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Describing urban soils through a faceted system ensures more informed decision-making

Franco Ajmone-Marsan[a], Giacomo Certini[b], Riccardo Scalenghe[c,*]

[a] Dipartimento di Scienze Agrarie, Forestali e Alimentari (DISAFA), Università di Torino, Grugliasco, Italy
[b] Dipartimento di Scienze delle Produzioni Agroalimentari e dell'Ambiente (DISPAA), Università di Firenze, Italy
[c] Dipartimento di Scienze Agrarie e Forestali (SAF), Università di Palermo, Italy

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ABSTRACT

Urban areas are increasing worldwide at a dramatic rate and their soils definitely deserve more attention than they have received in the past. In urban environments, soils potentially provide the same ecosystem services as in rural and wild environments, although in some cases they are depleted of their basic functions, such as when they lose their productive and filtering capacities because of sealing, and become mere supports for infrastructures. In other cases, soils of urban areas acquire new functions that are unique to these environments. Current soil classifications fail to effectively account for the complexity of urban soils and the information that is required for their management. Additionally, the survey of urban soils is difficult, due to fragmentation and rapid land use change and the fact that due to human pressure their properties seldom vary linearly and predictably according to landforms, which hinders the effectiveness of geostatistics. The conventional practice of grouping similar soils and transferring their information in a concise manner is not viable for urban soils. We advocate the introduction of a faceted system – i.e., a scheme using semantic categories, either general or subject-specific, that are combined to create the full classification entry – to organize the information on urban soils to support decision-making. The facets that such a system should be based on are not only the intrinsic physical and chemical properties that are usually used to describe any soil, but also other tangible or even immaterial properties that are particularly meaningful in an urban context, such as landscape metrics, or aesthetic, social and historical values. As well as providing more adequately the information of the type requested by urban planners and policymakers, a faceted system of classification of urban soil resources would have the flexibility to accommodate all available or future scattered, rapidly changing, or incomplete data.

1. Introduction

Soil provides food, biomass and raw materials to humankind. It is a platform for human activities, a main component of the landscape, an archive of heritage, a filter for groundwater quality, and the most important terrestrial storage of carbon and biodiversity. Soil stores, filters and transforms many substances, including water, nutrients and carbon (Commission of the European Communities, 2006). A thorough review of the literature about soil properties and the associated ecosystem services has been just compiled by Adhikari and Hartemink (2016). Soil sustains an expanding population that is increasingly living in cities (Anonymous, 2010; United Nations, 2014). As a consequence, urban areas are experiencing a progressive enlargement that involves peri-urban soils, completely removing or converting them to *urban* soils (Fig. 1). In urban contexts, soils potentially provide the same ecosystem services as other soils but their role of physical support for infrastructures frequently overcomes all others (Grimm et al., 2008). In most cases, urban soils experience serious depletion of their basic functions, in particular biomass production, biodiversity conservation, and carbon sequestration. Therefore, urban soils are different, in many aspects, from their agricultural, forest or natural counterparts (e.g., Biasioli et al., 2006; Ellis, 2011; Pickett et al., 2011), so much that the traditional approaches for describing and mapping them often seem inappropriate.

While in the countryside land use is mostly planned on the basis of the soil's intrinsic properties, in cities soil uses essentially depend on site location. However, cities are highly dynamic environments where soil use changes rather frequently due to the continuous reorganization of the urban tissue (Hollis, 1991;

* Corresponding author.
E-mail address: riccardo.scalenghe@unipa.it (R. Scalenghe).

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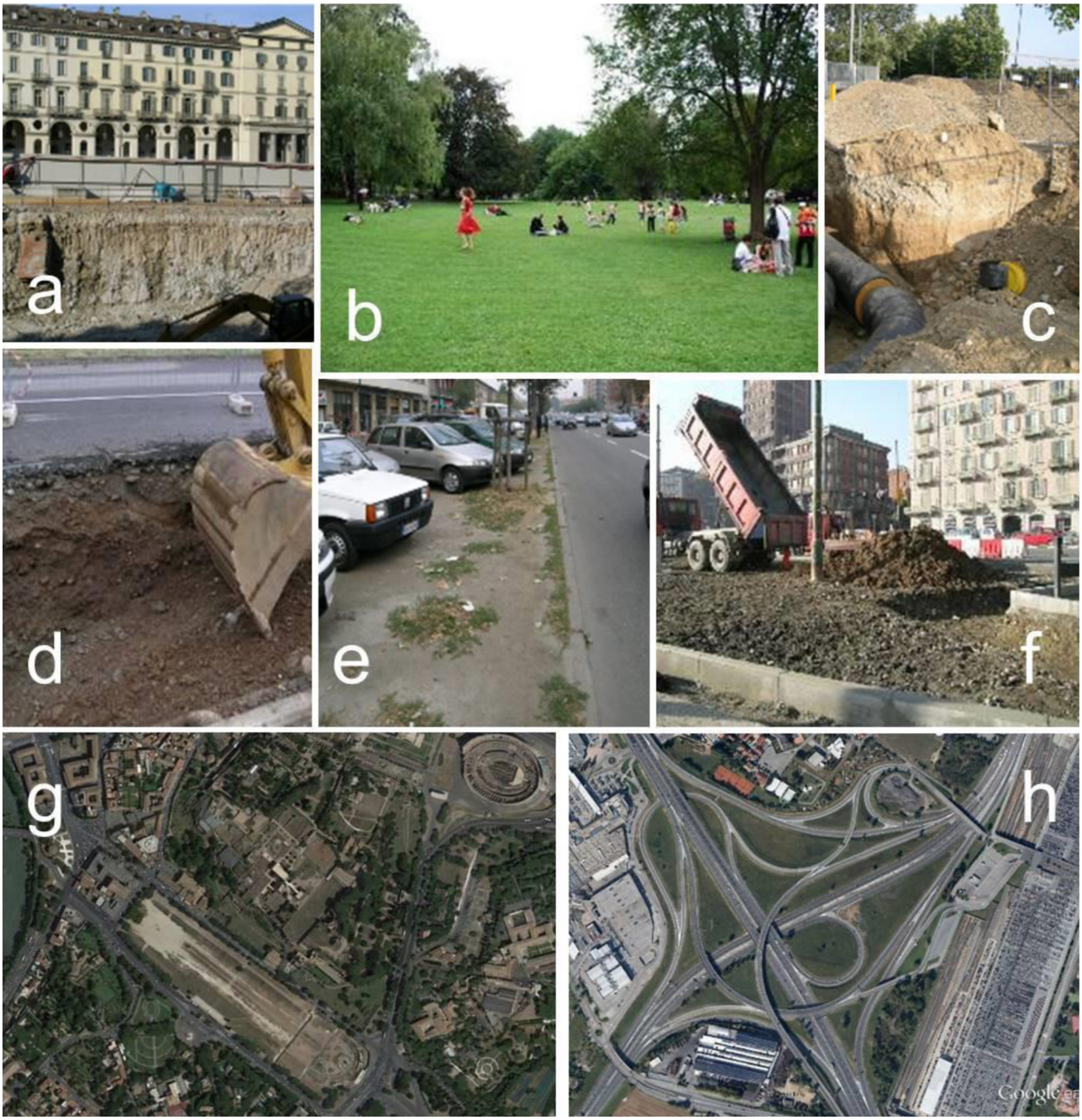

Fig. 1. (a–f) examples of soils in an urban and peri-urban environment; (g) the ancient Roman chariot racing stadium *Circus Maximus* (photo: Ministero dell'Ambiente e della Tutela del Territorio e del Mare; location 41°53′9.26″N, 12°29′8.53″E) (h) a road junction encompasses soils that are subtracted for any other use (photo: Google Earth; location 45°01′20″N, 7°35′52″E). The expression 'peri-urban', first used in France [and Switzerland], describes spaces shaped by the urbanization between the city and the rural area, in the urban fringe. Peri-urban both in a social [e.g., lifestyle] and in a physical [e.g., land use change] sense.

Norra and Stüben, 2003; Rossiter, 2007). Topsoil horizons are often reworked and obliterated, mixed with, or even replaced by, allochthonous materials (Nehls et al., 2013; Scharenbroch et al., 2005). Buildings and other infrastructures progressively sprawl in the country, sealing an increasing proportion of soils, making them unsuitable for performing crucial environmental purposes, such as draining rainwater or producing biomasses (Nuissl et al., 2009; Scalenghe and Ajmone-Marsan, 2009; Schmidt et al., 2004). As a consequence, urban soils appear fragmented and of very variable quality (European Environment Agency, 2011; Han, 2010; Kasanko et al., 2006; Kent, 2009). The patches of unsealed soils often experience some forms of degradation. For instance, a highway junction (Fig. 1) degrades the soils of the area it includes by changing their hydrology and imposing severe contamination from traffic, but also dramatically affecting the access to animals and seeds. Overall, the functional, ecological and aesthetic meaning of the area is drastically modified. On the other hand, the issue of city sprawl (Anonymous, 2010) calls for a smarter, more compacted city design and encourages the reclamation and reuse of dismissed soils (Hou and Al-Tabbaa, 2014). Vast urban and peri-urban industrial areas are being dismissed in Western countries as a result of the evolution and delocalization of manufacturing activities. Such areas, usually called *brownfields*, are sometimes reconverted to other uses after