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Research Paper

The viability of biofuel production on urban marginal land: An analysis of metal contaminants and energy balance for Pittsburgh's Sunflower Gardens

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HIGHLIGHTS

- Low-input sunflower production is possible on urban vacant lots in Pittsburgh.
- Urban marginal soil is subject to the risk of low Fe, Pb and As contamination.
- Sunflowers from urban land are safe biofuel feedstock due to limited metal uptake.
- Urban biofuel system can produce net energy under constraints of plot and method.

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ABSTRACT

After three years' monitoring of the concentration of Al, Fe, Zn, Ni, Pb, As, Cd, Cr and Se in soil, Fe, Pb and As in Pittsburgh's vacant lots were found sometimes to exceed the residential maximum soil contaminant concentrations set by the Pennsylvania Department of Environmental Protection. Heavy metal uptake by sunflowers was insignificant at the soil metal concentrations observed in Pittsburgh, indicating that sunflowers produced on marginal urban land could be a safe biofuel feedstock. However, there was a risk that sunflowers grown on more contaminated spoils could be unsafe. Calculations of the energy balance of the total biofuel production system suggested that lots in Pittsburgh of over 0.2 ha would be able to produce an energy gain, particularly if community volunteers were involved in the process. Using marginal urban land for biofuel production can be a worthwhile strategy to replace costly traditional vacant lot management methods.

1. Introduction

Like the City of Pittsburgh, many urban areas have a substantial amount of vacant or blighted lands that present both opportunities and problems. Over 14,000 vacant lots exist throughout Pittsburgh, which accounts for more than 10% of the municipalities' land (Colbert et al., 2010; Gaido, Wildfire, Zamarripa, & Rosenthal, 2006; Niblick, Monnell, Zhao, & Landis, 2013; Simons, 1998). Pittsburgh's public agencies collectively spend hundreds of thousands of dollars annually to maintain vacant lots in the city, and this covers only basic maintenance activities such as clearing brush and debris, mowing grass, and removing snow in the winter (Sandraluz et al., 2006; National Vacant Properties Campaign, 2005). Studies have shown that plant growth on urban vacant lots can increase the resilience of urban ecosystems, suppress crime, and raise the price of the land (Gao & Asami, 2007; Wolfe & Mennis, 2012; Yadav, Duckworth, & Grewal, 2012). Furthermore, wide use of the vacant lots in cities for biofuel crop production may contribute to the target set by the United States Renewable Fuel Standard 2 that requires 3.78 billion liters biodiesel being produced per year by 2020 (Niblick et al., 2013). Large-scale biofuel production

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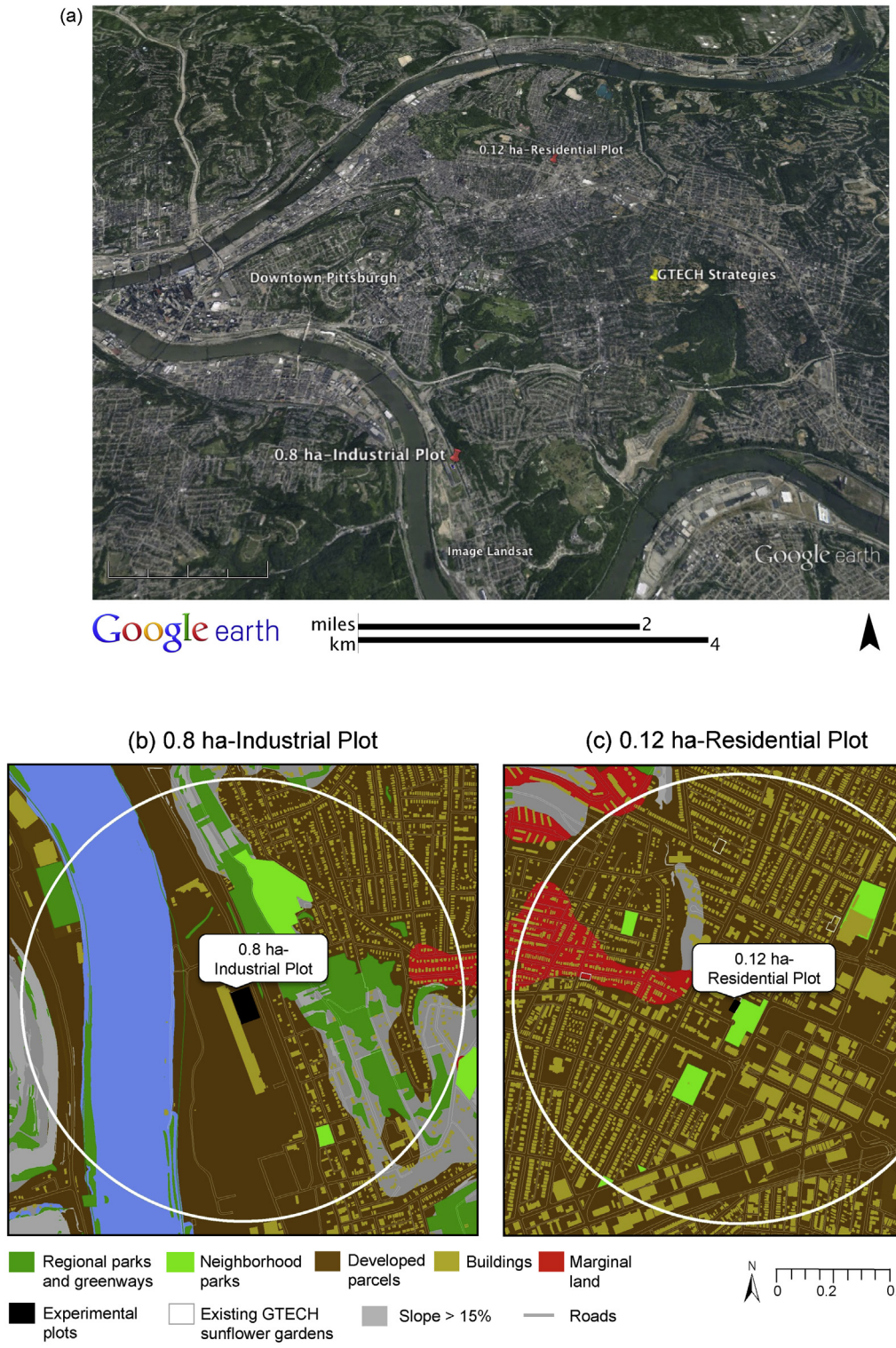

Fig. 1. Experimental plot locations and major land uses around the sites.

has caused wide social concerns about food security and land use rights due to its consumption of feedstocks that come largely from agriculture and forestry (Miller, Landis, & Theis, 2007; Shrake, Landis, Bilec, Collinge, & Xue, 2010; Walsh et al., 2007). Aligning biofuel production with urban vacant lot management will not only reduce government expenditure on land management and improve urban landscape but also mitigate the land use concerns regarding biofuel production.

Most urban vacant lots have poor soil quality and are concentrated in high crime areas or areas having limited infrastructure access. They are classified as marginal lands, a term that is used to define lands that have poor agriculture potential and are unsuited for housing and other uses (OECD, 2008). Evidences shows that marginal agricultural land can be used to grow biofuel crops with net environmental benefits (Cai, Zhang, & Wang, 2010; Field, Campbell, & Lobell, 2008; Hill,