ABSTRACT

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Effects of land cover, land-use history, and within-land cover variability on soil-based ecosystem services in urban Madison, WI

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Background/Questions/Methods

By 2050, 75% of people globally will live in cities, with urban areas expanding faster than urban populations. Yet while cities are increasingly recognized as providing important ecosystem services (ES) to their occupants, most urban ES studies measure only a single service, and often ignore the complex spatial heterogeneity and land-use history found in cities. Soil-based services (e.g. carbon storage, water quality regulation, runoff regulation) may be particularly susceptible to legacy effects and time lags in service provision; whereby past land use alters present-day service provision, perhaps superseding current land-cover patterns and management practices. We measured soil properties and nutrient pools indicative of multiple ES at three depths (0-5 cm, 5-10 cm, and 10-25 cm) in 100 sites across the city of Madison, WI. Sites encompassed 5 land-cover classes (forest, grassland, urban open space, low-density developed and medium-density developed) and spanned a historical development gradient of ~125 years, representing the transition from agricultural to urban land use. Sites included both private and public greenspaces, including both semi-natural and developed land. We asked: what are the relative roles of current land cover, land-use history, and within-land-cover variability in ES provision?

Results/Conclusions

Soil organic carbon (SOC) and available phosphorous (P) differed with land cover. Semi-natural sites stored less SOC (6.4 and 6.8 kg/m^2 for grassland and forest, to 25 cm depth) than developed sites (8.0, 9.2, 9.3 kg/m^2 for low density, medium density, and urban open space). Available P concentration was lowest in grassland and open space (39 ppm), followed by forests (50 ppm), and low- and medium-density developed (59 and 62 ppm). Thus, less-developed sites with semi-natural land cover would support higher water quality regulation services (lower P), while developed sites had the highest carbon storage. However, land-cover proxies alone had limited explanatory power. For SOC, a history-depth interaction was present in developed sites; at depths >5 cm, SOC increased with time since development, by 32-44% over 100 yrs. This suggests consistent accrual of SOC in developed sites following conversion from agriculture, particularly at depth. Surprisingly, available P also increased with time since development (25-70% increase over 100 yrs), suggesting factors other than agricultural legacies control soil P. Soil-based urban ES may depend on past and current land use, and the role of history should be considered to better understand urban ES provision.