Geoderma 230–231 (2014) 250–264

Contents lists available at ScienceDirect

Geoderma

journal homepage: www.elsevier.com/locate/geoderma

Soils of temperate rainforests of the North American Pacific Coast

Dunbar N. Carpenter [a], James G. Bockheim [b,*], Paul F. Reich [c]

[a] Department of Forest and Wildlife Ecology, University of Wisconsin-Madison, 1630 Linden Drive, Madison, WI 53706-1299, USA
[b] Department of Soil Science, University of Wisconsin-Madison, 1525 Observatory Drive, Madison, WI 53706-1299, USA
[c] World Soil Resources, USDA Natural Resources Conservation Service, 5601 Sunnyside Ave, Beltsville, MD 20705-5471, USA

ARTICLE INFO

Article history:
Received 8 November 2013
Received in revised form 7 April 2014
Accepted 16 April 2014
Available online 9 May 2014

Keywords:
Soil classification
Environmental gradients
Soil properties
Temperate environment
Rainforests
Forest soils

ABSTRACT

Temperate rainforests have high conservation and natural resource value, but the soils of this bioregion have not previously been studied as a unit. Here we examine the soils of North America's Pacific coastal temperate rainforests, utilizing databases from the United States Natural Resources Conservation Service and the Canadian Centre for Land and Biological Resources Research to (i) identify the soil taxa, (ii) evaluate the soil properties, and (iii) compare soils in temperate and tropical rainforests. There are strong climate gradients within these temperate rainforests, with the mean temperature declining from 11.7 °C to 6.1 °C and the mean annual precipitation increasing from 1500 mm to around 3000 mm from northern California (CA) to northwestern British Columbia (BC) and southeastern Alaska (AK). There is also high pedodiversity in this region, with soils representing 8 orders and 31 suborders, and, in the US portion, 65 great-groups, 142 subgroups, and 482 soil series. Twenty-six percent of described soil series are endemic to temperate rainforests in the US portion of the region, with the proportion declining with latitude. Dominant soil suborders vary along the latitudinal gradient from Humults–Udalfs/Ustalfs–Udepts–Udults in CA, to Udands–Udepts–Udands Humults in western Oregon (OR) and Washington (WA), to Orthods–Folists in BC and Cryods–Saprists in AK. The dominant diagnostic horizons are ochric/argillic (CA), umbric/cambic (OR, WA), and albic–histic/spodic (BC, AK). Whereas soils in CA, BC, and AK tend to have a mixed mineralogy, those in northern OR and WA commonly are derived from volcaniclastic materials and have a ferrihydritic or isotic mineralogy. Soils in this region are generally deep, hold abundant moisture, are not subject to deep-freezing, and are enriched in extractable Fe and Al. Organic C and total N contents are high overall, but also variable, with right-skewed distributions. Compared to tropical rainforest soils in the Pacific Basin, Pacific temperate rainforest have greater weatherable minerals, cation-exchange capacities, soil organic C, and total exchangeable base cations. However, soils of both bioregions tend to be deep, acidic Al-saturated, and can have large N reservoirs. This investigation provides a foundation for a more unified understanding of the soils of a globally significant bioregion.

© 2014 Elsevier B.V. All rights reserved.

1. Introduction

Temperate rainforests have not received th`e same attention as their tropical counterparts, and though they make up only about 2% of the world's forests, they hold high value for both conservation and natural resources (DellaSala et al., 2011). These forests, sometimes called wet temperate forests, have been defined in several ways. Alaback (1991) laid out four parameters, later refined by Kellogg (1992): (i) greater than 1400 mm of annual precipitation, with at least 10% occurring during the summer; (ii) cool, frequently overcast summers, with a July (or austral January) isotherm of <l6 °C; (iii) infrequent fires; and (iv) a dormant season caused by low temperatures, potentially accompanied by transient snow. For conservation purposes, DellaSala et al. (2011) built upon this definition and constructed a rainforest climate model that acknowledged rainforests in boreal regions and highlighted several outlier regions of previously less-recognized rainforests. Worldwide, temperate rainforests occupy over 400,000 km^2, and well over 1 million km^2 by some estimates and definitions (Table 1). The largest areas occur in northwestern North America and southwestern South America, with substantial areas also found in East Asia, Australasia, and western Eurasia.

Temperate rainforests, like their tropical counterparts, are highly productive and also contain some of the highest densities of biomass of any terrestrial ecosystem (Keith et al., 2009; Waring and Franklin, 1979). Soils in tropical rainforests are commonly Oxisols and Ultisols, which generally have low levels of nutrients and weatherable minerals (Coscione et al., 2005; Padmanabhan et al., 2012). To mitigate against the poor soil conditions, tropical rainforests have adapted special mechanisms to cycle nutrients more directly from the plant to the rooting zone (Stark and Jordan, 1978). Soils of temperate rainforests have not been studied as comprehensively as those of tropical rainforests. Maintaining the productivity of temperate rainforests to meet increasing

* Corresponding author. Tel.: +1 608 263 5903; fax: +1 608 265 2595.
E-mail addresses: dncarpenter@wisc.edu (D.N. Carpenter), bockheim@wisc.edu (J.G. Bockheim), paul.reich@wdc.usda.gov (P.F. Reich).

http://dx.doi.org/10.1016/j.geoderma.2014.04.023
0016-7061/© 2014 Elsevier B.V. All rights reserved.

Table 1
Global distribution of temperate rainforests.
Area estimates are compiled from Kellogg (1992) and DellaSala et al. (2011).

Region	Location(s)	Area estimates [km^2]
Northwestern North America	All	207,000–320,000
	Pacific Coast	207,000–273,000
	Inland Northwest	0–72,000
South America	Chile, southwestern Argentina	120,000–126,000
Australasia	Tasmania, New Zealand, eastern Australia	46,000–86,000
East Asia	Japan, Korea, eastern Russian	24,000–151,000
Western Eurasia	Caucasus, Alps, British Isles (relicts)	39,000–180,000
Others	Eastern North America, South Africa, Himalayas	0–100,000+
Total		436,000–1,308,000+
This study	North American Pacific Coast, excluding Cascades and Coast Mountains	166,331

human demands requires a complete understanding of these ecosystems, including their soils (Kimmins, 1996). Based on a few studies, these soils appear to be moderately weathered (Bockheim et al., 1996; Burt and Alexander, 1996; Hedin et al., 1995; Heilman and Gass, 1974) and enriched in soil organic carbon and nitrogen (Edmonds and Chappell, 1994; Huygens et al., 2008; Perakis and Sinkhorn, 2011; Smithwick et al., 2002). Most temperate rainforests occur near oceans that help maintain a mild climate conducive to a long growing season, evergreen vegetation, and slow rates of decomposition (Lawford et al., 1995; Waring and Franklin, 1979). Abundant precipitation can lead to rapid leaching (Burt and Alexander, 1996; Langley-Turnbaugh and Bockheim, 1998; Ugolini, 1968). Marine inputs appear to be important in the nutrition of these ecosystems and their soils (Bockheim and Langley-Turnbaugh, 1997; Gende et al., 2002). Diverse topography and histories of glaciation and volcanism in many temperate rainforest regions contribute to a variety of parent materials and weathering processes (Alexander and Burt, 1996; Bockheim et al., 1996; Briggs et al., 2006).

Given this particular combination of pedogenic factors, what sorts of soils are found in temperate rainforests, and how does this help us understand the ecosystems in this bioregion? To our knowledge, no one has yet investigated the characteristics of temperate rainforest soils as a unit. The objectives of this study are to delineate the soils in North America's Pacific coastal temperate rainforests, evaluate their properties, and discuss their role in rainforest ecosystems in comparison with their tropical counterparts. We utilize data from the US and Canadian soil databases and draw from a wide range of published literature to synthesize our knowledge of temperate rainforest soils of North America's Pacific Coast.

2. Coastal temperate rainforests of the North American Pacific Coast

2.1. Study area

We focus on the soils of the rainforests of North America's Pacific Coast (NAPC). This region, sometimes referred to as the Pacific Northwest, spans much of the west coast of the US and Canada, up to about 85 km inland. Though rainforests exist further inland (e.g. in the western Cascade mountains), there is less consensus over their delineation (DellaSala et al., 2011), and we decided to limit our study to the most quintessential rainforests on the coast. The study region consists of the Coast Range and Coastal Western Hemlock–Sitka Spruce Forest ecoregions (Level III), as defined by the North American Commission on Environmental Cooperation (Wiken et al., 2011; Fig. 1). Within the study region, soils have been divided into ecological units — Major Land Resource Areas (MLRAs; Natural Resource Conservation Service, 2006) in the US and Ecoregions in Canada (Demarchi, 2011; Ecological Stratification Working Group, 1996; Fig. 1). The US subregions include

Fig. 1. The coastal temperate rainforests of western North America and subregions.

Download English Version:

https://daneshyari.com/en/article/4573251

Download Persian Version:

https://daneshyari.com/article/4573251

Daneshyari.com