes).

2.4 Levels of characterization

The survey of GU can be carried out at different levels of characterization with increasing details defined as follows (Figure 1):

- **Broad level:** It consists of a general characterization of macro-units, i.e. presence/absence, areal extension and/or percentage relative to the spatial settings. It is carried out exclusively by remote sensing and GIS analysis, and can be applied to rivers with sufficient size and/or image resolution.
- **Basic level:** It consists of a complete delineation and a first level of characterization of all GU, i.e. presence/absence, number, area/length. Some macro-units types can also be described at this level. It is mainly carried out by field survey, but remote sensing and GIS analysis are also used in combination with field (e.g. large river size and very high image resolution).
- **Detailed level:** It aims at: (i) providing more detailed information and data for units (and some macro-units) on genetic processes, morphological, hydrological, vegetation and sediment; (ii) describing macro-units and units sub-types (when applicable); (iii) characterizing sub-units.

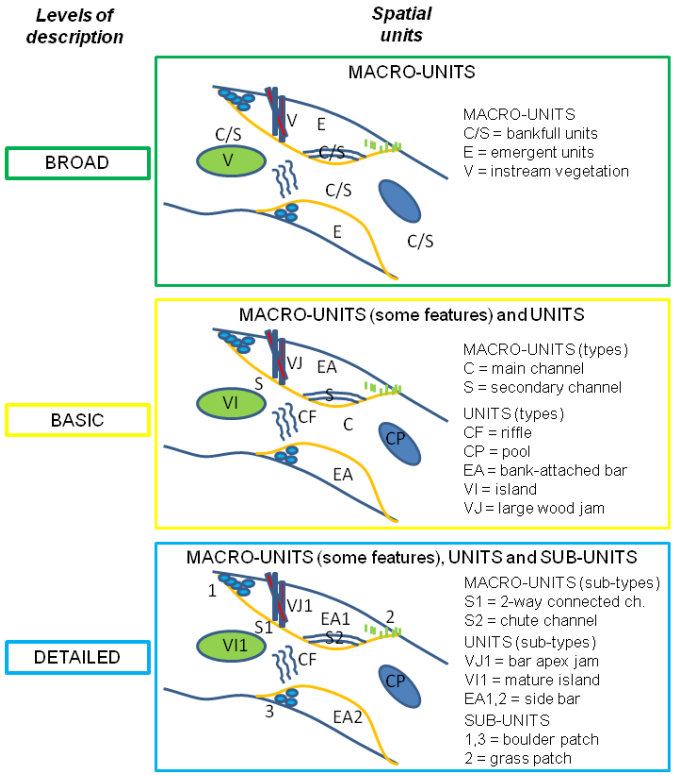

Figure 1. Levels of description and spatial units; examples of GU for different spatial contexts are also reported.

ACKNOWLEDGEMENTS

This work has received funding from the EU's FP7 under Grant Agreement No. 282656 (REFORM); the original Italian version was funded by ISPRA (Instituto Superiore per la Protezione e la Ricerca Ambientale, Roma, Italy).

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