Planning for a healthy landscape to provide healthy soils. Restoring the Headwater System

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Land use and management practices are the primary cause of land degradation, including soil loss, soil pollution, and biodiversity loss. The goal of achieving a healthy soil capable of providing a wide range of ecosystem services should be guaranteed by integrating these goals in the landscape planning system.

Landscape planning methodologies should integrate a perspective of understanding the ecological suitability for different activities to avoid the risk of taking land degradation to a level of difficulty to recover. Those methodologies also need to involve the landowners, define the best management practices, and inform about landowners' financial returns. In Portugal, municipal plans (PDM) are defined at a scale of 1:25000, binding private parties. However, they are very superficial in informing landowners about land potentiality and management practices, and they do not identify where ecosystem restoration should occur.

This work aims to show how priority areas for restoration can be identified and included in municipal landscape plans to provide a good chemical, biological and physical condition of soils. The methodology is defined in Geographic Information System (GIS), and it is based on ecological-based principles. In particular, it is shown how the headwater system's restoration could be planned. The Headwater System is located between the beginning of the water network and the ridgeline and plays an essential role in regulating water and returning quality to the soil. The best suitable land use in the headwater system is a mixed forest consisting of species of potential natural vegetation that will return nutrients to the soil, maximize organic matter, reduce the risk of erosion and regulate the water cycle, while being an essential tool for controlling human activities, also preventing actions that lead to soil pollution.

The headwaters were mapped in GIS considering a drainage area of 0.05 km^2, for the study area, which comprises 55 thousand hectares. The present study evaluates the current land uses in the headwaters, identifying Hotspots for ecological restoration and identifying opportunities for improving the landscape planning system.

The results show that about one-third of the study area is made up of headwaters located in a very hilly relief with very thin soils. The dominant land uses are eucalyptus forest, shrubs, and old areas of maritime pine that burned in the 2017 mega-fires. The potential natural vegetation shows

that these sites are suitable for *Quercus pyrenaica*, *Quercus suber*, *Quercus robur*, and *Castanea sativa*.

The adequate land use of the headwater system will significantly impact the ecological function of its river basin. The restoration of these areas will provide better ecosystem services by avoiding soil loss and reducing floods downstream, improving water infiltration and its quality, and increasing biodiversity. The integration of headwater restoration in the landscape planning system can be a crucial tool for attaining healthy soils.