

Forestry

Principles and Applications

Antony Joseph Raj
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FORESTRY

PRINCIPLES AND APPLICATIONS

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FOREWORD

Forests are a critical link in the transition to a green economy – one that promotes sustainable development and poverty eradication as we move towards a low carbon and more equitable future. Forests supply wood, fibre, fuelwood and non-wood forest products for industrial and non-industrial uses. Biologically-rich forest ecosystems provide a wide range of provisioning, regulating, cultural and supporting services for human well being collectively known as ecosystem services.

The sustainability of forest ecosystems depends on sustained management, efficient utilization and effective protection measures against deforestation and forest degradation. The role of ecosystem services are equally important for sustaining livelihoods and maintaining environmental conditions. The benefits of reducing deforestation for climate change alone is estimated to be in the trillions. Yet despite these huge ecological, economical, social and health benefits, forest are still being destroyed at an alarming rate of 13 million hectares annually for limited and short-term gains.

This comprehensive textbook “Forestry: Principles and Applications” by Dr. Antony Joseph Raj and Prof. (Dr.) S.B. Lal will provide a significant contribution in university and college lecture halls. This book forms a comprehensive and thoroughly up-to-date text on forestry and a detailed exploration of specific and modern technologies in the field of forestry. By bringing current knowledge on forestry and natural resources together in one place, this book will advance our ability to manage the remaining forest resources and safeguard their continuing contribution to human beings. It is my wish that students, teachers, scientists and professional foresters will find the information on this textbook valuable. In future, the acquired knowledge will be helpful not only for the development of sustainable forest management in India but also as an input to policy formulation with respect to Indian forests.

I welcome this latest book which is first of its kind in India as an editorial textbook on forestry. I believe this book, with its high standard, will serve the students for the preparation of competitive exams like UPSC Civil Service Exam, UPSC Indian Forest Service Exam, ICAR Scientists/NET Exam, etc. I would like to congratulate the authors, Dr. Antony Joseph Raj and Prof. (Dr.) S.B. Lal, for their meticulous and hard work in bringing this important textbook into being.



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PREFACE

The material resources and life supporting functions provided by forest lands are particularly important in developing countries where some people still rely on them directly as sources of food, fodder, fuelwood, medicine, shelter, building materials and as centers of certain cultural practices. In recent years, the capability of forests to mitigate climate change, provide renewable products and energy, maintain biological diversity, protect land and water resources, provide recreation facilities, improve air quality, help alleviate poverty and contribute to developing a greener economy have received increasing attention. But at the same time, these benefits are threatened by land and forest degradation, global warming and extreme weather events. An ever increasing population places enormous demands on the forest and land resources. Carbon sequestration in forest ecosystems has become an important issue both in the political discussion about abrupt climate change and forest ecosystem research.

National Forest Policy 1988 mandates expanding forest cover from 23.81 to 33 per cent of India's territory and the overarching objective of the Green India Mission is to increase forest and tree cover in 5 million hectares and improve quality of forest cover in another 5 million hectares. There is a challenge to devise comprehensive work plan for sustainable development of forests in India in next twenty years. To cope with challenging task, forest managers have to integrate modern knowledge resulting from all the disciplines of forestry into the management plans. We are expected to shift towards modern trends and latest concepts to upgrade the knowledge and skills in forestry. This book is the first in the forestry text book series to synthesize information on relevant processes, factors and causes of carbon turnover in forest ecosystem and the technical and economic potential of carbon sequestration. Accordingly the book is able to fill an important gap between the needs of global forest and environmental policies and local forest management. In fact, the book makes a valuable contribution to the knowledge of students, academicians, research scientists, modern foresters and policy makers, which will, in turn, guide efforts to manage the remaining forests and new forests in the millennia to come.

There are many forestry textbooks available in India which provide a more balanced account of subjects. The classic examples are textbooks authored by pioneers like P.K.R. Nair, D.N. Tewari, L.S. Khanna, A.P. Dwivedi, A.N. Chaturvedi, Tribhawan Mehta, Ram Prakash, S.S. Negi, R.K. Luna and others. In many aspects, the topics and structure of this

textbook is highly meritorious and unique. All the individual chapters are contributed by Subject Matter Specialists/ Experts of high repute carefully selected based on their experience and practical knowledge from throughout India and abroad (few chapters).

In fact, the book collates valuable knowledge on forestry and natural resources which will be useful to students for their regular semester exams, University entrance examinations for admission to M.Sc. & Ph.D. programmes, preparation of competitive exams like Civil Service Exams (UPSC), Indian Forestry Service (UPSC), ICAR-ARS Scientist Exam, ICFRE Forestry Scientist Exams, NET Exam, State Public Service Commission Exams, etc. This compilation will be most useful for the people in Universities and Colleges, Research Institutions dealing with biological sciences, agricultural sciences and forestry sciences and Forest Departments of all the States of India. The general subject matters available in the book will be beneficial to persons from forestry, agriculture and natural resources field in other countries.

This textbook will contribute significantly to academic teaching and scientific research. Additional information or suggestions that will improve this book are invited from experts. Finally we would like to express our deep gratitude to all our friends and well wishers for providing numerous comments and suggestions for enhancing the quality of the book.

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CONTENTS

PART 1: NATURAL RESOURCES

| | | |
|-----------|---|-------|
| Chapter 1 | Soil Resources – <i>Munish Kumar</i> | 1-25 |
| | What is Soil? - Soil Components - Soils of India - Nutrient Cycling - Nutrient Cycling in Forest Ecosystem - Weathering - Soil Formation - Organic Matter - Carbon Nitrogen Ratio - Humus | |
| Chapter 2 | Water Resources – <i>S. Chellamuthu</i> | 26-37 |
| | Introduction - Water Resources of India - Water Requirements of India - Water Resources Management in India - Conclusion | |
| Chapter 3 | Forest Resources – <i>Antony Joseph Raj & Afaq Majid Wani</i> | 38-52 |
| | Introduction - Forest Definition - Global Scenario of Forest Resources - Forest Profile of India - Chronological View of Indian Forestry - Forestry in Five Year Plans - Central Board of Forestry - National Forestry Action Programme | |
| Chapter 4 | Wildlife Resources – <i>Sharad Nema</i> | 53-72 |
| | Wildlife Definition - Values of Wildlife - Zoogeographic Regions of World - Indian Fauna and their Distribution - IUCN Categories of Wild Animals - Endangered Wild Animals in India - Protected Areas | |

PART 2: TREE AND FOREST

| | | |
|-----------|---|--------|
| Chapter 5 | Tree Growth and Forest – <i>P. Ratha Krishnan</i> | 75-92 |
| | Introduction - What is Forestry? - Branches of Forestry - Tree Structure and Growth - Classification of Forests - Direct and Indirect Benefits of Forests - Impact of Climatic Factors on Trees and Forest - Site Quality, Bioclimate and Microclimate of Forests - Stand Types - Natural and Artificial Regeneration - Rotation - Thinning | |
| Chapter 6 | Forest Ecology – <i>Munesh Kumar, Etefa Guyassa & Antony Joseph Raj</i> | 93-104 |
| | Introduction - Concepts of Ecology - Ecosystem - Forest Ecosystem - Succession - Vertical Structure - Forest Community Dynamics - Community Structure Characteristics - Methods of Studying Forest Communities - Competitive Exclusion Principle and Ecological Niche Concept | |

| | | |
|-----------|---|---------|
| Chapter 7 | Biodiversity and Conservation Biology – <i>Munesh Kumar & Rainer W. Bussmann</i> | 105-128 |
| | Introduction - Convention on Biological Diversity - What is Biodiversity? - Types of Biodiversity - The Value of Biological Diversity - Threats to Biodiversity - Loss of Biodiversity - Biodiversity Hotspots - Population Diversity - Measurement of Biodiversity - Biodiversity Conservation Strategy - <i>In Situ</i> and <i>Ex Situ</i> Conservation - Indian Scenario of Biodiversity Conservation - Medicinal Plants Conservation | |
| Chapter 8 | Dendrology – <i>S. Gopakumar</i> | 129-147 |
| | Introduction - History of Plant Classification - International Code of Botanical Nomenclature - Identification of Trees in a Tropical Forest Landscape - Botanical Spot Characters and Utilization Aspects of Selected Tree Families - Collection and Submission of Herbarium Specimens | |

PART 3: SUSTAINABLE TIMBER PRODUCTION

| | | |
|------------|--|---------|
| Chapter 9 | Plantation Forestry – <i>Etefa Guyassa & Antony Josphe Raj</i> | 151-163 |
| | Introduction - History of Forest Plantations - Status of Global Planted Forests - Significance of Forest Plantations - Paradigm Shifts in Tropical Forest Plantations - Sustainability of Plantations - Planted Forest Management - Constraints in Plantation Forestry | |
| Chapter 10 | Sustainable Forest Management – <i>Manikanda Ramanujam</i> | 164-174 |
| | Introduction - What is Forest Management? - Concept of Sustainable Forest Management - Concept of Sustainability - Components of Sustainable Forest Management - Criteria and Indicators of Sustainable Forest Management - Indian Initiatives for SFM - Challenges of Sustainable Forest Management - Constraints to Sustainable Forest Management - Forest Certification | |
| Chapter 11 | Working Plan – <i>Bheemsingh Mohandaas</i> | 175-187 |
| | Introduction - Working Plan Code - Organization - Objective and Scope of Working Plan - Brief History - Contents of Working Plan - Preparation of Working Plan | |
| Chapter 12 | Timber Measurements and Timber Inventory – <i>Antony Josphe Raj</i> | 188-213 |
| | Concept and Scope of Forest Mensuration - Tree Diameter Measurements - Tree Height Measurements - Tree Basal Area and Volume Measurements - Stem/ Log Volume Measurements - Stem Form - Timber Inventory - Point Sampling - Plot Sampling - Stand Measurements - Empirical Height Equations, Volume Equations and Volume Table | |
| Chapter 13 | Forest Pest Management – <i>C.T. Ashok Kumar & Veeresh Kumar</i> | 214-230 |
| | Introduction - Natural Forest Pest Control - Silvicultural Control - Silvicultural Practices to reduce Insect Activity - Mechanical and Physical Control - Biological Control - Microbial Control - Chemical Control - Classification of Insect Pests - Conclusion | |
| Chapter 14 | Forest Disease Management – <i>S.T. Naik</i> | 231-255 |
| | Introduction - Plant Disease - Nursery Diseases - Root Diseases - Heart Rots - Forest Disease Control: General Principles - Diseases of Teak, Sal, Shisham, Khair, Neem, Sandalwood, Casuarina, Eucalyptus and Bamboos | |

| | | |
|------------|---|---------|
| Chapter 15 | Forest Fire Management – <i>K. Sasikumar</i> | 256-268 |
| | Introduction - Classification of Forest Fires - Fire Environment - Occurrence of Forest Fire, Its Behaviour and Dynamics - Forest Fire Monitoring in India - Damages caused by Forest Fires - Methods of Extinguishing Forest Fire - Method of Protection against Damage by Fire - Fire Terminologies | |
| Chapter 16 | Problem Soils and Its Management – <i>S. K. Uttam</i> | 269-280 |
| | Introduction - Salt Affected/Saline Soils - Acidic Soils - Waterlogged Soils | |

PART 4: FORESTRY CONCEPTS AND TECHNOLOGIES

| | | |
|------------|--|---------|
| Chapter 17 | Tree Seed Technology – <i>P. Masilamani</i> | 283-306 |
| | Introduction - Seed Collection - Seed Extraction - Seed Drying - Seed Processing - Seed Dormancy - Pre-Sowing Seed Treatment - Seed Storage - Seed Testing- Conclusion | |
| Chapter 18 | Forest Tree Improvement – <i>Sanjeev Thakur & N.B. Singh</i> | 307-331 |
| | Introduction - Elements of Tree Improvement Programme - Species and Provenance Trials - Mass Selection - Plus Tree Selection - Seed Orchards - Progeny Testing - Advance Generation Breeding - Genetic Engineering - Clonal Forestry - Achievements in Tree Improvement - Glossary of Terms | |
| Chapter 19 | Wood Science and Technology – <i>R. Ezhumalai</i> | 332-349 |
| | Introduction - Tree Growth - What is Wood? - Wood Structure - Moisture Content of Wood - Wood Destroyers and Preservatives - Abnormal Wood and Wood Seasoning Defects | |
| Chapter 20 | Clonal Forestry – <i>A.V. Santhoshkumar & Jiji Joseph</i> | 350-358 |
| | Introduction - Vegetative Propagation Methods in Forest Trees - Application of Vegetative Propagation in Forestry - Incorporation of Vegetative Propagation Techniques in Tree Breeding - Applications of Clonal Forestry | |
| Chapter 21 | Wildlife Management – <i>K.C.A. Arun Prasad</i> | 359-378 |
| | Wildlife Management: Definition - Concept of Wildlife Management - What to Conserve? - How Protected? - Protected Area Planning - Ramsar Sites - World Cultural and Natural Heritage Sites - Biosphere Reserves - Tiger Reserves - Project Elephant - Habitat Management - Wildlife Census - Reintroducing Rare and Endangered Species - <i>Ex-Situ</i> Conservation | |
| Chapter 22 | Forest Nursery Technology – <i>J. Jayaprakash, Rajkumar & A.C. Rathore</i> | 379-396 |
| | Introduction - What is Forest Nursery? - Significance of Forest Nursery - Classification of Forest Nurseries - Seedling Quality - Nursery Planning and Management - Nursery Site Selection - Collection of Planting Materials (Seeds, Wildlings and Cutting) - Bareroot Nursery - Container Nursery - Rooted Cuttings - Plant Propagation Structures | |

PART 5: MODERN FORESTRY APPROACHES

| | | |
|------------|---|---------|
| Chapter 23 | Economic Value of Forest Ecosystem – <i>C. Sekhar & A. Vidhyavathi</i> | 399-419 |
| | Introduction - Valuation of Natural Resources - Forest Ecosystem - Valuation of Forest Cover - Costs on Forestry - Valuation Techniques - Selected Economic | |

| | | |
|------------|---|---------|
| | Valuation Methods for Intangible Benefits - Distributional Concerns - Practical Difficulties of Economic Valuation of Forests | |
| Chapter 24 | Application of Remote Sensing and GIS in Forestry – <i>N. Satheesh & T. Mohan Raj</i> | 420-433 |
| | Introduction - Remote Sensing Technology - Satellite Remote Sensing - Aerial Photography - Geographic Information System - Role of Remotes Sensing and GIS in Forestry - Forest Resource Monitoring - Forest Resource Estimation and Harvesting - Forest Resource Protection - Wild Animals Management & Others | |
| Chapter 25 | Forest Based Industries – <i>K.T. Parthiban, S. Umesh Kanna & S. Vennila</i> | 434-450 |
| | Introduction - Major Forest Based Industries - Pulp and Paper Industries - Match Industries - Timber and Sawnwood Industries - Plywood Industries - Particle Board Industries - Dendro Biomass Power Generation Industries - Oil and Biodiesel Industries - Value Addition Industries - Projected Wood Demand for Various Industries - Challenges of Forest Based Industries - Measures for Better Development of Forest Based Industries - Contract Farming Methods - Industrial Policy and Forest Based Industries - Conclusion | |
| Chapter 26 | Modern Logging Methods – <i>Smitha Rajesh & Rajesh G. Nair</i> | 451-467 |
| | Introduction - Impacts of Logging on Forests - Methods of Logging - Logging Terminologies - Felling: Manual Felling and Mechanized Harvesting Systems - Felling Equipments (Chain Saw, Harvester, Feller Buncher) - Extraction Equipments (Skidder, Forwarder, Yarder, Helicopter) - Processing Equipments (Delimber, Chipper, Mulcher)-Loading Equipments (Log Loader) - Transport (Trucks and Trailers) - Logging Operations in Tropics - Reduced Impact Logging | |
| Chapter 27 | Ecotourism – <i>Sanjayan Kumar</i> | 468-481 |
| | Introduction - Important Terminologies - What is Ecotourism? - Objectives of Ecotourism - Characteristics of Ecotourism - Principles of Ecotourism - Positive Impacts of Ecotourism - Threats to Ecotourism - Ecotourism in Protected Areas - Ecotourism Experiences from Parambikulam Tiger Reserve and Periyar Tiger Reserve in Kerala | |
| Chapter 28 | Biofuel from Tree Borne Oilseeds – <i>M. Paramathma & Ashutosh Pandey</i> | 482-500 |
| | Introduction - Biofuels - Tree Borne Oilseeds - Characteristic Features of Potential Tree Borne Oilseeds - Status of Biofuel Production from TBOs in India - Biofuel Production Processes | |

PART 6: PRACTICES FOR INCREASING FOREST COVER

| | | |
|------------|--|---------|
| Chapter 29 | Urban Forestry and Recreational Values – <i>Ramakrishna Hegde</i> | 503-516 |
| | Introduction - Increasing Impact of Process of Urbanization on Forests - Impact of Urban Growth on Indian Forest Resources - Urban Forestry in India - Benefits of Urban Forests - Establishment and Maintenance of Urban Forests | |
| Chapter 30 | Agroforestry Practices – <i>Sharad Nema</i> | 517-538 |
| | Introduction - Concept and Definitions of Agroforestry - Importance and Impact of Agroforestry - Classification of Agroforestry Systems - Selection Criteria for Suitable Agroforestry Trees - Multipurpose Tree Species in Agroforestry - Soil Fertility Improvement in Agroforestry - Agroforestry Models for Different Agro-Climatic Zones of India - Tree-Crop Interactions under Agroforestry System - Future Prospects of Agroforestry | |

| | | |
|------------|---|---------|
| Chapter 31 | Social Forestry – <i>A. Venkatesh, K.P. Mohapatra, Manoj-Kumar, D.J. Rajkhowa & I.S.L. Mawphlang</i> | 539-559 |
| | Introduction - What is Social Forestry? - Classification of Social Forestry - Social Forestry Plantations in Specific Areas - Social Forestry Programmes in India - Support for Social Forestry - Different Social Forestry Schemes Implemented in India | |
| Chapter 32 | Joint Forest Management (JFM) – <i>A. Venkatesh, Manoj Kumar, D.J. Rajkhowa & I.S.L. Mawphlang</i> | 560-577 |
| | Introduction - Origin and Evolution of JFM - JFM: Definition - Structures of JFM - Salient Features of JFM - Participatory Assessment and Planning - Role of NWFPs in JFM - Extent of JFM in India - Recent Policy Changes on JFM | |
| Chapter 33 | Land Degradation and Wasteland Management – <i>S.B. Lal & Antony Jospeh Raj</i> | 578-598 |
| | Introduction - Land Degradation - Types of Land Degradation - Causes of Land Degradation - Assessment of Land Degradation - Effects of Land Degradation - Wastelands - Land Degradation in India - Historical Background of Wasteland Development in India - National Action Programme to Combat Desertification - Wasteland Management | |

PART 7: SOCIAL VALUES AND BENEFITS

| | | |
|------------|--|---------|
| Chapter 34 | Forest Products Utilization – <i>Manmohan J.R. Dobriyal</i> | 601-627 |
| | Introduction - Lumber/ Timber - Composite Wood/ Engineered Wood - Veneers, Plywood and Other Composite Woods - Improved Wood/ Modified Wood - Fuelwood - Pulp and Paper Wood - Charcoal - Other Multiple Uses of Wood - Non-Wood Forest Products | |
| Chapter 35 | Forest Policy and Legislations – <i>L. Chandrasekar</i> | 628-647 |
| | What is Policy? - The 1894 Forest Policy - The 1952 Forest Policy - The 1988 Forest Policy - Indian Forest Act 1927 - Wildlife (Protection) Act 1972 - Forest (Conservation) Act 1980 - Forest Rights Act 2006 - International Tropical Timber Agreement | |
| Chapter 36 | Forest Tribes in India – <i>Jadegowda</i> | 648-670 |
| | Introduction - Concept and Definition of Forest Tribe - History of Forest Tribes in India - Classification of Indian Forest Tribes - Demography and Distribution of Forest Tribes in India - Tribal Economy - Policy related Tribal Development | |
| Chapter 37 | Soil and Water Conservation – <i>Munish Kumar & S.K. Uttam</i> | 671-687 |
| | Soil Erosion - Water Erosion - Wind Erosion - Factors Affecting Soil Erosion - Soil and Water Conservation Methods - Control of Wind Erosion - Predicting Soil Erosion | |

PART 8: FORESTS AND CLIMATE CHANGE

| | | |
|------------|---|---------|
| Chapter 38 | Climate Change and Forests – <i>C. Buvaneswaran</i> | 691-709 |
| | Introduction - What is Climate Change? - Stern Review - Greenhouse Effect - Climate Change and Its Influences on Forests - Global Initiatives on Climate Change - Observed Climate Changes in India | |

| | | |
|------------|---|---------|
| Chapter 39 | Forest Carbon Sequestration and Carbon Trade – <i>Antony Joseph Raj</i> | 710-737 |
| | Overview on Global Carbon Cycle - Carbon Dioxide Emissions - Carbon Sequestration - Carbon Sequestration in Forest - Forest Carbon Accounting - Carbon Trade and Carbon Market - Climate Change Mitigation Efforts in India | |

PART 9: EVENTS AND ORGANIZATIONS

| | | |
|------------|---|---------|
| Chapter 40 | International Conferences, Meetings and Conventions – <i>M. Senthil Kumar</i> | 741-763 |
| Chapter 41 | International and National Forest Organizations – <i>Antony Joseph Raj</i> | 764-786 |
| | Intergovernmental Organizations - Non-Governmental Organizations - International Research Institutes - Regional Institutes - Indian Forestry Research & Education Organizations | |
| | Bibliography | 787-805 |

LIST OF TABLES

| | | |
|------------------|---|-----|
| Table 1.1 | Three Types of Weathering | 16 |
| Table 1.2 | C:N Ratio of Organic Matter and Soils | 23 |
| Table 1.3 | Composition of Humus | 25 |
| Table 2.1 | Basin-wise Average Flow and Utilizable Water (in km ³ /year) | 27 |
| Table 2.2 | Groundwater Resources of India (in km ³ /year) | 28 |
| Table 2.3 | State-wise Dynamic Fresh Groundwater Resource of India (in km ³ /year) | 29 |
| Table 2.4 | Groundwater Potential in River Basins of India (pro-rata basis) (in km ³ /year) | 30 |
| Table 2.5 | Per-capita per year Availability and Utilizable Surface Water in India (in m ³) | 31 |
| Table 2.6 | Annual Water Requirement for Different Uses (in km ³) | 33 |
| Table 3.1 | Global Forest Cover by Region | 42 |
| Table 3.2 | Forest and Tree Cover of India | 44 |
| Table 3.3 | Forest Cover in Different Forest Type Groups | 46 |
| Table 4.1 | Zoogeographic Divisions of World | 56 |
| Table 4.2 | Zoogeographic Regions of World | 56 |
| Table 4.3 | State-wise Details of the Protected Area Network of India | 68 |
| Table 4.4 | National Parks and Wildlife Sanctuaries in India | 69 |
| Table 4.5 | List of some important Wildlife Sanctuaries and National Parks in India | 70 |
| Table 5.1 | Vegetation Types of India | 79 |
| Table 5.2 | Trees Removed during different intensities of Low Thinning | 91 |
| Table 6.1 | Life-Form Classes | 103 |
| Table 7.1 | Group-wise Record of Species | 108 |
| Table 7.2 | Number of Global Species under Threat | 113 |
| Table 7.3 | The Hotspots of the World | 116 |
| Table 7.4 | List of Biosphere Reserves of India | 122 |
| Table 7.5 | List of Prioritized Medicinal Plants in India | 127 |
| Table 9.1 | History of Plantation Forests in the World | 153 |
| Table 9.2 | Status of Global Planted Forest Development | 154 |

| | | |
|-------------------|--|-----|
| Table 10.1 | Features of the ITTO Guidelines Concerning Sustainable Forest Management at National and Forest Levels | 171 |
| Table 11.1 | Structure of Organization at Central Level | 176 |
| Table 11.2 | Structure of Organization at State Level | 177 |
| Table 11.3 | Index Used for the Purpose of Stock Mapping in Sal Forests | 182 |
| Table 11.4 | Method of Recording inside Regeneration Plot | 186 |
| Table 11.5 | Grading of Regeneration | 186 |
| Table 11.6 | Yield Regulation for Three Silvicultural Systems | 187 |
| Table 11.7 | Working Plan Vs Management Plan | 187 |
| Table 12.1 | Spiegel Relaskop Bands and BAFs | 208 |
| Table 12.2 | Sample Plots Size for Different Stocking Rates that will include about 20 trees | 209 |
| Table 13.1 | Predators of Insect Pests | 223 |
| Table 13.2 | Parasitoids of Insect Pests | 224 |
| Table 14.1 | Diseases along with Causal Pathogens occurring in Important Tree Species | 236 |
| Table 16.1 | Characteristics of Salt Affected Soils | 270 |
| Table 16.2 | Properties of Saline and Sodic Soils | 272 |
| Table 16.3 | Liming Materials | 276 |
| Table 16.4 | Tree Species Suitable for various Problematic Soils | 279 |
| Table 17.1 | Practical Maturity Indices for Forest Tree Fruits | 286 |
| Table 17.2 | Criteria for Judging the Maturation of different Tropical Forest Species | 287 |
| Table 17.3 | Seed Collection Months of <i>Dalbergia sissoo</i> in different States | 288 |
| Table 17.4 | List of Major Insect Pests and Damage to Fruits/Cones /Seeds on Standing Trees | 290 |
| Table 17.5 | Summary of Extraction Methods for various Fruit Types | 291 |
| Table 17.6 | Seed Extraction Methods of Fleshy Fruits | 293 |
| Table 18.1 | Phases of Species Trial | 312 |
| Table 18.2 | Phases of Provenance Trial | 313 |
| Table 18.3 | Plus Tree Record Form | 317 |
| Table 18.4 | Comparison between Seedling Seed Orchard and Clonal Seed Orchard | 319 |
| Table 18.5 | Comparison of Advantages and Disadvantages of Different Methods of Progeny Testing | 324 |
| Table 21.1 | Number of Documented Species in World and India | 361 |
| Table 21.2 | Growth of Protected Areas in India | 362 |
| Table 21.3 | Protected Area Details in various Biogeographic Zones | 364 |
| Table 21.4 | List of Ramsar Sites in India | 365 |
| Table 21.5 | List of Natural World Heritage Sites in India | 366 |
| Table 21.6 | List of Tiger Reserves in India | 368 |
| Table 23.1 | Methods for Valuing Forests | 414 |

| | | |
|-------------------|--|-----|
| Table 25.1 | Major Tree Borne Oil Seeds | 439 |
| Table 25.2 | Projected Demand of RWE for Sawn Wood Based Industries (million m ³) | 440 |
| Table 25.3 | Projected Demand of RWE for Pulpwood Based Industries (million m ³) | 440 |
| Table 25.4 | Projected Demand of RWE for Sleeper, Round Wood and Mine-Prop etc. (million m ³) | 441 |
| Table 28.1 | Comparison of Energy Species with Possible Potential | 486 |
| Table 28.2 | Botanical Names, Percentage of Oil/ Fat, Uses and Potential States of some of the TBOs as source of Bio-diesel Production in India | 488 |
| Table 29.1 | Per Capita Urban Green Space or Urban Forests in Important Cities | 506 |
| Table 29.2 | Important Urban Trees with Colourful Flowers | 514 |
| Table 29.3 | Urban Trees with Colourful Fruits or Seeds | 514 |
| Table 30.1 | Classification of Agroforestry Systems and Practices | 526 |
| Table 30.2 | Multipurpose Tree Species suitable for Agroforestry in India | 530 |
| Table 30.3 | List of Soil Improvement Tree Species for Agroforestry | 531 |
| Table 30.4 | Promising Agroforestry Models for Agro-Climatic Zones of India | 534 |
| Table 30.5 | Agroforestry Practices in Different Agro-Ecological Regions of India | 536 |
| Table 30.6 | Analysis of Interactions between Two Populations of Species A and B | 537 |
| Table 31.1 | Social Forestry Programmes Implemented in Gujarat | 551 |
| Table 31.2 | Cumulative Achievement of Social Forestry Works (1969-70 to 2003-04) in Gujarat | 551 |
| Table 31.3 | List of Completed Social Forestry Projects | 558 |
| Table 32.1 | State Trading Regulations Promulgated by State Governments | 570 |
| Table 32.2 | JFM as Percentage of Forest Cover in different States of India | 571 |
| Table 32.3 | Participants involved in JFM in different States of India | 572 |
| Table 32.4 | Financial Assistance Received from External Donor Agencies for JFM | 573 |
| Table 33.1 | Classification of Land based on Aridity Index | 580 |
| Table 33.2 | Wasteland Classes in India 1986-2000 | 588 |
| Table 33.3 | Land Degradation Assessment by Different Organizations | 590 |
| Table 33.4 | Types of Land Degradation and Improvement | 596 |
| Table 34.1 | Production Level of Top Ten Paper Producing Countries in 2010 | 615 |
| Table 34.2 | The world's Top 20 Paper and Paperboard Company Groups in 2010 | 616 |
| Table 36.1 | Major Primitive Forest Tribes of India | 654 |
| Table 36.2 | State-Wise Demographic Status of Forest Tribes in India | 655 |
| Table 36.3 | Trends in Growth and Proportion of Forest Tribes in India | 657 |
| Table 37.1 | Classification of Gullies based on the Size | 675 |
| Table 37.2 | Classification of Gullies based on the Shape | 675 |
| Table 37.3 | Classification of Gullies based on the State | 675 |

| | | |
|-------------------|--|-----|
| Table 38.1 | Tropospheric Concentration, GWP, Lifetime, Increased Radiative Forcing of Greenhouse Gases | 697 |
| Table 38.2 | Total Increase and Annual Rate of Increase in CO ₂ during different Decades | 697 |
| Table 38.3 | Summary of Published Change in Forest Productivity under recent Climate Change | 702 |
| Table 39.1 | CO ₂ Emissions from Fossil Fuel Combustion in 2009 of Top Ten Countries and World | 716 |
| Table 39.2 | Total Carbon Emissions of Top Ten Countries and World | 716 |
| Table 39.3 | Trends in Total Carbon Stocks in World's Forests, 1990-2010 | 721 |
| Table 39.4 | Carbon Stock in Indian Forests | 721 |
| Table 39.5 | Carbon Sequestration Practices | 722 |
| Table 39.6 | Carbon Market Evolution Values in \$ Billion | 734 |

LIST OF FIGURES

| | | |
|------------------|---|-----|
| Fig. 1.1 | Overview of Forest Nutrient Cycling | 13 |
| Fig. 3.1 | Forest Cover Map of India | 45 |
| Fig. 5.1 | Thematic Diagram of Tree | 78 |
| Fig. 6.1 | Energy Flow in an Ecosystem | 96 |
| Fig. 6.2 | Succession in Forest Ecosystem | 97 |
| Fig. 6.3 | Vertical Structure in Forest Ecosystem | 99 |
| Fig. 8.1 | Scheme of Classification under Bentham and Hooker's System | 131 |
| Fig. 8.2 | Outline of Bentham and Hooker's Natural Classification | 132 |
| Fig. 8.3 | Bentham and Hooker's Classification of Sub Class Polypetalae | 133 |
| Fig. 8.4 | Bentham and Hooker's Classification of Sub Class Gamopetalae | 133 |
| Fig. 8.5 | Bentham and Hooker's Classification of Sub Class Apetalae | 134 |
| Fig. 8.6 | Bentham and Hooker's Classification of Class Monocots | 134 |
| Fig. 11.1 | Layout of Sample Plot (0.1 ha) for Enumeration, Regeneration Survey and Biodiversity Survey | 185 |
| Fig. 12.1 | Under Bark and Over Bark DBH Measurements | 191 |
| Fig. 12.2 | Diameter Calliper | 192 |
| Fig. 12.3 | Wheeler's Pentaprism Caliper | 194 |
| Fig. 12.4 | Height Measurement using Christen Hypsometer | 198 |
| Fig. 12.5 | Height Measuring Instruments | 200 |
| Fig. 12.6 | Geometric Shape of Tree Stems/Logs | 202 |
| Fig. 12.7 | Wedge Prism Usage | 208 |
| Fig. 17.1 | Types of Materials Removed from Harvested Produce during Processing | 295 |
| Fig. 18.1 | Sequence of Stages in Tree Improvement | 310 |
| Fig. 18.2 | Regression Line for Plus Tree Selection | 318 |
| Fig. 18.3 | Establishment of Seedling Seed Orchard | 322 |
| Fig. 18.4 | Establishment of Clonal Seed Orchard | 323 |
| Fig. 19.1 | Vascular Bundles and Vascular Cambium | 334 |

| | | |
|------------------|---|-----|
| Fig. 19.2 | Meristems and Vascular Cambium Growth | 335 |
| Fig. 19.3 | Cross-section of Tree Stem | 337 |
| Fig. 19.4 | Three Methods of Sawing | 338 |
| Fig. 19.5 | Warping Defects | 348 |
| Fig. 23.1 | Division of Total Economic Value | 403 |
| Fig. 24.1 | Components of Remote Sensing | 422 |
| Fig. 24.2 | Components of GIS | 428 |
| Fig. 25.1 | Categorization of the Paper Mills Based on Cellulosic Raw Materials | 435 |
| Fig. 25.2 | Value Addition of Plantation Residues through Briquetting | 440 |
| Fig. 25.3 | A Value Chain Model for Industrial Forestry | 441 |
| Fig. 25.4 | Status of Industrial Wood Supply Chain | 443 |
| Fig. 25.5 | Tri-partite Model contract tree farming | 444 |
| Fig. 25.6 | Quad-Partite Model Contract Tree Farming | 445 |
| Fig. 25.7 | Industrial Forestry Trees | 447 |
| Fig. 25.8 | Industrial Forestry | 448 |
| Fig. 26.1 | Types of Feller Buncher | 459 |
| Fig. 26.2 | Types of Yarder | 462 |
| Fig. 26.3 | Types of Delimber | 463 |
| Fig. 26.4 | Types of Loader | 465 |
| Fig. 28.1 | Bio-diesel Production Reaction | 499 |
| Fig. 28.2 | Flow Diagram for Production of Bio-diesel | 499 |
| Fig. 30.1 | Benefits of MPTs - '6Fs' | 529 |
| Fig. 30.2 | Comparison of Pattern of Nutrient Cycling in Forest, Agriculture and Agroforestry | 532 |
| Fig. 30.3 | Pattern of Nutrient Cycling under Agroforestry | 533 |
| Fig. 34.1 | Composite Woods | 609 |
| Fig. 37.1 | Soil Erosion Agents | 673 |
| Fig. 37.2 | Water Erosion Control Measures | 680 |
| Fig. 38.1 | Costs of Climate Change as percentage of GDP | 695 |
| Fig. 38.2 | The Greenhouse Effect | 698 |
| Fig. 39.1 | Global Carbon Cycle – Units in Gigaton Carbon | 712 |
| Fig. 39.2 | Trend in Global Carbon and CO ₂ Emissions from Fossil Fuel Combustion | 717 |
| Fig. 39.3 | Flow Diagram for Estimation of Carbon Sequestration in Forest Ecosystem | 725 |

ABBREVIATIONS AND ACRONYMS

| | |
|-------------|--|
| AAUs | : Assigned Amount Units |
| ABA | : Absciscic Acid |
| ACF | : Assistant Conservator of Forests |
| AI | : Aridity Index |
| AOSA | : Association of Official Seed Analysts |
| APCCF | : Additional Principal Chief Conservator of Forests |
| APFC | : Asia-Pacific Forestry Commission |
| ASEAN | : Association of South East Asian Nations |
| ATO | : African Timber Organization |
| AYUSH | : Department of Ayurveda, Yoga & Naturopathy, Unani, Siddha & Homeopathy |
| BAF | : Basal Area Factor |
| BC | : Buffering Capacity |
| BDA | : Biological Diversity Act |
| B-I Process | : Bhopal-India Process |
| BMC | : Biodiversity Management Committees |
| BR | : Biosphere Reserve |
| BSI | : Botanical Survey of India |
| C&I | : Criteria and Indicators |
| C:N Ratio | : Carbon Nitrogen Ratio |
| CAI | : Current Annual Increment |
| CAZRI | : Central Arid Zone Research Institute |
| CBD | : Convention on Biological Diversity |
| CBF | : Central Board of Forestry |
| CBP | : Conservation Breeding Programme |
| CBT | : Conservation Bench Terraces |
| CCF | : Chief Conservator of Forests |
| CCS | : Carbon Capture and Sequestration |

| | |
|------------|---|
| CDM | : Clean Development Mechanism |
| CEC | : Cation Exchange Capacity |
| CERs | : Certified Emission Reductions |
| CF | : Conservator of Forests |
| CGIAR | : Consultative Group on International Agricultural Research |
| CIFOR | : Centre for International Forestry Research |
| CITES | : Convention on International Trade in Endangered Species of Wild Fauna and Flora |
| CMS | : Convention on the Conservation of Migratory Species of Wild Animals |
| COC | : Chain of Custody |
| COFO | : Committee on Forestry |
| COP | : Conference of the Parties |
| CPF | : Collaborative Partnership on Forests |
| CR | : Contingent Ranking |
| CSD | : United Nations Commission on Sustainable Development |
| CSIRO | : Commonwealth Scientific and Industrial Research Organization |
| CSO | : Clonal Seed Orchard |
| CVM | : Contingent Valuation Method |
| CWLW | : Chief Wild Life Warden |
| CZA | : Central Zoo Authority |
| DANIDA | : Danish International Developmental Agency |
| dbh | : diameter at breast height |
| DBHOB | : Diameter at Breast Height Over Bark |
| DCF | : Deputy Conservator of Forests |
| DF | : Diesel Fuel |
| DFO | : Divisional Forest Officer |
| DoLR | : Department of Land Resources |
| ECOSOC | : United Nations Economic and Social Council |
| EIA | : Environmental Impact Assessment |
| EMC | : Equilibrium Moisture Content |
| ENSO | : El Nino - Southern Oscillation |
| ERUs | : Emission Reduction Units |
| ESP | : Exchangeable Sodium Percent |
| FAO | : Food and Agricultural Organization of the United Nations |
| FDA | : Forest Development Agency |
| FFA | : Free Fatty Acids |
| FMU | : Forest Management Unit |
| FORWORKNET | : Forestry Workforce Network |

| | |
|--------|--|
| FPC | : Forest Protection Committee |
| FRA | : Global Forest Resources Assessment |
| FRI | : Forest Research Institute |
| FRM | : Forest Reproductive Material |
| FSC | : Forest Stewardship Council |
| FSI | : Forest Survey of India |
| FSO | : Forest Settlement Officer |
| FSP | : Fibre Saturation Point |
| FYM | : Farm Yard Manure |
| FYP | : Five Year Plan |
| GA | : Gibberellic Acid |
| GA | : Genetic Advance |
| GATT | : General Agreement on Tariffs and Trade |
| GCA | : General Combining Ability |
| GEF | : Global Environment Facility |
| GPMC | : Global Fire Monitoring Center |
| GHGs | : Green House Gases |
| GIM | : Green India Mission |
| GIS | : Geographic Information System |
| GLASOD | : Global Assessment of Soil Degradation |
| GM | : Genetically Modified |
| GPS | : Global Positioning System |
| GtC | : Gigatons of Carbon |
| GWP | : Global Warming Potential |
| HYV | : High Yielding Variety |
| IAA | : Indole Acetic Acid |
| IBA | : Indole Butyric Acid |
| IBWL | : Indian Board for Wildlife |
| ICAR | : Indian Council of Agricultural Research |
| ICBN | : International Code of Botanical Nomenclature |
| ICFRE | : Indian Council of Forestry Research and Education |
| ICIMOD | : International Centre for Integrated Mountain Development |
| ICRAF | : World Agroforestry Centre |
| IFAD | : International Fund for Agricultural Development |
| IFF | : Intergovernmental Forum on Forests |
| IIFM | : Indian Institute of Forest Management |
| IIRS | : Indian Institute of Remote Sensing |

| | |
|---------|---|
| IPCC | : Intergovernmental Panel on Climate Change |
| IPF | : Intergovernmental Panel on Forests |
| IPIRTI | : Indian Plywood Industries Research and Training Institute |
| IPM | : Integrated Pest Management |
| ISRO | : Indian Space Research Organisation |
| ISTA | : International Seed Testing Association |
| ITTA | : International Tropical Timber Agreement |
| ITTO | : International Tropical Timber Organization |
| IUCN | : International Union for Conservation of Nature |
| IUDZG | : International Union of Directors of Zoological Gardens |
| IUFRO | : International Union of Forest Research Organizations |
| IVI | : Importance Value Index |
| IWRM | : Integrated Water Resources Management |
| JFM | : Joint Forest Management |
| JFMC | : Joint Forest Management Committees |
| JI | : Joint Implementation |
| KFRI | : Kerala Forest Research Institute |
| LaCONES | : Laboratory for Conservation of Endangered Species |
| LADA | : Land Degradation Assessment in Drylands |
| LULUCF | : Land Use, Land Use Change and Forestry |
| M ha | : Million Hectare |
| MA | : Millennium Ecosystem Assessment |
| MAB | : The Man and the Biosphere Programme |
| MAI | : Mean Annual Increment |
| MAP | : Medicinal and Aromatic Plants |
| MC | : Moisture Content |
| MDGs | : Millennium Development Goals |
| MOA | : Ministry of Agriculture |
| MoEF | : Ministry of Environment and Forests |
| MOP | : Meetings of Parties of the Kyoto Protocol |
| MoRD | : Ministry of Rural Development |
| MPT | : Multipurpose Tree |
| MUSLE | : Modified Universal Soil Loss Equation |
| MW | : Megawatt |
| MXD | : Maximum Latewood Density |
| NAEB | : National Afforestation and Eco-Development Board |
| NAPCD | : National Action Programme to Combat Desertification |

| | |
|----------|--|
| NBA | : National Biodiversity Authority |
| NBSS&LUP | : National Bureau of Soil Survey and Land Use Planning |
| NCA | : National Commission on Agriculture |
| NCDMA | : National CDM Authority |
| NFAP | : National Forestry Action Programme |
| NFT | : Nitrogen Fixing Tree |
| NLBI | : Non-Legally Binding Instrument on All Types of Forests |
| NMPB | : National Medicinal Plants Board |
| NPV | : Nuclear Polyhedrosis Virus/ Net Present Value |
| NRCAF | : National Research Centre for Agroforestry |
| NRSA | : National Remote Sensing Agency |
| NRSC | : National Remote Sensing Center |
| NTFP | : Non-Timber Forest Products |
| NWDB | : National Wasteland Development Board |
| NWFP | : Non-Wood Forest Products |
| OECD | : Organisation for Economic Co-operation and Development |
| OM | : Organic Matter |
| PA | : Protected Area |
| PCCF | : Principal Chief Conservator of Forests |
| PCR | : Polymerase Chain Reaction |
| PIP | : Pugmark Impression Pads |
| POPs | : Convention on Persistent Organic Pollutants |
| PRA | : Participatory Rural Appraisal |
| PROFOR | : Programme on Forests |
| PTGs | : Primitive Tribal Groups |
| PVTGs | : Particularly Vulnerable Tribal Groups |
| PWPR | : Preliminary Working Plan Report |
| RAPD | : Random Amplified Polymorphic DNA |
| REDD | : Reducing Emissions from Deforestation and forest Degradation |
| RFLP | : Restriction Fragment Length Polymorphism |
| RFO | : Range Forest Officer |
| RIL | : Reduced Impact Logging |
| RMUs | : Removal Units |
| RSG | : Re-introduction Specialist Group |
| RUPFOR | : Resource Unit for Participatory Forestry |
| RWE | : Round Wood Equivalent |
| SBA | : Stand Basal Area |

| | |
|--------|--|
| SBB | : State Biodiversity Boards |
| SCA | : Specific Combining Ability |
| SFM | : Sustainable Forest Management/ Soil Fertility Management |
| SIA | : Social Impact Assessment |
| SLEM | : Sustainable Land and Ecosystem Management |
| SMPB | : State Medicinal Plants Board |
| SOC | : Soil Organic Carbon |
| SOFO | : State of the World's Forests |
| SOM | : Soil Organic Matter |
| SPA | : Seed Production Area |
| SSO | : Seedling Seed Orchard |
| SSR | : Simple Sequence Repeat |
| TBA | : Tree Basal Area |
| TBOs | : Tree Borne Oilseeds |
| TEV | : Total Economic Value |
| TIES | : The International Ecotourism Society |
| TOF | : Trees Outside Forests |
| UNCCD | : United Nations Convention to Combat Desertification |
| UNCED | : United Nations Conference on Environment and Development |
| UNCHE | : United Nations Conference on the Human Environment |
| UNCOD | : United Nations Conference on Desertification |
| UNCTAD | : United Nations Conference on Trade and Development |
| UNDESA | : United Nations Department of Economic and Social Affairs |
| UNDP | : United Nations Development Programme |
| UNEP | : United Nations Environment Programme |
| UNESCO | : United Nations Educational, Scientific and Cultural Organization |
| UNFCCC | : United Nations Framework Convention on Climate Change |
| UNFF | : United Nations Forum on Forests |
| UNISDR | : United Nations International Strategy for Disaster Reduction |
| UNPFII | : United Nations Permanent Forum on Indigenous Issues |
| UNWTO | : United Nations World Tourism Organization |
| USEPA | : United States Environmental Protection Agency |
| USLE | : Universal Soil Loss Equation |
| VA | : Village Associations |
| VERs | : Verified Emission Reductions |
| VFC | : Village Forest Committee |
| WAZA | : World Association of Zoos and Aquariums |

| | |
|------|---|
| WBG | : World Bank Group |
| WCFS | : World Commission on Forests and Sustainable Development |
| WF | : Weightage Factor |
| WHC | : World Heritage Convention |
| WII | : Wildlife Institute of India |
| WMO | : World Meteorological Organization |
| WPO | : Working Plan Officer |
| WSSD | : World Summit on Sustainable Development |
| WTA | : Willingness To Accept |
| WTO | : World Trade Organization |
| WTP | : Willingness To Pay |
| WWF | : World Wide Fund for Nature |

PART 1:

NATURAL RESOURCES

