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Foreword I

Recent dramatic examples of the improvement and utilization of saline soil have received a great deal of worldwide attention. The development of practical afforestation techniques to turn saline lands green has been especially important to foresters and other professionals in environmental science fields. Presently, the area of saline soil resources covers about 10 million hectares in China, with nearly 5.3 million hectares located in the four coastal provinces of Jiangsu, Shandong, Hebei and Liaoning. Therefore, it is clear that abundant ecological, economic and social benefits could be attained if these saline lands are remedied and developed sufficiently.

During the past two decades, Chinese scientists have made great advances in the fields of rehabilitation and utilization of coastal saline soils. In particular, research has indicated that, by vegetation restoration in saline land, soil properties can be enhanced, and consequently the degraded soils can be ameliorated, and the mount of arable land area increased. Furthermore, the establishment of coastal shelterbelts can help these areas withstand natural disasters such as typhoons, tsunamis and storm surges, and bring about remarkable ecological and economic benefits. For more than 20 years, Prof. Zhang Jianfeng, from the Institute of Subtropical Forestry at the Chinese Academy of Forestry, has conducted outstanding research on salinity-tolerance mechanisms of trees and saline soil rehabilitation technologies. He initiated a valuable integrated technology system for saline soil amelioration focusing on vegetation restoration and forestry utilization. He summarizes the integrated technology and principles in his book entitled *Coastal Saline Soil Rehabilitation and Utilization Based on Forestry Approaches in China*. In light of the current environmental situation in China, the publication of this book will provide scientific guidance for ecological remediation in coastal saline lands in the future. The book contributes to the effort of realizing a harmonious relationship between ecological construction and economic development.

Performing research on saline soil improvement and utilization is especially important in coastal regions, which are heavily populated and have less available land. Obviously, reserve land resources will be increased when saline soils are rehabilitated. Hence, I hope that many more forestry professionals and scientists

will recognize the importance of this task and will continue to make contributions to saline soil improvement and develop new techniques oriented to ecological rehabilitation. No doubt it will have a profound effect on alleviating the current disparities between the increasing population and the decrease in available land resources. Moreover, it will encourage civilization to become more ecologically-minded while helping to develop the beautiful country of China.

Beijing Zhao Shucong
January 30, 2013

Foreword II

Actually salinization is one of the most serious long-term threats to the sustainability of land and water resources in the world. Salinization results from the accumulation of free salts to an extent that causes severe degradation of vegetation and soils. In developing countries, arable lands decrease with population growth and corresponding land use pressure. Accordingly a great amount of forests, grasslands and wetlands was exploited to cultivate and intensively management, leading to damage of original vegetation and soil structure in regions where salt accumulation occurs. On the other hand, irrational human practices have increased soil salinity by changing the natural balance of the water cycle in landscape by allowing excess recharging of groundwater. This reduces suitability to plant growth and increases the potential for other forms of land degradation such as soil erosion and structural decline. It is estimated that saline land increases annually 1–1.5 million ha worldwide.

In China, the situation seems much more crucial. With population growth and socioeconomic development, urbanization speeds up, more and more cultivated lands having been transferred, which results from heavier burden on the current farming land. Hence it is vital to reclaim and remedy disturbed land, especially saline land in the country. The key to deal with the issue is conducting rational land use systems, restoring salt tolerant plant communities and improving soil structure. Intensive research revealed that trees can tolerant a certain level of salinity due to high avoidance and tolerance abilities. Therefore in the viewpoint of biological amelioration of salt-affected soil, planting trees in salt affected landscapes may contribute to restore land capability for biomass production and reducing unproductive water lasses of the vegetation. After trees are established in saline land, the water table could be declined through increasing discharge and decreasing recharge. Additionally total salt content could be decreased, especially in soil surface profile and topsoil as well as soil physical and chemical state could be ameliorated.

In view of the principles, Prof. Dr. Zhang Jianfeng for a long time is going for probing that how to utilize and exploit saline soil as a geo-resource. During his research he emphases on ecological amelioration based on forestry approach

from the angle of vegetation restoration instead of physical methods. Based on this consideration the book was developed. The first four parts mainly introduce characteristics of salt-affected soil and its amelioration by trees, including the concepts of saline soils, characteristics and occurrence of salt alkaloids, the resources condition and distribution, as well as urban salinization and ecological remediation which is a new environmental problem occurring recently. Moreover, principles and practice of afforestation in saline soils is discussed as a general description, covering the mechanism of salinity-tolerance of plants and salt-resistant plants selecting and breeding, the ecological rehabilitation principle and related technologies, approaches to the improvement progress as well as agroforestry and its application of saline soils along with general afforestation techniques in China.

Meanwhile, the Yellow River Delta as a typical and specific coastal region and the problem of wetland degradation and water shortage is discussed, too. Furthermore, the issue of saline soil utilization for biomass production is touched upon. It is well-known that biomass and bioenergy is keen demanded, but the land resources are limited in the country. Hence developing salt-affected soils for biomass production is necessary and significant. The both are concerned with soil salinization, consequently they are reciprocal in cause.

Finally in the fifth part some cases such as salinity tolerance features of trees in different growing stages are separately described based on the experiments of seed germination, physiological property measurement under salt stress, in addition to some parameters concerned with salt resistance of forest stocks, and black locust forests as biomass energy resource. Meanwhile planting techniques of *Tamarix chinensis* and *Nitraria sibirica* in worst salt-affected soil and its effect on soil amelioration were introduced. The disciplinary structure outlined above is exploited in some examples.

I am glad to read the manuscript and congratulate Prof. Zhang gaining a new achievement. Frankly spoken, this is the one of the best book I've reviewed on saline soil ameliorations based on forestry approach. It will provide an excellent resource for researchers, students, practical workers and other users. I believe that its value will emerge with years to come.

Dresden University of Technology
Dresden, Germany
March 10, 2013

Franz Makeschin

Preface

Across the world, soil salinization is becoming a serious environmental problem. It is an issue especially relevant in developing countries owing to their rapidly increasing levels of population growth and urbanization. As a result of these factors, there is increasing demand for staple goods such as grain and vegetables, which then leads to greater intensities of farming and corresponding adverse environmental impacts. One such impact is soil degradation, in which salinization, deforestation and desertification play major roles. In Australia, salinization is called "white death" because of its enormous harmful effects. Globally, an area of about 0.95 billion ha of soil is affected by salt, of which almost one tenth is distributed in China—mainly in the Huang-Huai-Hai, "three-river plain", and northwestern semi-arid and arid areas, as well as the coastal beach lands in the east of the country.

The coastline of China extends for more than 18,000 km, along which lay the Bohai Sea, Yellow Sea, East China Sea and South China Sea. With socioeconomic development, more and more people move to the east of the country to seek better opportunities and higher standards of living. No better example of the region's prosperity exists than China's "oriental pearl": Shanghai. Situated in the coastal area along the Yangtze River and the Yangtze River Delta, Shanghai represents an important component of the unique geographical advantage of this region, strategically positioned on land where resources are both rich and abundant. Today, coastal Shanghai plays a major role in expediting the development of the Yangtze River Delta region for industrial expansion. In doing so, China can continue to strengthen the productivity of its coastal areas nationally, as well as promote the development of the central and western regions of the country. As a result, exchange and cooperation between China and both Central/Northeast Asian countries and Europe can be maximized.

In view of the environmental situation faced currently by China, saline soils are important land resources and should play a crucial role in promoting socioeconomic development. The key to this is improving our understanding of how to recognize soil salinization, as well as how to manage and cope with it. The Chinese government has stated that the nation must provide 1.8 billion Mu (1 Mu = 1/15 ha) of cultivated land, and that the country must not fall below this "red line" in order

to guarantee food security for its 1.3 billion people. Under such circumstances, the improvement, amelioration and exploitation of alkaloid salts carries vital significance, particularly in coastal regions.

In the above context, the present book has been written based partly on my own understanding and knowledge of the topic of soil salinization, but also by synthesizing the research of others in the field. As such, I consider the book very much as "standing on the shoulders of those more senior", summing up findings from their research in the area of alkaloid salt improvements. In doing so, I draw upon the help of currently emerging ecological theory and methods, and probe how best to utilize and exploit saline soils as an important resource. Hence, there is an emphasis on ecological amelioration based on forestry approaches from the perspective of vegetation restoration, as opposed to physical methods. This is a new line of thinking, set apart from past practice in the field.

Throughout the book, I have tried to make explanation and clarity key features. Explaining a topic, theme or argument clearly and succinctly is intended to make the book useful for students, professionals and researchers alike. Readers—whether engaged in formal education or self-study—can expect to be able to read and digest the contents of the book quickly and easily. That said, while a good book should be clear, it must also be well structured. Its readers, as do all analysts, need to feel secure in order to confidently confront and engage new problems. A book that neglects to empower the reader, in this manner, has failed. Thus, in this book, the principle of writing is followed from concepts to mechanisms; from general description to specific definition; from *theoretical interpretation* to examples and illustrations.

The book is divided into five parts. The first part is mainly devoted to introducing the characteristics of salt-affected soil and its amelioration by trees, including the concepts of saline soils; characteristics and occurrence of alkaloid salts; the resources, conditions and distribution of saline soils; urban salinization; and the ecological remediation of salinization, which is a new approach to mitigating this environmental problem. In the second part, the principles and practices of afforestation in saline soils are discussed, beginning with a general description, but then also going on to cover the mechanisms of salinity-tolerance in plants; selective breeding of salt-resistant plants; the principles, technology, approaches and progress improvements involved in ecological rehabilitation; and agroforestry and its application in the amelioration of saline soils, along with general afforestation techniques in China. The third part of the book looks at the issue of saline soil utilization for biomass production. It is well known that bioenergy is in high demand, but that land resources to meet this demand are limited. Hence, developing salt-affected soils for biomass production is necessary and significant. In the fourth part, the issues of wetland degradation and water shortages—both of which are linked to soil salinization in a *reciprocal causation* relationship—are addressed by specifically examining the Yellow River Delta region as a typical case. Finally, the fifth part of the book first discusses features of salinity tolerance in trees at different growth stages. This topic is discussed from a number of different angles, such as results from seed germination experiments and measurements of

physiological properties under salt stress. In addition, some parameters concerned with salt resistance of forest stocks and black locust (*Robinia pseudoacacia*) forest as a biomass energy resource are considered. Meanwhile, as an example, the planting techniques of *Tamarix chinensis* and *Nitraria sibirica* in some of the worst-affected salinized soils and their role in soil amelioration are introduced. The structure outlined above is embellished throughout the text with many other examples and case studies. However, the Yellow River Delta region remains a core theme throughout and, to end, the changes in response of the plant community in terms of wetland degradation in this region are discussed.

My aim in writing this book was to present the concepts of salinity tolerance and afforestation as simply as possible, but at the same time for the text to be long and detailed enough for readers to feel, upon completing the material, that they subsequently possess a strong foundation of knowledge in the topic area upon which they can build. They will hopefully have acquired understanding from the book's clear exposition, a sense of its formal structure, and a perspective of salt-affected soil rehabilitation based on forestry approaches both in terms of its historical development and its potential future applications in China.

As with all projects of this kind, readers are bound to spot mistakes or areas for improvement in the book. If this is the case, I encourage you to send me your feedback and suggestions, which I will build into future editions of the book should opportunities to do so arise.

Hangzhou Jianfeng Zhang
March 12, 2013

Acknowledgements

I take this opportunity to express my gratitude to the people who have been instrumental in the successful completion of this book.

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Apart from the efforts of oneself, the success of any project depends largely on the encouragement and guidance of many others. The present book was no different in this regard, with its successful completion being very much the result of teamwork. Colleagues from the Institute of Subtropical Forestry, Chinese Academy of Forestry, such as Dr. Chen Guangcai, Dr. Shan Qihua, Prof. Jiang Jingmin, Prof. Yu Mukui (Project No. 2009BADB2B0304), Prof. Wang Yangdong, Prof. Zhou Benzhi, Prof. Gu Xiaoping, Dr. Wu Ming, Dr. Yang Xiaosheng, Dr. Li Sheng and Dr. Fang Xuezhi, all lent helping hands in various ways, as did my students Wang Qingbing, Li Zebo, Wang Ying, Wang Li, Wu Hao, Zhang Ying, Yang Quanquan, Li Jie and Sun Hui.

In addition, I take immense pleasure in thanking the Shandong Academy of Forestry, where I have worked for over 15 years. Colleagues such as Prof. Xing Shangjun, Prof. Jiang Yuezhong, Prof. Xu Jingwei, Prof. Liu Dexi, Prof. Song Yumin, Prof. Fang Yifu, Prof. Li Shanwen, Prof. Ma Hailin, Prof. Qin Guanghua, Dr. Du Zhenyu and Associate Prof. Ma Bingyao provide me with particular ongoing assistance. Furthermore, I also wish to thank my close friends Prof. Xi Jinbiao, Prof. Zhang Deshun, Prof. Li Xiufen and Prof. Qiao Yongjin, who have now left the Academy, for their kind co-operation and encouragement.

Time flies like a shuttle. In 1983, I enrolled at the Department of Forestry of Shandong Agricultural University. Since then, I have been learning and working in this field for 30 years, during which time I have gained a broad level of experience in forestry and related disciplines. I spent 7 years studying for a B.Sc. in forestry and

M.Sc. in silviculture. When I pursued my master's degree, Prof. Long Zhuangru—who sadly passed away in 2012—and Prof. Liang Yutang were my supervisors. These two gentlemen were rigorous scholars, and possessed a great accumulation of knowledge between them. However, they were at the same time both peaceful and humble in character, and I feel it is through their guidance and influence that I entered the world of science, and followed the road of academic research without looking back. I am enormously grateful for their inspiration, counseling and support.

After graduation in 1990, I began working at the Shandong Academy of Forestry, guided by Prof. Gong Hongzhu, who has long been working in the area of improvements of saline-alkali soils based on forest technology. He presided over the compilation of China's first textbook on the topic, entitled "Silviculture in Saline-alkali Land", which was a key milestone for saline-alkali soil amelioration and forest cultivation. It is through his advice and encouragement that I have enjoyed success along the rugged road of saline soil amelioration research.

Owing to the policy of reform and opening up in China, I also had the opportunity to study abroad between 1995 and 1997, sponsored by DAAD (the German Academic Exchange Service), whereupon I studied for an M.Sc. at the Institute of International Forestry and Forest Products at the Technological University of Dresden (TUD). Furthermore, I was later able to take up a position as a visiting scholar at the Institute of Soil Science, again at the TUD, from 2001 to 2002, supported by the China Scholarship Council. During these periods, many people provided me with an enormous level of help and advice; in particular, Prof. Franz Makeschin, Prof. Juergen Pretzsch, Prof. Holm Uibrig, Prof. Andreas Roloff, Dr. H. Pohris, Prof. Karl-Heinz Feger, Dr. Zhong Zheke, Dr. Dirk Landgraf, Dr. Frank Haubrig, Dr. Abi, and many others.

From 1999 to 2003 I studied for a Ph.D. at the College of Resource and Environment, Beijing Forestry University, supervised by Prof. Li Jiyue, who was the first person in China to be awarded a doctorate in silviculture (his Ph.D. tutor was Prof. Shen Guofang, academician and former president of the Beijing Forestry University). Prof. Li has a profound knowledge and rich experience in teaching. During the 4 years spent with Prof. Li, not only did I improve my level of professional knowledge, but he also imparted upon me the spirit of rigorous scholarship, a down-to-earth style of work, and the ability to rise above the crowd with personality and charm.

Having achieved my Ph.D., during 2003–2007 I then went on to perform postdoctoral research at the Institute of Forestry, Chinese Academy of Forestry, under the guidance of Prof. Peng Zhenhua, Chief Scientist and Kandidat Nauk from the former Soviet Union. Hence, he is both Chinese and Western in terms of his educational background, and possesses a rich farsightedness in scientific research, a pioneering scientific attitude, takes leave of dedication, and deeply affects everyone with whom he works. During the period, I also received support from Dr. Sun Qixiang, Prof. Zhang Xudong, Prof. Sun Zhenyuan, Prof. Meng Ping, Prof. Zhang Jianguo, Prof. Lu Mengzhu, Prof. Wang Cheng, Prof. Li Lubin, Prof. Wang Yan, Prof. Zhou Jinxing, Dr. Qiu Erfa, Prof. Sun Xiaomei, Prof. Wang Bing, Prof. Cui Lijuan, Prof. Fan Baomin, Prof. Guo Zhihua and Dr. Zhang Weiyin.

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Hangzhou Jianfeng Zhang
May 9, 2013

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