

Temporal changes in potential regulating ecosystem services driven by urbanization

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Ecosystem services (ES) are understood to be the capacity of the landscape of a particular area to provide goods and services to society. In terms of human benefits, four categories of ES are usually considered: provisioning (e.g. seafood), regulating (e.g. climate regulation, air quality, water purification and natural hazard protection), supporting (e.g. maintenance of biodiversity), and cultural (e.g. recreation). The potential supply of ecosystem services has received increasing interest as a tool for natural resource management. Nevertheless, the capacity to supply ES depends on biophysical conditions, as well as climate and land-use changes, induced by human activities. This study aims to investigate the potential for regulating ecosystem service supply of a Portuguese peri-urban catchment, and attempts to understand the temporal changes in ES over the last decades driven by urbanization.

The study was developed in Ribeira dos Covões catchment (6.2 km^2), in Portugal. Due to its proximity to Coimbra, a major city in the central region of Portugal, the catchment has undergone major land-use changes over the last half-century. Since 1958, the agricultural area, comprising mainly olives and arable land, has declined from 48% to 4%, due to increases in urban land (from 8% to 40%) and forest (from 44% to 53%), as well as a temporary creation of open spaces (from 0% to 3%). The nature of forest cover also changed, from native species, such as oaks (*Quercus* sp.), to commercial timber plantations, mostly of *Pinus pinaster* L. and *Eucalyptus globulus* L.. Urbanization became more pronounced after 1973, exhibiting a discontinuous pattern until 1995, and then later more continuous urban areas through the infilling of areas between the earlier urban cores.

Quantification of regulating ES in the study catchment was achieved using GIS techniques, in order to gain a spatial dimension of ES distribution (Burkhard et al., 2009). Mapping ecosystem service capacities at a $5 \times 5\text{m}$ resolution involved the use of CORINE land cover data and aerial photographs, available for the years 1958, 1973, 1979, 1990, 1995, 2002, 2007 and 2012. The resulting land-use maps include 11 land cover classes: equipment and infrastructure, discontinuous urban fabric, continuous urban fabric, natural areas with shrubs and herbaceous plants, softwoods, hardwoods, mixed forest, permanent crops, arable land, bare soil and water bodies. Quantitative assessment of regulating services of these land-use classes was achieved based on interviews with 31 experts. Each expert prepared a matrix using a scale from "0" to "5", where "0" refers to the land cover as having no capacity to provide regulating services, while 5 indicates that the land cover provides a wide range of ecosystem services. A final matrix was prepared based on mean values of all the experts. This matrix was then integrated with the land-use maps of different years to generate a spatially explicit potential ecosystem service supply model.

The results showed decreasing ecosystem regulation services over time, mainly due to increasing urban area but also changes on forest types. The methodology used can be easily applied to test distinct urbanization scenarios, thus, providing a valuable support for urban planning.