Tropical Forestry

Sven Günter
Michael Weber
Bernd Stimm
Reinhard Mosandl *Editors*

Silviculture in the Tropics

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Silviculture in the Tropics

With 49 Figures and 59 Tables

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Preface

In 1998, Dawkins and Philip published their important book *Tropical Moist Forest Silviculture and Management. A History of Success and Failure*. In that book they stated: "The main message from the past is that natural forest management can be done; conservation and production are not incompatible; in fact, in some of the circumstances the only way to conservation will be through the management of the production of goods and services from the forest."

Convinced of the trueness of this statement silviculturists working in all tropical areas of the world have contributed to this book. It reflects the efforts of 46 authors to specify the state of the art in tropical silviculture. The book aims at combining two complementary aspects of tropical silviculture: first we would like to emphasize its role as integrative scientific discipline linking ecological and socioeconomic dimensions, and second we call attention to its role as an instrument to satisfy the manifold demands of the multiple forest users, from livelihood over timber production to provision of environmental services. Therefore, this book contains contributions from scientists, as well as from representatives of international institutions. While the first parts of the book focus on forest users and new aspects in silviculture, the latter parts are structured according to forest types. For maintenance of high scientific standards, all articles are peer reviewed. All ten parts of the book (with the exception of introduction and conclusions) are subdivided into one review chapter giving an overview and introduction into the topic, followed by case studies from Africa, Asia, and Latin America highlighting special aspects.

We hope this book will be useful to scientists, practitioners, and students working in tropical forestry, especially to those managing tropical forests for the provision of goods and environmental services in supporting them to do this in a wise, adaptive, and sustainable manner and under concern of human needs and social requirements.

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The Editors

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Abbreviations

a.s.l.	Above sea level
ATSC	Australian Tree Seed Centre
BMP	Best management practice
CAI	Current annual increment
CBD	Convention on Biological Diversity
CDM	Clean Development Mechanism
CF	Community Forestry
CFM	Collaborative Forest Management
CFUG	Community Forestry User Group
CIFOR	Center for International Forestry Research
CoP	Conference of Parties (Organized by United Nations)
CSIRO FFP	CSIRO Forestry and Forest Products
DBH	Diameter at breast height
DFCC	District Forest Coordination Committee
DFRS	Department of Forest Research and Survey
dsm^{-1}	Deci siemens per meter
FAO	Food and Agriculture Organization
FCT	Future crop tree
GBH	Girth at breast height
GFRA	Global Forest Resource Assessment
GHG	Green house gas
GM	Genetic modification
ha	Hectare
IAD	Institutional analysis and development
IDH	Intermediate disturbance hypothesis
ILO	International Labor Organization
INGO	International Non Governmental Organization
IPM	Integrated pest management
ITTO	International Timber Trade Organization
IUCN	International Union for Nature Conservation

LAI	Leaf area index
LLP	Long-lived pioneer
m	Meter
MAHI	Mean annual height increment
MAI	Mean annual increment
MMAI	Maximum mean annual increment
MCD	Minimum cutting diameter
MDF	Mixed dipterocarp forest
MED	Minimum exploitable diameter
MFD	Minimum felling diameter
MOFSC	Ministry of Forest and Soil Conservation
NGO	Non Governmental Organization
NPLD	Non-pioneer light demanders
NPP	Net primary production
NPV	Net present value
NTFP	Non-timber forest product
PPFD	Photosynthetic photon flux density
PST	Partial shade-tolerant
REDD	United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
RGR	Relative growth rate
RIL	Reduced-impact logging
R-PIN	Readiness Plan Idea Note
SFM	Sustainable forest management
SMFE	Small and medium-sized forest enterprises
TAS	Traditional agroforestry system
TCBFM	Traditional community based forest management
TFD	The Forest Dialogue
TST	Total shade-tolerant
UNEP	United Nations Environment Programme
UNU-WIDER	United Nations University-World Institute for Development Economics Research
y	Year

Part I
Introduction

Chapter 1
Introduction to Silviculture in the Tropics

Sven Günter

Abstract This chapter provides an introduction to the book *Silviculture in the Tropics*. The development of the scientific discipline of silviculture is closely related to the evolvement of the term "sustainability" from stable provision of wood in the eighteenth century to the provision of environmental services and non-timber forest products nowadays. Silviculture as a scientific discipline aims at mediating between natural sciences and societal disciplines. Several definitions of silviculture in this context are presented in the text. Many principles of silviculture in temperate ecosystems are generally valid in the tropics too. However, one main difference from temperate silviculture is the exorbitant biodiversity of most of the tropical forest ecosystems. This makes silvicultural planning and interventions much more complicated, on the one hand, and compatibility with the aims of conservation of biodiversity much more important, on the other hand. Since many people in the tropics in contrast to those in most countries in temperate ecosystems depend on forests for their subsistence and livelihood, silvicultural goals should match the aims of rural development and reducing poverty. The second part of this chapter provides an overview of the chapters in the book, which is subdivided into eight main parts, each consisting of an introductory overview chapter, accompanied by some case studies from different tropical continents. Parts II and III set the stage for the following more specific parts. Part II deals with the different demands of users towards forests, whereas Part III deals with the multiple new aspects in modern forestry with strong impact on silviculture, from conservation of biodiversity to use of non-timber forest products to modeling approaches in science and practice. Parts IV–VI deal with silviculture in natural humid forests, dry forests and special ecosystems such as mangroves and mountains. Parts VII–IX discuss forests with stronger human interventions: secondary forests and planted forests for productive purposes and for restoration. The book ends with a final, concluding chapter.

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1.1 Tropical Forests and Changing Requirements

Almost half of the world's forests are located in tropical countries (FRA 2010). Latin America[1] has the largest tropical forest area (810 million hectares), followed by Africa[2] (627 million hectares) and Asia[3] (489 million hectares). However, the extent of annual deforestation is still enormous, mainly owing to conversion of forests into agricultural land, especially in the tropics. More than seven million hectares of forests are lost every year. An alarming loss of 2.2 million hectares per year is attributed to Brazil and 0.7 million hectares are lost in Indonesia each year. Also, the relative rates of deforestation are highest in the tropics: 9.7% in the Comoros, 5.8% in Togo and 4.0% in Nigeria. The increasing demands on land use, especially for food and energy, will probably aggravate this dilemma in the future. Although direct employment of people in the forestry sector in relation to the whole labor force of a country is usually below 1% (FRA 2010), the dependence of people on forests for their livelihood is much higher. If deforestation in the tropics continues, an increasing number of poor people will lose even their low existence base, and the global human population will have to face the negative effects in relation to climate, biodiversity and other environmental services. Of course, silviculture alone cannot stop deforestation, but it can contribute to more sustainable management of the renewable forest resources and hence can mitigate negative effects of deforestation and climate change.

The requirements of societies towards forests, forest services and products differ in time and between cultures. Although early in human history the main aims were collecting non-timber forest products (NTFPs) and hunting, in recent centuries the main focus was on harvesting timber. Especially since the Brundtland Report of the World Commission on Environment and Development (1987), the requirements and aims have changed to meeting social objectives for values other than timber (Benskin and Bedford 1995). Today, new challenges arise for forest management and silviculture by the need to fulfill both the demand for products such as NTFPs and timber on a local or regional scale and the needs for environmental services such as conservation of biodiversity and mitigation of climate change on a global scale.

1.2 Definitions and Concepts of Silviculture

The two main pillars of silviculture are reflected by the Latin words *silva* (meaning "forest") and *cultura* (meaning "cultivation"). Silviculture in this very basic sense hence describes cultivation of forests, without implying any qualitative criteria or

[1]Without Argentina and Chile.

[2]Without Mediterranean countries.

[3]Only South Asia, Southeast Asia and Oceania.

thresholds for best management practices. Thus, in its very literal meaning, silviculture is rooted in social sciences as well as in natural sciences. However, it is notable that "culture" is sometimes defined as the opposite of "nature" (Liebsch 2004). The composition of two apparently antipodal terms indicates the overarching objective of silviculture of balancing culture and nature. Silviculture in its literal meaning consequently aims at mitigating and balancing the objectives of conservation of forest ecosystems and functions and anthropogenic uses. Dawkins and Philip (1998) stated that the basis for silvicultural objectives is defined by social requirements within the limits of what is technically possible.

Managing forests without considering the impacts of interventions on an ecosystem, as a kind of "one-way-management," is as old as humankind. The increasing human population and pressure exceeding the regeneration capacity of forest ecosystems necessarily causes destruction of wilderness and loss of biodiversity, e.g., by overhunting of animals and intensification of agriculture several thousand years ago (Eastwood et al. 2007; Horan et al. 2003) or exploitation of high-timber-value species such as mahogany in Central America starting some 100 years ago (Lamb 1966). With forest goods and services becoming scarce (not exhausted), it is essential to look for a long-term balance between the needs of humans and conservation of nature. The beginning scarcity of natural resources can be considered as an alarming signal from nature for humans to modify and adapt their silvicultural activities. Increasing awareness that forests are limited natural resources is hence the basis for silviculture in the context of sustainable forest management. A proactive balancing between apparently detrimental objectives requires a sound analysis of ecological and economic processes and optimization of trade-offs and interactions in order to avoid exploitation of natural resources. Thus, measuring and quantifying the signals of scarcity are important instruments for silviculture.

Price is frequently considered to be a good indicator of scarcity or shareholders' perception of scarcity. "The conventional economic approach seeks to maximize the present value of a stream of aggregate benefits less costs" (Toman and Ashton 1996). The difficult task of including public goods and services in the microeconomy is one example of "imperfect markets" (Stiglitz and Walsh 2010). This term indicates the possible limitations of purely market driven forestry to achieve sustainability. Additionally, the current revenues are based on decisions and silvicultural operations carried out decades and sometimes even hundreds of years ago. Silviculture today, in turn, has to set the course for economically profitable and ecologically sustainable management in the future. A further problem of markets is strong time preferences of forest users, since future yields are less reflected in current prices than yields today. Discounting is a common instrument to overcome this problem, but it is questionable if all economic and ecological risks can really be represented correctly by discount rates. Unfortunately, it is still common practice to manage tropical forests without sound knowledge of sustainable yields or significant impacts of human interventions on ecosystem functions and services. Forest management under uncertainty and without considering risks, on the one hand, and lack of ecological knowledge (especially regarding yields and long-term damage to the remnant stand), on the other hand, may hardly set the stage for sustainability in

the future (Knoke 2010). Besides economic indicators, globally comparable ecological indicators for disturbance of ecosystem functions and for defining thresholds of "responsible management" are required (Raison et al. 2001). Several international organizations are working on transparent and reproducible lists of indicators of sustainability. However, bridging this gap of missing knowledge may be the major challenge for foresters and economists in the future.

Despite economic and ecological dimensions, social aspects play a key role in sustainable forestry too (Weber-Blaschke et al. 2005). Dawkins and Philip (1998) gave an illustrative example: "what happens to a swiss forester if his precautions against protective functions of alpine forests such as avalanches, fail and result in a loss of human life?" The answer of the forester is: "I have to walk behind the coffins to the graveyard with the villagers." In this example, the protective functions are less driven by economic processes than by social control. On a global scale this may raise the question of who will take responsibility for global climate change or loss of biodiversity due to human pressure. Although social control may lead to effective management of protective functions on a local scale, the global mechanisms of social control for achieving "responsible management" are still unsolved (Toman and Ashton 1996).

In the context of sustainable forest management, several definitions of silviculture have been proposed. In the following I will highlight just a few of them:

- Silviculture "is sometimes called the growing side of the forestry business: the cultivation of woods or forests; the growing and tending of trees as a department of forestry (in Oxford English Dictionary 2nd edition, 1989)" (Dawkins and Philips 1998).
- The art of producing and tending a forest; the application of knowledge of silvics in the treatment of a forest; or the theory and practice of controlling forest establishment, composition and structure, and growth (Smith et al. 1996).

Although these definitions mainly refer to application of activities in the forest, the following ones include aims and objectives. They integrate the requirements of society towards the forests. These more comprehensive definitions explicitly imply ecosystem functions and products and services far beyond timber production. They create a link to sustainable forest management. In the following definitions, the scientific character of silviculture is highlighted instead of the rather descriptive and artistic point of view above. They are generally valid for the tropics too.

- In his book *Silviculture in the Tropics*, Lamprecht (1986) cites Leibundgut: "Today, silviculture considers the forest as ecosystem. It aims at regulating all life processes in an ecologically stable forest and organizing its establishment and regeneration in a way that all needs related to forests are fulfilled best possible and sustainably, i.e. in a permanent and rational manner."
- Silviculture investigates the consequences of decisions about the treatment of forest ecosystems in order to fulfill present and future human needs (Knoke 2010).

- Silviculture is designed to create and maintain the kind of forest that will best fulfill the objectives of the owner and the governing society. The production of timber, though the most common objective, is neither the only nor necessarily the dominant one (Smith et al. 1996).

1.3 Main Differences Between Silviculture in the Tropics and Temperate Zones

There are two main aspects from both natural and social dimensions with a strong impact on silvics and management in the tropics that have to be stressed with more emphasis:

- The high number of tree species complicates botanical identification in the field. Mostly, fertile samples are required for correct identification. Additionally, higher tree diversity is usually accompanied by a lower number of harvestable individuals per hectare, with some exceptions (e.g. in Southeast Asia, where dipterocarps with high timber value dominate the upper canopy in many cases, peat swamp forests, mangroves). Further, biodiversity is recognized as a global value, but up to now does not provide economic benefits to tropical land owners. Thus, balancing conservation and economic interest will be of higher importance than in temperate forests.
- Many countries in the tropics are developing countries or countries in transition. In addition to all forest functions in temperate zones, tropical forests have to fulfill subsistence needs in many cases and suffer from higher human pressure. They are frequently converted into alternative land-use forms which provide either food or cash crops with higher economic returns, at least from a non-sustainable and short-term point of view. Further, many governments have poor or almost no control over the forests and cannot balance conflicting land-use interests properly. Users' needs, of course, are different from and often much more dynamic than those of users in temperate ecosystems. According to the above-mentioned definitions, silviculture in the tropics therefore requires much more careful integration of the social and political dimensions. Decisions and treatments which have long-term effects on the ecosystem should consider that the users' needs may change rapidly.

1.4 Focus and Structure of the Book

The book addresses scientists as well as professionals from the fields of tropical forestry, conservation and landscape management. Each part starts with a general overview chapter as an introduction to the topic and which summarizes the state of the art. Case studies from different tropical regions in each part give more detailed

insight into special regional, technical or social aspects. All chapters have been peer-reviewed.

To provide a broad overview of the different concepts of tropical silviculture, the book is designed as a participative coproduction by authors from all regions of the world, i.e. authors from Africa, the Americas, Asia, Europe and Oceania. It is scientifically based, but is addressed at application. Therefore, authors from non-scientific institutions which aim at finding practical solutions for balancing human interests with conservation such as the Food and Agriculture Organization of the United Nations (FAO), Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Deutscher Entwicklungsdienst (DED) and Stichting Nederlandse Vrijwilligers (SNV) contributed several articles.

Forest users are given greater attention in this book than in other books related to tropical silviculture. This is attributed to the consideration that the requirements of humans finally set the frame and define the aims for management and silviculture. In Part II (with a review in Chap. 2 by Kotru and Sharma) we include three case studies representing different points of view covering "classical" forestry management by concessions, community forestry and the latest developments in access and benefit sharing.

Part III (with a review in Chap. 6 by Weber) introduces current global aspects which may have a strong influence on silviculture in the future. On the one hand, short-rotation plantations are emerging around the world, aiming at the highest possible yields in the shortest possible intervals (see Chap. 9 by Onyekwelu). On the other hand, there is increasing demand for buffer zone management mitigating the increasing human pressure on protected areas and conservation of biodiversity and genetic resources (see Chap. 7 by Putz and Chap. 8 by Finkeldey), for example by including NTFPs in silvicultural practices (see Chap. 10 by Vantomme). The demands for both maximization of timber and conservation do not necessarily fit together and require appropriate management and decision-supporting tools. Growth and yield predictions are essential prerequisites for sustainable management. Thus, it is surprising that wood production and, even worse, the financial consequences of forest management and silviculture are poorly assessed in many areas of the tropics (see Chap. 11 by Knoke and Huth).

After forest users and new aspects in tropical silviculture have been introduced, the book is subdivided into parts on (semi-)natural forests and planted forests according to the FAO's classification (FAO 2006). The (semi-)natural forests are discussed in four book parts. Whereas Part IV (with a review in Chap. 12 by Ashton and Hall) refers to humid forests with emphasis on timber-rich forests of Southeast Asia, Part V (with a review in Chap. 16 by Fredericksen) covers the drier ecosystems with a more pronounced dry season or less rainfall, or both. Here, the main focus is on the neotropics. However, the chapters on both wet and dry forests cover the whole of the tropics and are accompanied by case studies from all tropical regions. Changes in dry season length and precipitation among forest types and regions are continuous and any classification will cause abrupt interruptions in some cases. The authors and the editors roughly followed Holdridge's classifications, with exception of the Meliaceae. The latter are placed in Part IV, despite their

distribution ranges covering both wet and dry forest formations. However, their silviculture tends to be more typical of humid forests. Additionally, the silviculture of the major tropical tree families Dipterocarpaceae and Meliaceae with highly appreciated timber can be compared directly in one book part.

Because it is not possible to cover all forest ecosystems in the world in this book, Part VI (with a review in Chap. 20 by Günter) considers two climatically azonal forest formations, mangroves and montane forests, both of them at opposite positions along the altitudinal gradient. Exemplarily to other forest ecosystems at ecological margins, the role of payments for environmental services is discussed in this part. Owing to increasing human pressure, secondary forests are an expanding forest formation worldwide. Therefore, special reference is given to this often neglected topic in Part VII (with a review in Chap. 23 by Akindele and Onyekwelu).

Parts VIII and IX on planted forests cover forest types with a stronger human component. The two parts are dedicated to two different aims: Part VIII (with a review in Chap. 27 by Onyekwelu et al.) provides an overview of the broad field of plantation forestry in terms of wood production, and Part IX (with a review in Chap. 30 by Weber et al.) refers mainly to planting for restoration purposes and rehabilitation of ecosystem functions. However, these two parts have smooth transitions: protective functions do not exclude wood production and wood production could be compatible with ecosystem functions.

Final conclusions are given in Chap. 34. On the basis of the contributions to this book, Günter et al. extracted five trends for modern tropical silviculture.

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Part II
Forest Users: Past, Present, Future

Chapter 2
Review
Forest Users: Past, Present, Future

Rajan Kotru and Sudhirender Sharma

Abstract From a frugal use of tropical forests by primitive indigenous communities a few centuries ago, their utility has grown to global significance with a wide array of goods and services sought by the world community. This evolutionary role of tropical forests, however, has come at a cost as these forests are under severe threat owing to persistent overuse. It is widely accepted that with the dawn of colonialism across the tropical belt, extraction of forest products for industrial use and infrastructure became intensive, and energy and livelihood demands of the growing population of forest-dependent communities soared. The resultant deforestation and forest degradation under state ownership was countered by handing over management to local communities. It has clearly emerged that tenure security is the key for getting communities committed to judicious management in the long run. With the increased demand for sustainable yield of goods and services, consultative processes amongst a range of stakeholders became important to minimise conflicts and influence policy and management in practise. Learning experience shows that for sustainable management of tropical forests state and community partnership is unequivocal, social inclusion and governance issues must be resolved, value addition of forest products must add to the local economy and employment, technical management must be simplified and the climate agenda must be addressed. Moreover, since sustainable forest management can no longer be seen in isolation from the politics and practise of other sectors regarding forests, it is inevitable that institutional capacities, learning and knowledge networks, participatory monitoring and advocacy forums are consolidated across vertical and horizontal levels of governance and relevant sectors.

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2.1 Context

2.1.1 Forest Use in the Tropics from a Historical Perspective

From a mere frugal use of intact tropical forest ecosystems by insignificant forest dweller populations barely a few centuries ago, these forests in the twenty-first century have evolved to a global natural asset for a broader delivery of goods and services sought by a range of stakeholders (e.g. subsistence farmer, wood industry, conservationists, traders). Since CoP 13 (e.g. the Bali road map in 2007), the status of "free for all" of tropical forests owing to their immense growth and biodiversity potential has found defining attention in the emerging challenge of countering greenhouse gas emissions as the root cause of climate change. Following it up, CoP 15 in Copenhagen (2009) highlighted the role of forests in sequestering greenhouse gases and made cost-effective and efficient forest management a prime agenda. However, this radical shift in the thinking on and use of tropical forests has come at a significant loss. The Global Forest Resources Assessment 2005 (FAO 2006) of the Food and Agriculture Organisation of the United Nations (FAO) mentions the net loss in forest area at the global level during the 1990s was an estimated 94 million hectares – an area larger than Venezuela and equivalent to 2.4% of the world's total forests. In another estimation for tropical forests, natural dense broad-leaved forest covers 1,260 million hectares, or 9% of Earth's total land area (Barbier and Burgess 2001). Despite increased awareness of the importance of these forests, deforestation rates have not slowed.[1] Analysis of figures from the FAO shows that tropical deforestation rates increased by 8.5% from 2000 to 2005 when compared with the 1990s, whereas loss of primary forests may have expanded by 25% over the same period. The rate of primary forest loss has doubled in Nigeria and Vietnam since the 1990s, whereas Peru's rate has tripled.

Although extensive, the world's forests have shrunk by some 40% since agriculture began 11,000 years ago. Three quarters of this loss occurred in the last two centuries as land was cleared to make way for farms and to meet the demand for wood. As a classic example of forest decimation, Haiti, with a forest cover estimated at 3% of all land area, has experienced severe degradation of its natural resources and a significant change in its land cover. Although deforestation in Haiti is obviously multifaceted, one issue emerges from empirical analysis in explaining deforestation: land tenure. A study was made on the causes of deforestation in Haiti, particularly in the Forêt des Pins Reserve, using the annual average area of cleared forest per household as the dependent variable. Data were collected with the use of a survey instrument administered to 243 farm households in 15 villages inside the

[1]The Draft Global Forest Resource Assessment 2010 of the FAO reports that there is slowdown of the deforestation rate. However, South America and Africa are having a higher net annual loss of forests (2000–2010) and Asia, especially owing to afforestation in China, India, Vietnam and Indonesia, is showing a net gain. Between 2000 and 2005, Africa and South America experienced the largest net forest losses (21.87 and 19.01 million hectares, respectively).

reserve. Tobit regression results revealed that household size, education of the head of the household, land tenure regime and farm labour are important factors affecting land clearing.

Given the above account and accelerated changes in tropical forests occurring since the early 1960s, largely attributed to population and economic growth, the mechanisation of extraction techniques, and increasing means for transportation (ITTO 2006), the tropical forest ecosystems are rated as the most threatened forest ecosystems in the world (Millennium Ecosystem Assessment 2005). The grave implications of such devastation can be seen from the fact that these forests shelter nearly half of Earth's biodiversity, capture carbon, protect water, food and soil resources, and provide timber and other forest products for consumption and commercial use (FAO 1995, 2001). Subsequently, this has serious implications for an estimated 350 million indigenous and tribal peoples at least partly dependent on forests, including some 60 million who are substantially dependent on forests for their subsistence and livelihoods. These forests are particularly located in developing tropical countries and therefore are very important to the poor and women, who shoulder much of the burden of hauling wood and collecting and marketing forest products. Many such forest-dependent communities, ethnic minorities or farmers lack both land security and political representation (Wolvekamp 1999).

2.1.2 State Control of Tropical Forests

Transformation of the use and expectation from forests has historically started from very primitive tribal/indigenous communities living within or on the fringe of forest areas fulfilling their livelihood-oriented basic needs. Tropical forests thinly surrounded by humans were the ultimate local saviour socially, economically, culturally and spiritually. On the other hand, there are some areas where civilisation was built in harmony with the forest. Forest civilisation, developed by Indio people, which was destroyed by the European invasion, is a good example of coexistence between humans and nature. However, it has to be acknowledged that the low-population factor certainly helped the cause of balanced use of the forest. Similarly, for more than 400 years two distinct ethnic groups, the Chachi and Afro-Ecuadorians, through their respective cultural practises have managed forests sustainably, providing them with food, clothing, medicine and ritual necessities (Gamboa, in Colchester 2001). This umbilical relationship between tribal people and forests was first disturbed in the colonial era. Heske (1937) described dense forests in India as the ultimate edifice for the spiritual philosophy this country has given to the world. Colonial expansion in the mid-nineteenth century in India was marked by the establishment of railways spurring greater access to forest resources which were fed to industrial revolution back home. Hence colonial government claimed large tracts of forests as forest administration also was established in the 1860s. Since then, the issue of land rights and indigenous peoples, especially in the forestry sector in India, has been highly sensitive because many tribal communities