

# The Soils of Chile



## **World Soils Book Series**

Series Editor

Prof. Alfred E. Hartemink
Department of Soil Science, FD Hole Soils Laboratory
University of Wisconsin–Madison
Madison
USA

For further volumes: http://www.springer.com/series/8915

# Aims and Scope

The World Soils Book Series brings together soil information and soil knowledge of a particular country in a concise and reader-friendly way. The books include sections on soil research history, geomorphology, major soil types, soil maps, soil properties, soil classification, soil fertility, land use and vegetation, soil management, and soils and humans.



**International Union of Soil Sciences** 

Manuel Casanova • Osvaldo Salazar Oscar Seguel • Walter Luzio

# The Soils of Chile



Manuel Casanova
Osvaldo Salazar
Oscar Seguel
Walter Luzio
Department of Soil and Engineering
University of Chile
Santiago
Chile

Library of Congress Control Number: 2012954627

#### © Springer Science+Business Media Dordrecht 2013

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed. Exempted from this legal reservation are brief excerpts in connection with reviews or scholarly analysis or material supplied specifically for the purpose of being entered and executed on a computer system, for exclusive use by the purchaser of the work. Duplication of this publication or parts thereof is permitted only under the provisions of the Copyright Law of the Publisher's location, in its current version, and permission for use must always be obtained from Springer. Permissions for use may be obtained through RightsLink at the Copyright Clearance Center. Violations are liable to prosecution under the respective Copyright Law.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

While the advice and information in this book are believed to be true and accurate at the date of publication, neither the authors nor the editors nor the publisher can accept any legal responsibility for any errors or omissions that may be made. The publisher makes no warranty, express or implied, with respect to the material contained herein.

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

#### **Preface**

Imagine the narrowest and longest country in the world, where high snow-covered mountains can be seen from the ocean and huge rivers sculpt the landscape, where frequent volcano eruptions cover the land with ash, where earthquakes shake the earth and tsunamis overwhelm the coastline, where enormous glaciers are retreating, and finally imagine a place where it never rains.... then you are seeing the majesty and magnificence of Chile.

It should be noted that within Chilean territory you can find almost all the soil types observed in the world, but unfortunately these represent a scarce and fragile natural heritage. Natural resources are one of more important economic assets in Chile, but to avoid over-exploitation of those considered nonrenewable, a transition toward sustainable development should be a priority.

The vision of local soil scientists about the problems that afflict Chilean soils has been extended to a broader concept than erosion, namely soil degradation. Such problems were unsuspected a few decades ago, but nowadays soils are studied in light of a wide range of complex and interconnected problems, which cast a long shadow over the future of fertile Chilean land and await the light of wisdom.

In response to increasing concerns about soil degradation and the sustainability of agricultural production potentials in almost all regions of Chile, many researchers and institutions have developed diverse and valuable initiatives. These efforts include resource inventories, the design and development of low-cost technological options, the development of ecologically sound cropping systems, and options designed to conserve and manage the agrobiodiversity and forest resources that exist in the country.

However, because the use and management of soils depends on many different actors, only limited progress is possible unless all are involved in planning and implementing programs to conserve this vital natural resource. In this regard, involvement takes on a very wide connotation, from having a deep knowledge of soil dynamics to planning management within an ethical context of this true work of art by nature.

## **Acknowledgments**

A large number of people over a long period of time have greatly assisted in the development of soil science in Chile. A particular debt is owed to all those largely unknown stewards, the pioneer soil surveyors, who made it possible to understand the complex distribution of soils in Chile. We also thank all the soil scientists that have forged and are building daily soil knowledge in Chile, while apologizing to those who may have been inadvertently omitted in this book. Finally, the authors reserve special gratitude for the University of Chile, their current workplace and always revered alma mater, which allowed them to translate their passion for the Soils of Chile into this document.

# Contents

1	Gen	General Chile Overview				
	1.1		ory Formation: Geology and Geomorphology	1		
	1.2	Climat	te: From Desert to Glaciers	9		
	1.3	Vegeta	ation	17		
	1.4	Land U	Use	20		
	Refe	erences .		23		
2	Mai	Main Features of Chilean Soils				
	2.1	1 Soil Formation in Chile		25		
	2.2	Major	Soil Zones	27		
		2.2.1	Soils of the Hyper-Arid to Semi-Arid Zone	27		
		2.2.2	Soils of the Mediterranean Zone	56		
		2.2.3	Soils of the Rainy and Patagonian Zone	71		
		2.2.4	Soils of the Insular (Easter-Juan Fernández) and Antarctic Zone	80		
	2.3	A Soil	Map of Chile	93		
	Refe	erences .		93		
3	Mar	Management of Soil Properties in Chile				
				cal Properties	99	
		3.1.1	Soil Reaction	99		
		3.1.2	Soil Salinity and Sodicity	102		
		3.1.3	Nutrient Availability	102		
	3.2	Physic	al Properties	106		
		3.2.1	Bulk Density	106		
		3.2.2	Particle Size Distribution and Water Retention	108		
		3.2.3	Structural Stability	109		
		3.2.4	Pore Functionality	111		
	3.3	Biolog	rical Properties	113		
		3.3.1	Soil Organic Carbon	113		
		3.3.2	Soil Biodiversity	115		
	Refe	rences .		116		
4	Hun	nan-Ind	luced Soil Degradation in Chile	121		
	4.1	Erosiv	e Soil Degradation	121		
		4.1.1	Water Erosion	122		
		4.1.2	Wind Erosion	126		
	4.2	Non E	rosive Soil Degradation (Physical, Chemical and Biological)	127		
		4.2.1	Soil Physical Degradation	127		
		4.2.2	Soil Chemical Degradation	136		
		4.2.3	Soil Biological Degradation	141		

x Contents

4.3	Desertification			
	4.3.1 Coquimbo Region and Patagonia, Two Emblematic			
	Cases of Desertification in Extremes Zones of Chile	145		
	4.3.2 Easter Island, an Example of Collapse by Soil Degradation	149		
4.4	Future of Soil Conservation in Chile	150		
Refe	erences	152		
Appendix				
Authors' Biographies				
Index		183		