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Soil ecosystem services and human health

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Abstract

The impact of soils on human health is well-documented, and the ecosystem services (ES) provided by soils are important to human health. However, previous works on soils and human health have not approached the topic from a soil ES perspective. This paper provides examples of ways that soil ES support human health. Provisioning services ensure a plentiful supply of nutritious food products, building supplies that allow the construction of housing that protects human health from inclement weather, fibers for clothing that aid in body heat regulation, and fuel to heat houses during cold weather. Several of these relationships, like the provisioning of shelter and heat, have not been previously explored in the soils and human health literature. Regulating services relevant to human health include pathogen regulation and greenhouse gas cycling. Cultural services are important in healing, stress reduction, and recreation. The examples presented in this paper demonstrate the influence that soil ES have on human health and that taking an ES approach when considering soils and human health has the potential to identify areas that need further investigation.

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Introduction

The profound impact of soils on human health is well documented [1–5], and soils are now recognized as influencing human health in a number of ways. This includes positive influences such as the supply of essential nutrients to produce nutritious food products for the human diet, water purification services, and a source of medications, especially antibiotics. However, soil can also negatively influence human health due to exposure to hazardous substances and pathogens within the soil. Soils are not often recognized in the literature as influencing human health through their production of products such as wood (for lumber or timber) and clay (used for brick) that are important in the construction of shelters that provide refuge from inclement weather, fibers such as cotton that provide clothing for body temperature regulation, and fuel sources such as wood that provide heat. Soil degradation decreases the ability of a soil to support human health and efforts to end or reverse degradation improve that ability [6,7].

Studies investigating the natural services provided by soils go back to the 1960s, and by the 1970s and 1980s soil scientists were classifying these services into soil functions [8]. However, including soils in ecosystem services (ES) assessments was rare until the 2000s as broad, general approaches to evaluating ES were favored [8,9]. General interest in ES increased after 2000 and again after 2005 [9], with an increasing focus on the contributions of soils to ES after about 2009 [8]. The most commonly used ES classifications are elucidated by the Millennium Ecosystem Assessment (MEA), the Economics of Ecosystems and Biodiversity, the Common Classification of Ecosystem Services (CICES), and OpenNESS [10]. The CICES system was developed with the MEA [11] as its starting point but has been constantly updated over time [12]. The CICES classification divides ES into three categories: 1) provisioning, 2) regulation and maintenance, and 3) cultural [12]. The CICES classification will be used for the discussion that follows.

A number of papers have given general overviews of ES and human health in recent years [e.g., 13, 14]. There have also been reviews looking at more specific issues, such as the links between ES, human health, and biodiversity [15], green infrastructure [16], social depravation [17], oceans [18], and climate change [19]. In fact, the ES concept was originally developed to assess the effects of lost ecosystem function and biodiversity on human well-being [20]. Given the information above, soil ES should be important in supporting human health. However, few previous works on soils and human health have approached the topic from an ES perspective. Keith et al. [21] connected ecosystem services to the One Health initiative through soil

stewardship, however, their evaluation very specifically addressed One Health and did not step through links between individual soil ecosystem services and human health. Therefore, the objective of this paper is to review examples of soil ES that are important to human health and point out the need for studies into soils and human health that take a soil ES approach.

Provisioning services

Provisioning services refer to all nutritional, non-nutritional material, and energetic outputs from living systems as well as abiotic outputs [12]. While this gives a fundamental description of provisioning services, at times the MEA explanations are more clear and straightforward than the CICES definitions. The MEA defines provisioning services as products that soil ES make available for human use [11]. These include nutrients, water and other materials that are important for the growth and production of food and fiber products, fuelwood, potable drinking water, medicines, and genetic resources [11]. The production of large quantities of quality food is one area of soils and human health that has received much attention [22] (Figure 1). The links between food production, particularly plant-based food products and soils, are straightforward and simple to understand and people tend to focus on fairly obvious health connections [23]. Many of the nutrients that are important to human health originate in soil. These nutrients are supplied to plants as they grow in soil, and are then passed on to humans who consume plant material directly or the meat of animals that fed on those plants [24]. In some cases, organisms can improve human health by enhancing plant production and be a source of food themselves. Some of the most sought after edible mushrooms belong to the mycorrhizal fungi group [25], which provide a food source and help plants, ranging from crops to trees, obtain needed soil-derived nutrients [26].

The importance of building materials, fiber, and fuel that are provided by soils in the promotion of human health have received much less discussion in the soils and human health literature than other provisioning service topics. Building materials such as wood (for lumber or timber) and clay (for brick) are important in the construction of homes and other buildings that provide shelter from storms and allow the creation of controlled spaces where temperatures can be regulated. Plant fibers such as cotton, flax, and hemp are important to make clothing; approximately 68% of women's and 85% of men's clothing in the USA contains cotton [27]. Over 5300 people are estimated to have died in the USA between 2004 and 2013 due to extreme weather events, with more than 1400 of those deaths due to temperature extremes [28]. To combat extreme cold, sheltered spaces are heated and wood is the

Figure 1

The production of large quantities of quality food (top), a provisioning service, is one of the most studied and recognized links between soils and human health. The importance of the provisioning services supplied by soils in the production of products such wood (bottom), which is important as a building material for shelter against extreme weather and fuel for a source of heat to combat extreme cold, is often overlooked when discussing soil-human health connections. Photos by E.C. Brevik.