Fundamental Ecohydrology of Ecological Restoration and Recovery in Sandy Desert Regions of China

中国沙区生态重建与恢复的生态水文学基础

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内 容 简 介

本书根据中国科学院沙坡头沙漠研究试验站在腾格里沙漠东南缘60年的长期生态学研究，以及在其他中国沙区的调查研究，论述了中国沙区以植被建设为主的生态重建与恢复中存在的主要科学问题和实践需求；阐述了沙区人工固沙植被对土壤水文过程的长期影响和适应，以及水文过程的改变对固沙植被演替的驱动机理；解释了沙区生态过程和水文过程互馈互调的作用机理，并在不同水平尺度上解析了植物对水分胁迫的适应策略；研究了沙区土壤生境的变化对植被-土壤系统水量平衡和固沙植被可持续性的影响；探讨了植被格局与分布、土壤水分的植被承载力、沙地水量平衡对人工植被稳定性维持的重要意义；提出并分析了生态水文阈值对固沙植被稳定性维持等生态系统管理和对未来植被建设的重要性。

本书可供生态、环境、地理、地质、大气、水文、农业和林业等领域科研人员、高等院校师生及相关管理和决策者参考。

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前言

中国的沙区面积大、分布范围广，由西至东横跨极端干旱区、干旱区、半干旱区和半湿润区等不同的生物气候带，含温带荒漠和温带草原两大区，年降水从西至东在 50 ~ 450 mm。其中，风沙危害和土地沙漠化严重的区域也是干旱和半干旱区人口密集、人类活动强烈、生物生产力较高，自然条件相对优越、国家发展和战略地位相对突出的地区，主要包括贺兰山以东的毛乌素沙地、浑善达克沙地、科尔沁沙地和呼伦贝尔沙地，以及贺兰山以西的沙漠与绿洲过渡区、沙漠与荒漠草原的过渡区，总面积大约 30 万 km^2。沙害造成直接经济损失每年超过 540 亿元，已成为制约中国北方经济和社会以及生态安全可持续发展的重要因素。该区是进行植物固沙、生态重建和恢复的关键地区，也是国家北方生态屏障建设的主要区域。

中国的防沙治沙和沙区生态重建与恢复工作始于 20 世纪 50 年代，至今已有 60 余年的历史。特别是 70 年代中期实施的“三北”防护林建设工程，以及 21 世纪初开始的退耕还林还草工程有效地遏制了土地沙化和风沙危害的蔓延。沙化是指在各种气候条件下，由于各种因素形成的、地表呈现以沙（砾）物质为主要标志的土地退化，具有这种明显特征的退化土地为沙化土地。截至 2014 年全国沙化土地面积为 172.12 万 km^2，占国土面积的 17.93%，相比于 2009 年净减少 9902 km^2，年均减少 1980.4km^2。有明显沙化趋势的土地面积为 30.03 万 km^2，占国土面积的 3.12%。实际有效治理的沙化土地面积为 20.37 万 km^2，占沙化土地面积的 11.8%。目前沙化土地面积占国土面积的 1/6 以上，虽然沙化土地面积整体呈缩小趋势，但是治理和保护的任务依然艰巨，仍是我国最为严重的生态问题之一。

2015 年中央出台的《中共中央国务院关于加快推进生态文明建设的意见》中明确提出，到 2020 年我国 50% 以上可治理的沙化土地要得到有效治理。可是沙区生态系统脆弱，破坏容易恢复难。已有效治理的沙化土地中，初步治理的面积占 55%，但极易出现反复，后续巩固与恢复任务繁重。如果治理利用不当，一些沙区未破坏的生态系统和已得到恢复的土地极易成为新的沙化土地。过去在晋西北和毛乌素沙化土地上大量地种植杨树使当地地下水下降明显，盖度曾达到 80% 的固沙植被大面积退化，结果流沙并没有得到根治，却引发土壤水环境的恶化。浑善达克沙地近几十年因地下水下降使大面积的固沙林死亡。20 世纪 50 年代在河西民勤沙区营造的密集沙枣和杨树等乔木为主的固沙林为 4.4 万 hm^2，由

于地下水位的下降，其中有 3 万 hm^2 全部枯死。毛乌素沙地的红碱淖尔湖从 1969 年的 67 km^2减缩至 2015 年的 32.8 km^2。除了气候变化因素以外，不合理的人类活动有着无法推卸的责任，正所谓“建立一片林地，消失一片湿地”。同样，在科尔沁沙地、乌兰布和、青海共和沙地和新疆沙区的许多植物固沙区出现了大面积固沙植被退化、地下水下降，甚至发生新的沙化现象。固沙植物的选择不当、种类组成单一、空间配置简单和密度过大，固沙植被的功能群组成单一，对区域沙地水分承载力与植被建设规模（面积）关系不清，即植物固沙实践中缺少对选择固沙植物种的地带性分布规律、植被格局与演替的特点，以及植被–土壤系统生态–水文过程和作用机理等问题的科学认识是其主要原因。研究和解决这些问题正是国家防沙治沙的重大科技需求。

另外，沙区，特别是东部沙区的无序开发建设现象严重，开垦、超载放牧、水资源过度开发利用等问题突出。2010 ~ 2015 年沙区耕地和沙化耕地面积分别增加了 3.60% 和 8.76%。沙区牲畜超载、内陆湖泊面积萎缩、河流断流现象时有发生，在东部沙地许多地区地下水位仍然逐年下降。理论研究不能及时回答实践中面临的新问题，即理论研究的滞后导致了我们不能提出行之有效的生态系统管理对策和措施。由此可见，沙区生态重建和恢复，以及恢复的可持续性仍然面临着前所未有的挑战。

沙区生态重建和恢复是一项十分艰巨和复杂的任务，绝不是简单的“挖坑栽树”，其中许多关键科学问题的回答必须建立在长期生态学研究的基础之上，即对沙区生态和水文互馈互调的长期监测和研究是探究沙区生态重建和恢复过程与机理的有效途径。建站于 1955 年的中国科学院沙坡头沙漠研究试验站（沙坡头站）是我国，乃至全球最早开展沙区生态重建与恢复研究的几个单位之一，对沙区植被，包括人工植被的格局与过程，以及沙区水文过程的连续监测研究已有 60 年的历史，开创了我国干旱沙区无灌溉植被建设的先河，建立了举世闻名的包兰铁路沙坡头段植被防护体系，成为国际上沙区植被重建与恢复的成功范式，于 1988 年获得了国家科技进步特等奖和联合国环境规划署（UNEP）颁发的全球环境 500 佳荣誉。在解决了沙区交通干线风沙防治这一科学问题和技术难题的基础上，构建了我国沙区沙漠生态系统研究为主的研究平台，建立了不同时段人工固沙植被演替的时间序列（采用完全相同的建植方式，在完全相同沙丘的生境上分别于 1956 年、1964 年、1973 年、1992 年和 2002 年建立不同年份的固沙植被区），并从“七五”期间开始综合水量平衡观测，形成了一系列人工植被与天然植被水量平衡的比较生态学研究样地和大量的控制实验，为沙区生态重建与恢复、人工植被与天然植被的生态水文过程的长期定位研究创造了得天独厚的条件和技术支撑。本书的研究正是基于沙坡头站前辈科学家的这些工作，从 1997 年开始，以国家重大需求和恢复生态学、生态水文学等学科发展前沿和热点为导向，在国家杰出青年科学基金（40825001）、重点基金（90202015、40930636、41530746）和国家重点基础研究发展计划（973 项目）“植物固沙的生态水文过程、机理和调控”（2013CB429900）的支持下进行的。其研究内容不仅全面涵盖了腾格里沙漠东南

缘人工植被格局、演变和沙地水文过程的耦合作用及机理，还包括了我们研究团队在河西沙地、古尔班通古特、阿拉善沙区、鄂尔多斯沙地和科尔沁沙地的部分研究工作，具有较好的代表性，反映了中国主要沙区以植被建设为主的生态重建与恢复的核心科学问题，阐述了固沙植被建设的生态水文学基础。

此外，本书突出了长期生态学研究的魅力，如近60年固沙植被土壤水分的监测除了揭示了土壤水文过程变化规律外，也客观刻画了我们对沙区植被建设的认识过程。早期固沙植被建立的实践中往往采用高密度植物配置，多以沙枣、胡杨、梭梭、杨树、樟子松和油松等乔木树种造林，在初期沙区土壤水分和地下水下降并不明显，且植被成活率高。受此影响，许多沙区植被建设带有一定的盲目性，规模浩大的群众运动式“治沙造林”随处可见；人工植被建立20年后，不同沙区的大面积固沙林区土壤水分和地下水开始明显下降（无论降水多大，深层土壤含水量始终处下降趋势），原来郁郁葱葱的植被开始衰退或死亡，这时人们才意识到固沙植被物种合理选择、密度和盖度控制等科学问题的重要性，在一些沙区开始了因地制宜的低覆盖的植被建设；人工植被建立40年后，灌木经自疏盖度降低后，深层土壤水分回升，开始处于稳定状态，此间人们已意识到水量平衡是固沙植被稳定性维持的根本所在，在许多沙区已总结出了固沙植被建设的优化模式，并进行推广；人工固沙植被发展到50年后，植被-土壤系统达到稳定的水量平衡，深层和浅层土壤水分含量与植被建立之初的一样，都随降水而波动，植被区土壤成土过程使植被由原来单一的灌木或乔木层片结构演变为植物种类组成多样，包括草本层和结皮参与的复杂结构，且草本多以同一生物气候带分布的乡土种为主。与一些经历几十年的杨树固沙植被相比，我们认识到植被在沙区的暂时恢复是表象，并不代表生态系统的恢复，而沙区生态的真正恢复主要取决于土壤生境的重建和恢复，“皮之不存、毛将焉附”，健康的土壤生境才能支撑稳定持续的植被。该例说明了只有长期连续定位的生态学研究才是解析区域水文和生态过程及相互作用机理的有效途径。

基于长期定位研究对沙区生态重建和恢复机理的认识正是本书和我们研究团队工作的特色和创新点。在恢复生态传统理论研究的基础上，我们通过对生态格局和过程的认识，分析了其对局地或区域水文过程的影响，以及土壤水文过程的反馈机制。针对沙区固沙植被生态功能的稳定性和可持续性维持的生态系统管理，我们研究了沙区土壤水分的来源、在植被-土壤系统中的循环和再分配等传输机理，量化了各个水文要素及其变化和相对应的固沙植被的数量学特征；在不同水平尺度上研究了固沙植物的耗水量和水分利用特点，以及对水文胁迫不同水平尺度的响应；分析了植被水分关系和水量平衡规律，提出了评估植被稳定性的数量方法，模拟了植被的可持续性，提出了不同沙区土壤水分的植被承载力及其经验界定，研究探讨了植被稳定可持续性的生态水文阈值，据此，为不同沙区植被的生态水文调控和生态系统管理提供了依据和参考。相信这些研究对中国风沙危害的治理和防沙治沙将会起到有益的参考和理论指导。

本书由7章构成，第1、2章着重论述了风沙治理的科学问题和国家重大需求，以及国内外相关进展、国内外已有的相关理论和假说及已取得的成绩，分析了它们对中国防沙治沙实践的启示和指导意义；第3章主要论述了沙区水文过程及其机理；第4章研究了固沙植被建立后的土壤过程及演变规律；第5章突出了人工植被建立后的沙区生态格局和演变，包括动植物多样性对水文过程的响应；第6章重点介绍了沙区人工植被的重要构建者植物在不同水平尺度上对水文动态和胁迫的应答和适应对策；基于前面6章的研究，第7章分析了植被格局和过程对土壤水文过程的响应及对水文过程的影响和两者互馈互调的作用机理，提出了沙区生态重建与恢复的土壤水分植被承载力、判别人工植被的稳定、人工植被稳定性维持的生态水文阈值和对植被稳定的生态水文调控策略。本书是我们研究团队的集体研究成果，近20年来，先后有50余名科研人员和研究生参与了野外观测和实验分析。在具体撰写过程中得到了黄磊、张亚峰、虎瑞、王进、鲍婧婷、冯丽、谭会娟、潘颜霞、赵洋、刘艳梅、陈应武、刘美玲等博士的大力帮助，在此一并致谢！

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尽管本书是在沙坡头站前辈科学家的工作基础之上，对我们近20年研究的总结和凝练，但中国沙区的生态和水文过程十分复杂，尤其是在全球变化的大背景下，正如真理是相对的，目前我们的一些认识还有待于进一步的实践检验，因此，书中难免存在一些不足，亟待我们后续研究的加强和完善，在此也恳请读者批评指正。

李新荣

2016年8月30日于宁夏沙坡头

Preface

Desert ecosystems have an extensive distribution throughout China. This classification includes extremely arid, arid, semi-arid, semi-humid and other bioclimatic zones and includes ecosystems ranging from temperate desert in the west to temperate grasslands in the east. Annual precipitation from west to east in China increases from 50 to 450 mm. Desert regions in China are experiencing increasingly severe and frequent climatic events such as wind storms leading to land desertification. Desertification refers to land deterioration leading to the presence of sand or gravel and is caused by various factors and diverse climatic conditions. Arid and semi-arid regions are experiencing the most severe changes to climate and are also the most densely populated regions in China. These regions not only have high biodiversity but are also important areas for agriculture and national development and in terms of strategic position. The area is over 300 000 km^2 and includes a multitude of ecosystems including deserts, oases, the desert-desert grassland transition west of Helan Mountain, the four main sandy lands in eastern China, and the neighboring transition region of cultivated land and rangeland. Sandstorm hazards have caused direct economic losses of more than 54 billion yuan every year. Climatic hazards have become an important factor restricting the sustainable development of the economy as well as societal and ecological safety of northern China. These regions in northern China have been the focus of extensive vegetative sand-control and ecological reconstruction and restoration.

Efforts to prevent desertification and implement ecological reconstruction and restoration began in the 1950s. Ecological projects combining artificial vegetation reconstruction and spontaneous restoration have a long history in China. The construction of the northwest-north-northeast China network of shelter belts was implemented in the mid-1970s. Additional projects returning farmland to forests or grasslands implemented at the beginning of this century have effectively contained the spread of desertification and reduced the frequency and severity of sand storms. On December 29, 2014 the State Council Information Office held the "5th National News Conference on Desertification and Desertified Land Monitoring". In 2014 the area of desertified land nationwide was 1 721 200 km^2, or 17.93% of the national territorial area. This is a reduction of 9 902 km^2 since 2009 and an annual average reduction of 1 980 km^2 per year. The area of land with significantly desertification was 30.03 km^2, accounting for

3. 12% of the national territorial area. The area of effectively controlled desertified land was 203 700 km^2, accounting for 11. 8% of the total desertified land. At present, the area of desertified land accounts for over 1/6th of the national territorial area. Although the area of desertified land shows a decreasing trend as a whole, control and protection is still an large task and desertification is still one of the most severe ecological problems in China.

The *Opinions on accelerating the construction of ecological civilization* published in 2015 stated that more than 50% of desertified land in China will be effectively controlled by 2020. However, the natural conditions of desert regions are harsh, and ecosystems are fragile making restoration difficult. A total of 55% of desertified land has been effectively controlled, however maintenance of conditions and continued restoration are difficult. Re- desertification is common when there is misuse following restoration. For example, past afforestation initiatives planted *Populus alba var. pyramidalis* on desertified land in the northwest of Shanxi Province. However this species caused a serious reduction in ground water and the native sand-fixing vegetation which had once reached 80% was greatly reduced. This resulted in a failure to stabilize desertified areas and lead to a deterioration of the soil water environment. In recent decades, ground water decline has caused the death of a large area of *Ulmus pumila* in the Otindag Sandy Land. In the 1950s, a sand- fixing forest with extensive *Elaeagnus angustifolia* and *Populus* planted in Minqin Desert Area in Hexi Corridor was reduced from 44 000 hectares to 30 000 hectares due to a decline of ground water levels. The area of Hongjiannao Lake in the Mu Us Sand Land has shrunk from 67 km^2 in 1969 to 32. 8 km^2 at present. In addition to the climate change, human activities also impact desertification. Improper selection of sand- fixing species, monocultures, and excessive plant density all lead to restoration failures. In addition, poor understanding of the relationships between soil moisture capacity and the scale of vegetation restoration projects, as well as vegetation succession and hydrology has led to failures. Recent desertification has been observed in many sand- control regions in Horqin Sandy Land, Ulan Buh, Qinghai Gonghe Sandy Land and Xinjiang Desert Region. Studying and solving these problems is of scientific and technological importance to China to prevent and control desertification.

Overgrazing and exploitation of water resources can have serious implications in desert regions. These factors seriously affect areas of East China. From 2010 to 2015, the area of arable land in desert regions and desertified arable land increased by 3. 60% and 8. 76%, respectively. Additionally, the area of inland lakes was reduced, river blanking was observed, and the level of ground water in many regions in East China declined each year. Currently there is lag between theoretical research and practices. As a result, there is a lack of effective ecological system management practices. Ecological reconstruction and restoration in desert regions and the sustainability of restoration still face many challenges.

Ecological reconstruction and restoration in desert regions is a complex. Long-term ecological studies and monitoring of the relationships between vegetation and hydrology in desert regions is an effective way to understand the processes and mechanisms of ecological reconstruction and restoration. Shapotou Desert Research and Experiment Station (Shapotou Station) of Chinese Academy of Sciences, established in 1955, is a leader in the study of ecological reconstruction and restoration in desert regions in China and globally. The station has over 60 years of research on the ecology of vegetation (including artificial vegetation) and continuous monitoring of hydrologic process in desert regions. An irrigation-free vegetation construction in China's desert and arid regions was established by researchers at the station creating an internationally recognized vegetation prevention system for the Shapotou Section of the Baotou-Lanzhou Railway. In 1988, this system won the "National Scientific and Technological Progress Special Award" and the honor of "Global 500 Roll of Honor for Environmental Achievement" issued by UNEP.

The center also has a research focus on sandstorm prevention and control of traffic arteries in desert regions, centering on succession experiments using artificial sand-fixing vegetation. Sand-fixing vegetation areas established with the same methodology from 1956, 1964, 1973, 1992 and 2002 are used as a chronosequence. A comprehensive water balance observation network was established in 1997 during the "Seventy-five Year Plan" period facilitating comparative ecology research sample plots a long-term observation network for the study of ecological reconstruction and restoration as well as eco-hydrological process of artificial and natural vegetation in desert regions. This water-balance study was initiated from the previous work of scientists at Shapotou Station in response to the State's demand for the development of restoration ecology and ecological hydrology with the support of the National Science Foundation for Distinguished Young Scholars, the Major Program of National Natural Science Foundation of China (40825001, 90202015, 40930636, 41530746) and the National Key Basic Research Program of China (2013CB429900). The research not only covers the succession of artificial vegetation and the coupling of hydrological process in the southeast margin of Tengger Desert but also in the Hexi Corridor, Gurbantunggut Desert, Alxa Desert Region, Ordos Sand Land and Horqin Sand Land. This research focuses on the core scientific questions concerning ecological reconstruction and restoration, prioritizing vegetation establishment and hydrology.

This book highlights the long-term ecological research of the Shapotou Station. Nearly 60 years of monitoring of sand-fixing vegetation and local hydrology has led to a thorough understanding of soil hydrological process and vegetation establishment in desert regions. Initially, high-density planting of *Elaeagnus angustifolia*, *Populus*, *Pinus sylvestris var. mongolica*, *Pinus tabuliformis* and other tree species was adopted. Soil moisture and ground water decline was immediately obvious at this initial stage, and vegetation survival rate was high. During this period large-scale sand control and reforestation was common. After 20 years of this practice, soil moisture in large sand-fixing forests, and ground water levels started to decline despite normal precipitation and the vegetation began to die. From this, scientists realized the importance of species selection of sand-fixing vegetation, as well as density and coverage. Now, low-density vegetation establishment projects based on local conditions is practiced throughout desert regions in China. Soil moisture and ground water levels have increased and stabilized forty years since artificial vegetation projects were established. This experience high-lighted the importance of water balance in maintaining the stability of sand-fixing vegetation and led to optimized models of sand-fixing vegetation projects. With these optimized projects and ideal soil-formation conditions, vegetation succession has led to complex structure and diverse plant composition and with a herbaceous layer of native species and a biological soil crust. Overall, these studies have high-lighted that the key to ecological resotarion in desert regions is in fact soil restoration. Long-term ecological study is the most effective way to understand regional hydrology, ecological process and their interactions and in turn, the most effective way for successful restoration.

This book provides an overview of the innovative long-term ecological reconstruction and restoration research in desert regions. Using a theoretical approach to traditional ecological restoration, we have analyzed the influences of ecological processes on local and regional hydrological processes and the feedback mechanisms of soil hydrological processes. Aimed at ecological system management and the stability and sustainability of sand-fixing vegetation in desert regions, we have studied the following ecological processes and mechanisms: the source, circulation and redistribution of soil moisture in the vegetation-soil system; the quantification of water-use characteristics of sand-fixing vegetation; the response of vegetation to different hydrological stress; water balance mechanisms; a quantitative method for assessing the stability of vegetation; a simulation of the sustainability of vegetation systems; the vegetation carrying capacity of soil water in different desert regions and the experience in defining the capacity; and the eco-hydrological threshold values of vegetation stability and sustainability. These studies have provided a basis and reference for eco-hydrological regulation and control as well as ecological system management of sand hazards and desertification.

This book consists of seven chapters. Chapter Ⅰ and Chapter Ⅱ discuss the scientific problems, the State's great demands, relevant progress as well as relevant theories and hypotheses at home and abroad, achievements made concerning sandstorm control and an analysis of their role in China's sandstorm control practice; Chapter Ⅲ discusses hydrological process and mechanisms in desert regions; Chapter Ⅳ studies soil processes and evolution after initial sand-fixing vegetation establishment; Chapter Ⅴ highlights the ecological patterns and succession after artificial vegetation establishment, including the response of animals and plant diversity to changes in local hydrology; Chapter VI introduces the response and adaption of important artificial vegetation in desert regions to different hydrological dynamics and stresses; Chapter VII, analyzes the response of vegetation patterns and processes to soil hydrological processes, the influence of vegetation on hydrological processes, and the mechanisms of intermodulation and presents the vegetation carrying capacity of soil moisture for the ecological reconstruction and restoration in desert regions, the eco-hydrological threshold values for distinguishing and maintaining the stability of artificial vegetation, and the eco-hydrological control strategy for the stability of vegetation. This book is a collective of research achievements of Shapotou Station. Over the past nearly 20 years, more than 40 researchers and graduate students have participated in field observation and experimental analyses. We would like to acknowledge Dr. Huang Lei, Dr. Zhang Yafeng, Dr. Hu Rui, Dr. Wang Jin, Dr. Bao Jinting, Dr. Feng Li, Dr. Tan Huijuan, Dr. Pan Yanxia, Dr. Zhao Yang, Dr. Liu Yanmei, Dr. Chen Yingwu and Dr. Liu Meiling.

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This book is the basis of nearly 20 years of work done by scientists at Shapotou Station. However, the ecology and hydrological processes of desert regions are very complex, especially in the context of global change. As such we acknowledge that this is not a complete study of these ecological processes and greatly appreciate your comments and suggestions.

By Li Xinrong
In Shapotou, Ningxia
August 30, 2016

目　录

第 1 章

中国沙区的生态重建与恢复

中国风沙区主要分布在东经 75°~125°，北纬 35°~50°，形成了一条西起塔里木盆地西段，东至松嫩平原西部，横贯西北、华北和东北地区，东西长 4500 km，南北宽 600 km 的断续弧形沙漠带（包括沙地），横跨干旱、半干旱和半湿润气候带，约占全国陆地面积的 28%，是我国八大沙漠、四大沙地的分布区。东部沙地、贺兰山以西的沙漠与绿洲、沙漠与荒漠草原交错带是受风沙危害最为严重的区域。降水从东至西在 450~100 mm，是在雨养（无灌溉）条件下进行植物固沙、生态重建与恢复的关键地区和国家北方生态屏障带的重要建设区（Li et al.，2014a；环境保护部和中国科学院，2015）。

中国沙区一般泛指从东至西分布的呼伦贝尔沙地、科尔沁沙地、浑善达克沙地、毛乌素沙地及其相邻的北方农牧交错带部分地段、库布齐沙漠、乌兰布和沙漠、腾格里沙漠、巴丹吉林沙漠、库姆塔格沙漠、柴达木沙漠、塔克拉玛干沙漠、古尔班通古特沙漠、青海共和沙地，以及西藏部分沙化土地分布区的沙漠与绿洲过渡区、沙漠与荒漠过渡区等地区，其地表风蚀、沙埋等风沙危害是主要自然灾害类型，总面积约有 30 万 km^2。相对于沙漠，这些地区自然条件较好，生物生产力较高，人类活动频繁，是干旱、半干旱地区的主要人口集聚区，生态环境十分敏感和脆弱。

本章介绍了我国的风沙危害与治理情况，以及实践中所面临和理论上亟待解决的科学问题，提出了人为促进生态重建与恢复的重大国家需求和科学意义，总结了国内外相关研究的现状和发展态势。