PARTNERSHIP FOR LAND USE SCIENCE (Forest-PLUS) PROGRAM

RESOURCE MATERIAL FOR AN ECOSYSTEM APPROACH TO FOREST MANAGEMENT IN INDIA

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ACRONYMS

ACF	Assistant Conservator of Forests
ADMADE	Administrative Management Design
AFOLU	Agriculture, Forestry, and Other Land Use
APCCF	Additional Principal Chief Conservator of Forests
ASEAN	Association of Southeast Asian Nations
BMP	Best Management Practice
CBA	Cost-Benefit Analysis
C&I	Criteria and Indicators
CBC	Community-based Conservation
CBD	Convention on Biodiversity
CBFM	Community-based Forest Management
CBNRM	Community-Based Natural Resource Management
CAMPA	Compensatory Afforestation Fund Management and Planning Authority
CAMPFIRE	Communal Areas Management Program for Indigenous Resources
CCF	Continuous Cover Forestry
CEC	Central Empowered Committee
CFR	Code of Federal Regulations
C&I	Criteria & Indicator
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CNFM	Close-to-Nature Forest Management
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COP	Conference of Parties
CoP	Chief of Party
CTS	Capture, Transport, and Store
DCF	Deputy Conservator of Forests
DbD	Development by Design
DGPS	Differential Global Positioning System
DEM	Digital Elevation Model
DoE	Department of Energy
DoWD	Department of Wastelands Development
EAFM	Ecosystem Approach to Forest Management
EBFM	Ecosystem-based Forest Management

EBM	Ecosystem-based Management
EIA	Environmental Impact Assessment
ENVIS	Environmental Information System
ESIA	Environmental and Social Impact Assessment
EM	Ecosystem Management
EU	European Union
FAO	Food and Agriculture Organization (of United Nations)
FC	Forest Corporation
FD	Forest Department
FDA	Forest Development Agency
FDC	Forest Development Corporation
FEM	Forest Ecosystem Management
FICCI	Federation of Indian Chambers of Commerce & Industry
FLEGT	Forest Law Enforcement, Governance, and Trade
Forest-PLUS	Forest-Partnership for Land Use Science
FPP	Forest-Plus Program
FSI	Forest Survey of India
FYP	Five Year Plan
GCF	Green Climate Fund
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIS	Geographic Information Systems
GOI	Government of India
GNP	Gross National Product
GS	Growing Stock
HoFF	Head of Forest Force
ICDP	Integrated Conservation and Development Project
ICFRE	Indian Council of Forestry Research and Education
ICT	Information and Communication Technology
IFF	Intergovernmental Forum on Forests
IIFM	Indian Institute of Forest Management
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
IPF	Intergovernmental Panel on Forests
IUCN	International Union for Conservation of Nature
ITTO	International Tropical Timber Organization
IUFRO	International Union of Forest Research Organizations
JFM	Joint Forest Management

LSP	Landscape-Scale Planning
MoA	Ministry of Agriculture
MoERCC	Ministry of Environment, Forests, and Climate Change
MA	Millennium Ecosystem Assessment
MAP	Medicinal and Aromatic Plant
MDF	Moderately Dense Forest
MDG	Millennium Development Goal
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MIS	Management Information Systems
MoRD	Ministry of Rural Development
MMRV	Monitoring, Reporting and Verification
MoTA	Ministry of Tribal Affairs
NAEB	National Afforestation and Ecodevelopment Board
NCA	National Commission on Agriculture
NDM	Natural Disturbance Model
NDP	Net Domestic Product
NFP	National Forest Policy
NGO	Nongovernmental Organization
NPV	Net Present Value
NRSA	National Remote Sensing Agency
NRM	Natural Resource Management
NTFP	Non-Timber Forest Products
NWDB	National Wastland Development Board
OED	Operations Evaluation Department
OP	Open Forest
PA	Protected Area
PCCF	Principal Chief Conservator of Forests
PES	Payments for Environmental Services
PESA	Panchayats (Extension to Scheduled Areas) Act
PROFOR	Program on Forests
PWPR	Preliminary Working Plan Report
RCP	Representative Concentration Pathways
REL	Reference Emission Level
RFA	Recorded Forest Area
RL	Reference Levels
RDC	Rural District Council
REDD	Reduction of Emissions from Deforestation and Forest Degradation

RUSLE	Revised Universal Soil Loss Equation
SBSTA	Subsidiary Body for Scientific and Technological Advice
SBSTTA	Subsidiary Body on Scientific, Technical, and Technological Advice
SBI	Subsidiary Body for Implementation
SFD	State Forest Department
SFI	Sustainable Forestry Initiative
SFM	Sustainable Forest Management
SIDA	Swedish International Development Cooperation Agency
SMF	Sustainable Management of Forest
SPWD	Society for Promotion of Wasteland Development
TEEB	The Economics of Ecosystem and Biodiversity
TEV	Total Economic Value
TNC	The Nature Conservancy
TOT	Training of Trainers
TTM	Tools, Techniques, and Methods
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Program
UNDESA	United Nations Department of Economic and Social Affairs
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
UNFF	United Nations Forum on Forests
UNODC	United Nations Office on Drugs and Crime
USFS	United States Forest Service
USAID	United States Agency for International Development
USA	United States of America
USEL	Universal Soil Loss Equation
VDF	Very Dense Forest
VPA	Voluntary Partnership Agreements
WCED	World Commission on Environment and Development
WCO	World Customs Organization
WP	Working Plan
WPC	Working Plan Code
WPA	Wildlife (Protection) Act
WPO	Working Plan Officer
WRI	World Resources Institute
WWF	World Wildlife Fund

ABOUT FOREST-PLUS

The Partnership for Land Use Science (Forest-PLUS) program is a five-year initiative between USAID/India and the Government of India (GOI). Forest-PLUS contributes to USAID/India's Development Objective of accelerating India's transition to a low emissions economy by providing technical assistance to develop, demonstrate, and institutionalize forest management practices. These practices reduce greenhouse gas emissions (GHG) from forested landscapes; increase sequestration of atmospheric carbon in forests; protect forest biodiversity health; and protect and/or enhance forest-based livelihoods, forest ecosystem services, and other social contributions of forests in India. Forest-PLUS will help position India to participate in any final REDD+ (reducing emissions from deforestation and forest degradation) mechanism.

Forest-PLUS develops improved tools, techniques, and methods (TTMs) for forest management with climate change mitigation benefits. Forest-PLUS Component I develops TTMs by facilitating scientific exchange and technical cooperation between India and the United States.

Forest-PLUS Component II deploys these TTMs in pilot landscapes to demonstrate and validate their effectiveness. Across both components, Forest-PLUS develops and deploys TTMs in three general technical areas:

- Ecosystem approach to forest management (EAFM),
- Scientific data acquisition and analysis, and
- Forest governance and institutional structures.

Forest-PLUS includes capacity-building and communications programs that develop and deploy TTMs for training and public awareness in all three technical areas. Forest-PLUS coordinates its work with the Ministry of Environment, Forests, and Climate Change (MoEFCC) and state forest departments (SFDs).

PREFACE

The economic position of the forestry sector in India is changing. Once Indian forests were managed to maximize sustainable timber yield. Indian Forest Department officials at all levels are trained in traditional forest management techniques that were introduced in India during the mid-nineteenth century. These techniques are based on sound technical principles with a central focus on sustained yield of forest products (mostly timber). The forest management techniques have not incorporated the management of the ecosystems that the forests support. The practice of forestry management is changing throughout the world with a growing emphasis on sustainable forestry management (SFM). Forest management with a focus on ecosystem sustainability—Ecosystem-Based Forest Management (EBFM or EBM) or Forest Ecosystem Management (FEM)—is an evolving concept and approach, and is finding increasing acceptance throughout the world.

Forests are recognized not only for providing timber, but also for contributing to India's political and economic stability by providing services such as climate change mitigation; water for hydropower, drinking, and agriculture; and habitat for fauna and flora. Whether Indian forests contribute to a better quality of life or contributions are derived through the harvesting of forest products or ecosystem services, these contributions will be greater and more stable if the ecosystem processes that maintain forest diversity, productivity, and resilience are in a healthy state. An ecosystem approach to forest management (EAFM) recognizes this and its overriding objective the protection, restoration, and enhancement of forest ecological health. EAFM is based on modern ecological understanding and adaptive management fed by a stream of timely and accurate field data.

The Forest-PLUS training program has established an EAFM curriculum committee composed of Indian experts supported by external experts from the US. The committee has developed a training program on EAFM for India. This training program will continue through 2017, and the curriculum, which consists of a training syllabus, this reading material, and presentation slide decks, will be made publically available thereafter for use in India.

OBJECTIVES

The objective of the training program is to enable for forestry professionals, state forest department front line field staff, village communities, civil society and other stakeholders to acquire an understanding and skills to shift from traditional forest management to a holistic and more proactive integrated forest management. This new management is based on ecological principles to ensure sustainable flow of goods and services to society from managed ecosystems.

After completing the training program, participants will understand EBFM and have the tools to initiate and implement forestry activities based on that approach. Participants will also gain a better understanding of EBFM consistent with the India

National Forest Policy, National Working Plan Code, laws relating to forests, and India's commitment to global community as a Party to the United Nations Framework Convention on Climate Change (UNFCCC), Paris Agreement on Climate Change (2016), Convention on Biological Diversity (CBD), and United Nations Convention to Combat Desertification.

We would like to thank USAID and the American people for making this exchange of technical information and expertise feasible. The training material provided in this compendium is a combined contribution of forest, soil, water, and biodiversity experts from India and the United States. The contributors bring hands-on experience from the United States, India, Africa, Asia, and South America.

NOTES ON THE READING MATERIAL

This reading material is structured around six modules, each of which contains a number of lectures. The first module consists of two lectures, and contains materials that introduce the reader to the modern history of forest management, globally and in India, and on the evolution and current discourse on EAFM. The second module focuses on ecology and its implications for forest management. The first lecture gives an overview of ecology and forest ecology; the second explains forest management at scale using a landscape approach to planning and management. The last lecture discusses forest soils, their health, and their management considerations from an EAFM perspective. In the third module, four lectures deal with the management of forests for ecosystem services, including valuation, and management for biodiversity and clean reliable water. While climate regulation is in itself an ecosystem service, this material has a separate module on climate change and forest management, Module 4, which includes a lecture on climate change mitigation and adaptation through forests. Recognizing that the primary audience for this material is practitioners of forest management, Module 5 gives five separate approaches to implementing EAFM in India's forest. The concluding module and lecture is on the governance of forest resources in India.

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R.D. Jakati on Lecture 13: Incorporation of an Ecosystem Approach to Forest Management in the Working Plan System in India, and Lecture 15: Ecosystem Management - Uneven Aged, Mixed, and Close to Nature Forestry.

MODULE 1: EAFM IN INDIA

As humans interact with their environment, society's priorities for forests will necessarily change over time. This module first charts the history of forest policy priorities and its interaction with development globally, and then reviews how political priorities for forests have shifted in India from the British Colonial period until present day.

With that socio-political context understood from the first lecture, the second lecture covers recent management priorities for forests in India, compares and contrasts EAFM with sustainable forest management, and concludes with the added value of EAFM as compared with sustainable forest management.

LECTURE 1: OVERVIEW AND HISTORICAL PERSPECTIVE OF FOREST MANAGEMENT

This lecture covers the following:

1A An overview of forest management

- Global issues
- Environment/ conservation
- Sustainable development
- India specific

1B Historical perspective from colonial era

- Post-independence
- Current state of management

1A ENVIRONMENT, DEVELOPMENT AND COMMUNITY FORESTRY: A GLOBAL HISTORICAL PERSPECTIVE[1]

1A.1 Introduction

This paper explores the global history of narratives related to environment and development, and how these narratives have influenced the global forestry sector. The paper is divided into four broad sections. The first section explores the intellectual roots of sustainable development, which originated from the confluence of environment and development narratives. The international experience with community-based conservation (CBC) and community-based forest management (CBFM) approaches is presented in the second and third sections, respectively. The key ongoing international debates related to community-based natural resource management (CBNRM) are discussed in the concluding section.

1A.2 Intellectual Roots of Sustainable Development[2]

The intellectual roots of sustainable development lie in the evolving narratives on environment and development. The objective of this section is to explore the evolution of key ideas within both these narratives that ultimately led to the emergence of CBC/CBFM.

1A.2.1 Concern over Environment

The interest in and concern over environment has a long history in both Western and Eastern thought (Glacken, 1967; Guha, 2000). However, the roots of modern environmentalism can be traced to 18th and 19th century Europe (especially England) and the United States, where ecology emerged as a holistic way of looking at “nature’s economy” (Worster, 1994).

The initial ideas were developed by a few concerned individuals, who drew attention to environmental issues through their publications. Two books are noteworthy—*The Natural History of Selborne* by Gilbert White (1788; England) and *Man and Nature* by George Perkins Marsh (1864; United States) (McCormick, 1989). The key idea that emerged from White’s work was the need to adopt a simple lifestyle for peaceful coexistence with nature (McCormick, 1989; Worster, 1994). Marsh’s work highlighted

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[1] Extracted from Saigal, 2012.

[2] The narratives are studied from the perspective of CBC/CBFM rather than attempting to provide historical accounts. For more detailed historical accounts of these narratives, see, for example, Pepper, 1984; McCormick, 1989; Martinussen, 1997; Guha, 2000; Adams 2004, 2009.

the adverse impacts of human activities on natural environment and challenged the myth of inexhaustibility of natural resources (Marsh, 1864).

Although a beginning had been made in the 18th century, it was in the next century that the concern for the environment broadened from individuals to include special interest groups and even some governments. It was during this time that the first legal measures to protect environment against polluting industrial emissions were introduced in England (McCormick, 1989). A number of ideas were developed in the United States that had a major influence on conservation (and CBNRM) subsequently (Worster, 1994). A key idea was the notion of *wilderness*—an area "untrammeled by man"[3]—that was popularized through the work of John Muir (founder of Sierra Club) and others (Guha, 2000; see also Nash, 1967). This, in turn, led to development of the concept of national parks, the first of which were established in the United States in the second half of the 19th century (Adams, 2004). The influence of this idea can be gauged from the fact that by the beginning of the 21st century, over one-ninth of the terrestrial surface of the earth was covered under the protected area network (Mulongoy and Chapa, 2004).

This period also saw the beginning of a long-drawn debate between the proponents of *preservation* and *conservation*. Epitomized by John Muir of the Sierra Club, the former group emphasized moral imperative of nature preservation. The latter group adopted a more utilitarian approach. Gifford Pinchot—founder of the United States Forest Service—was one of its main champions (McCormick, 1989; Guha, 2000; Adams, 2004; see also Worthington, 1983). Although these terminologies have changed over the period, the debate continues to echo in discussions about *fortress conservation* and *sustainable use* that have direct relevance to CBNRM (see, for example, Kramer, van Schaik, and Johnson, 1997; Terborgh, 1999; Bruner, Gullison, Rice, and da Fonseca, 2001; Peres and Zimmerman, 2001; Hutton and Leader-Williams, 2003).

Colonialism has also played an important role in shaping ideas about environment, especially preservation of species. Although colonialism negatively impacted local flora and fauna in many cases, especially through introduction of exotics (Crosby, 2004), the colonial powers also introduced many conservation measures. The driving force behind these measures was often the colonial hunter, who was keen to preserve native wildlife, especially "game"" animals (Adams, 2004). It has also been argued that there was no simple one-way flow of conservation ideas from the metropoles to the colonies. In fact, many different ideas and experiences from the colonies, including those of native people, played a key role in shaping the emerging

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[3] From the definition provided in The Wilderness Act (1964) of the United States (Source: http://www.wilderness.net/index.cfm?fuse=NWPS&sec=legisAct#2, accessed 28.10.2010).

environment and conservation thinking (Grove, 1990, 1995). Many of these ideas still play an important role in contemporary debates about conservation (Adams, 2003). The most dominant of these ideas is preservation of species (Ehrlich and Ehrlich, 1982; Leakey and Lewin, 1996; Norton, 1986; Myers, Mittermeier, Mittermeier, da Fonseca, and Kent, 2000; Salafsky Margoluis, Redford, and Robins, 2002; Wilson, 2002; Adams, 2004; Millennium Ecosystem Assessment [MEA], 2005).

Although concern for the environment had broadened during the 19th century beyond a select group of individuals, it was only in the 20th century that it became a major topic, so much so that it has even been called the "ecological century" (Worthington, 1983). The first international environment-related organization made its appearance at the beginning of the century when the Society for the Preservation of the Wild Fauna of the Empire was founded in 1903,[4] although a few national-level organizations already existed (McCormick, 1989; Adams, 2004). The level of internationalism increased considerably after World War II ended, primarily due to two reasons: development of the United Nations system, and decolonization. A number of major international organizations emerged then, the most important of which were the International Union for Conservation of Nature (IUCN) in 1948 and World Wildlife Fund (WWF) in 1961 (Worthington, 1983; Holdgate, 1996; Adams, 2004). The United Nations Scientific Conference on the Conservation and Utilization of Resources held in 1949 became one of the key events that placed the environment firmly among other important international issues (McCormick, 1989).

While environment (including conservation) had found a place on the international agenda, these concerns had remained mostly confined to scientific, professional, and policymaking circles. This, however, was about to change. People in the industrialized countries in the North had started to directly experience environmental degradation in the form of air and water pollution. There was also a growing concern over nuclear contamination (McCormick, 1989; Worster, 1994). It has been argued that the first images of Earth taken from space sensitized people regarding our planet's finite size and fragile appearance (Worster, 1994).

A number of alarmist books were published in the post-war period that highlighted the need for action on a planetary scale.[5] However, two books caught people's imagination. The first was the 1949 classic *A Sand County Almanac* by Aldo Leopold, containing a poetic description of the passing seasons. Leopold introduced a simple yet powerful idea of "land ethic:"

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[4] Later renamed as Fauna & Flora International.

[5] The major such books were *Our Plundered Planet* and *The Limits of the Earth* by Fairfield Osborn, and *Road to Survival* by William Vogt (McCormick, 1989; Worster, 1994).

> *A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise* (Leopold, 1949, pp. 224-225).

The second was *Silent Spring* by Rachel Carson in 1962, which poignantly brought home the horrors of widespread and indiscriminate use of pesticides on natural environment as well as human health (Carson, 2002). By the 1960s, environmentalism had become a mass movement (Guha, 2000).

It has been argued that the greater concern over environment witnessed in the global North in the decades following World War II was a direct result of increasing affluence, which shifted people's focus from material needs to quality-of-life issues (Inglehart, 1977; see also Galbraith, 1958). This argument has major implications for CBNRM as it almost precludes the prospect of environmentalism among the poor, sometimes referred to as "too-poor-to-be-green" thesis (Martínez-Alier, 1995; Guha, 2000). However, a number of examples of "environmentalism of the poor" have been documented that challenge this post-materialistic thesis (Martínez-Alier, 1995; Guha and Martínez-Alier, 1997; Guha, 2000). In addition, it has also been pointed out that in many traditional societies, stewardship of natural resources is nothing new and is based on "traditional ecological knowledge" that has been passed down through generations (Berkes, 1999).

Alongside environmental degradation, another key concern emerged during the late 1960s and early 1970s. This was about resource degradation and depletion, especially in the context of a rapidly growing population (Hardin, 1968; Ehrlich, 1971; Commoner, 1972; Meadows, Meadows, Randers, and Behrens, 1972). A number of "prophets of doom" (McCormick, 1989, p. 69) emerged that painted a bleak picture of the future. Even a "blueprint for survival" (Goldsmith, Allen, Allaby, Davoll, and Lawrence, 1972) was issued by the newly launched journal, *The Ecologist*, to enable the human race to live in harmony with nature (Pepper, 1984; McCormick, 1989; Worster, 1994; Guha, 2000). Some more radical ecological ideas such as "deep ecology" also originated around this time (Naess, 2008).

As environmental consciousness rose to unprecedented levels among the public; measures such as the enactment of environmental legislations were taken in many countries. Important international initiatives (e.g., International Biological program and subsequently Man and Biosphere program) were also launched (Worthington, 1983). However, it was the United Nations Conference on Human Environment and Development, held in Stockholm in 1972, that became instrumental in placing environment at the forefront of the intergovernmental agenda. The conference resulted in creation of the United Nations Environment Program (UNEP) (McCormick, 1989). It heralded the beginning of the "Age of Ecology" (Worster, 1994, p. ix) and environment has remained firmly on the intergovernmental agenda since then, at least at the rhetorical level.

The increased concern for environment led to signing of a number of international agreements (Carter, 2001) and even establishment of a Global Environment Facility in 1991 to fund environment-related projects in the global South (Chatterjee and

Finger, 1994). Many national and local initiatives were also launched (Dryzek, 1997; Carter, 2001). Another key milestone was the United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro in 1992. Although it did not bring about a radical shift in thinking (Chatterjee and Finger, 1994), it helped to mainstream many environment-related ideas such as biodiversity conservation, climate change, polluter pays, and the precautionary principle.

1A.2.2 Imperative of Development

The reasons for unequal distribution of wealth (and poverty) among different nations (and social groups) have been a subject of interest at least since the time of Adam Smith (Sachs, Mellinger, and Gallup, 2001). "Development" has often been the tool proffered to address this imbalance. However, development is an ambiguous concept easily amenable to a precise definition (Hettne, 1990; Thomas, 2000a; Power, 2003). This ambiguity is in part due to different concepts for which the same term is employed: 1) normative (vision of a desirable society), 2) immanent (historical process of social change), and 3) intentional (deliberate efforts aimed at improvement) (Hettne, 1990; Cowen and Shenton, 1996; Thomas, 2000a). In spite of its ambiguity, development has been one of the dominant global ideas of the post-World War II period.

The modern idea of development originated during the early industrial capitalism in Europe (Cowen and Shenton, 1996). By the 19th century, its core thesis of progress as a linear phenomenon based on Western capitalism had been established firmly (Watts, 1995). However, the main intentional development project in the global South, which is most relevant to CBNRM, started after World War II.

Most commentators date the formal beginning of this "big D" development project (Hart, 2001) to January 20, 1949 when U.S. President Harry S. Truman delivered his inaugural address. The following extract from his speech captures the essence of this development project:

> *[W]e must embark on a bold new program for making the benefits of our scientific advances and industrial progress available for the improvement and growth of underdeveloped areas. More than half the people of the world are living in conditions approaching misery...Their poverty is a handicap and a threat both to them and to more prosperous areas...we should make available to peace-loving peoples the benefits of our store of technical knowledge...And...we should foster capital investment in areas needing development.*[6]

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[6] Source: http://www.trumanlibrary.org/publicpapers/index.php?pid=1030&st=&st1= (accessed 09.11.2010).

Truman's speech ushered in the "era of development" (Thomas, 2000b). In his speech, Truman urged other countries that were industrially and technologically advanced to join the United States in this global development effort.

A large number of people in the "underdeveloped" areas in the global South were believed to be trapped in the vicious circle of poverty, which was considered a threat not only to them but also to more prosperous countries in the global North. It was believed that lack of capital was one of the main reasons for the continued underdevelopment, and if some initial capital was injected from outside, the vicious circle could be broken (see Bauer, 1976 for an outline of the thesis and its critique). Great faith was also placed in science and technology, not just for material advancement but as a modernizing force as well. According to Escobar (1995, p. 36) "technology was theorized as a sort of moral force that would operate by creating an ethics of innovation, yield, and result." There was also a renewed faith in the role of state and public intervention in economy, perhaps due to prevailing influence of Keynesianism at the time (Escobar, 1995).

As the global development project got underway, a large number of international organizations, including the Bretton Woods institutions and the United Nations, got involved (Watts, 1995). A number of statistical exercises were carried out that resulted in country league tables based on criteria such as per capita income (Escobar, 1995). Focus areas in the 1950s and 1960s—termed as the "golden years" of development (Hewitt, 2000)—were economic growth and modernization (Martinussen, 1997). Largely based on these criteria, an evolutionary scale of development was imagined with subsistence-oriented traditional societies at the lower end and mass-consuming industrial societies at the other (Rostow, 1990). Traditional societies were expected to imitate key features of industrialized societies through the process of development (Martinussen, 1997). As the state was expected to play a key role in this process, the bulk of development effort was state-centered (Watts, 1995).

However, the actual development experience was dismal in most areas of the global South (Hettne, 1990). The initial challenge to the global development project came in the form of dependency theory that questioned the stages-of-growth hypothesis (Martinussen, 1997). But soon the fundamental ideas of economic growth and modernization themselves came into question (see, for example, Seers, 1979; Norgaard, 1994). In 1979, Dudley Seers of the Institute of Development Studies, Sussex, showed in a simple yet elegant manner that per capita income was a poor indicator of development. He devised a simple litmus test for development:

> *The questions to ask about a country's development are therefore: What has been happening to poverty? What has been happening to unemployment? What has been happening to inequality? (Seers, 1979, p. 12).*

The World Bank, one of the main promoters of development, also realized by the early 1970s that economic growth had not been able to alleviate poverty in the global South (Rahnema, 1992). A senior staff member noted:

> *It is now clear that more than a decade of rapid growth in under-developed countries has been of little or no benefit to perhaps a third of their population...the very idea of aggregate growth as a social objective has increasingly been called into question (Chenery, 1974, p. xiii).*

By the early 1970s, questions had begun to be raised about the efficacy of foreign aid (Bauer, 1976). Subsequently, the state-centered approach, which had dominated development, was also questioned (Lal, 1983). It was also becoming clear that the economic growth model had serious adverse impacts on the environment and natural resources (Mishan, 1967; Schumacher, 1973; Daly, 1977).

Continued widespread global poverty, in spite of decades of development effort, led to a widely shared feeling that development thinking (theory and praxis) was facing a "crisis" or an "impasse" (Aseniero, 1985; Hettne, 1990; Booth, 1993; Schuurman, 1993; Booth, 1994; Watts, 1995; Leys, 1996). The sense of crisis was particularly felt in the 1980s, which was termed as the "lost decade" for development, mainly due to debt crises in many southern countries (Hewitt, 2000). It led to calls to abandon development itself (Sachs, 1992; Escobar, 1995), which was seen as a "nomalizing, deeply destructive discursive formation emanating from 'the west'..." (Hart 2001, p. 654). Sachs (1992, p. 1) felt that by the early 1990s it was time to write the obituary of development:

> *The last 40 years can be called the age of development. This epoch is coming to an end. The time is ripe to write its obituary.*

However, alongside these more radical assessments of development, a number of reformist ideas had also started emerging from the 1970s onward. These ideas did not reject development altogether but suggested an alternative path. These approaches were termed as "another development" (Cardoso, 1977; Nerfin, 1977a) or "alternative development" (Hettne, 1990; Martinussen, 1997). The essential features of "another development" required it to be 1) *need-oriented* (meeting basic needs, material and non-material); 2) *endogamous* (stemming from the heart of each society—no universal model); 3) *self-reliant* (relying primarily on own strengths and resources, especially at the local level); 4) *ecologically sound*; and 5) *based on structural transformations* (related to social and economic relations and power structure) (Nerfin, 1977b). Alternative development mainly focused on the "third system," that is people rather than state or market (Friedmann, 1992). A number of other related ideas emerged from the 1970s to 1990s that contributed to reforms in development theory and practice. Prominent ideas from among these are discussed below briefly.

One influential idea was about "basic needs." which was actively promoted by the International Labor Organization in the mid-1970s (Esteva, 1992; Martinussen, 1997). It aimed to tackle poverty directly rather than indirectly through supposed "trickle down" benefits from economic growth (Stavenhagen, 1977; Hettne, 1990).

Another major idea was about "participation" that emphasized involvement of people, especially of disadvantaged groups such as indigenous peoples and women, to

improve development planning as well as implementation. A great emphasis was also placed on the involvement of civil society groups such as grassroots voluntary organizations and nongovernment organizations (NGOs), which came to be known as “the Third Sector” (Chambers, 1983; Cohen and Arato, 1992; Hulme, 1994; Blair, 1997; Clark, 1997; Hulme and Edwards, 1997a, 1997b; Martinussen, 1997). Gran (1983) advocated adopting “participatory development” and emphasized the need for empowerment of citizens if development was to be meaningful, effective, and sustainable. The programs that followed a bottom-up “learning process” approach rather than blueprint approach were deemed to be more effective (Korten, 1980; see also, Friberg and Hettne, 1985). It was advocated that even development research was best carried out through participatory methods (Edwards, 1989; Manzo, 1991).

“Decentralization” was another key idea that came out of the belief that some tasks were best done at the local level,[7] especially in democratic settings (Rondinelli, McCullough, Johnson, 1989; Moore, 1993; Martinussen, 1997). Efforts were made to involve local institutions owing to perceived benefits such as greater efficiency of resource use due to their location-specific knowledge, better monitoring and inclusion of adaptive changes, and improved conflict management (Uphoff, n.d.).

Yet one more idea that had a considerable impact on development thinking was that of “human development,” which took center stage in the 1990s. The United Nations Development Program (UNDP) started publishing the *Human Development Report* from 1990 onward. It moved beyond narrow interpretations of development in terms of per capita income, and defined human development as “a process of enlarging people’s choices” (UNDP, 1990, p. 10). The work of influential thinkers such as Amartya Sen also showed that development was best seen in terms of expansion of “real freedoms that people enjoy” (Sen, 1999, p. 3).

All these ideas led to redefinition of development goals and changes in the means of achieving development. These ideas led to the emergence of people-centered development that got further impetus following the World Summit on Social Development held in Copenhagen in 1995.

1A.2.3 Confluence of Environment and Development Narratives

Linking of environment and development problems is not new, but serious attempts at combining the two issues started from the 1970s onward (Martinussen, 1997). The 1972 Stockholm Conference played an important role in bringing the debate on these issues on a common platform through its emphasis on *human* environment (Ward and Dubos, 1972; McCormick, 1989). The link between environment and development was articulated even more clearly in the *Cocoyoc Declaration* that

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[7] From the perspective of efficiency, effectiveness, and responsiveness.

came out of another United Nations conference in 1974: “We recognize the threats to both the ‘inner limits’ of basic human needs and the ‘outer limits’ of the planet’s physical resources”.

The growth of alternative development strategies in the 1970s played an important role in bringing environmental issues into the development narrative but the real push for the link came from the environmental movement. One of the key documents that highlighted the importance of sustainability of development was the *World Conservation Strategy* brought out by IUCN with support from UNEP and WWF (Redclift, 1992; Adams, 2009). The focus of this document was, however, on ecological sustainability, and its engagement with development issues was mostly strategic. It was only with the publication of the report of the World Commission on Environment and Development (*Brundtland Report*) in 1987 that environment and development issues began to be dealt with in an integrated manner (Jacobs, 1991; Adams, 2009). The Brundtland Report also popularized the concept of sustainable development through its now famous definition that it is “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development [WCED], 1987).

Although the concept of sustainable development lacked conceptual clarity (Lélé, 1991; Pearce, 1993; Beckerman, 1994) and led to a vigorous academic debate (Beckerman, 1995; Daly, 1995; Jacobs, 1995), its beguiling simplicity and offer of *win-win* solutions appealed to those concerned with the environment as well as those interested primarily in development.

The concept gained wide popularity after UNCED in 1992. The two main outputs of UNCED, *Agenda 21* and the *Rio Declaration on Environment and Development*, focused primarily on sustainable development (Grubb, Kock, Munson, Sullivan, and Thomson, 1993; Carter, 2001; Adams, 2009). The United Nations even established a Commission on Sustainable Development to follow up on implementation of Agenda 21 (Chatterjee and Finger, 1994). The theme of the *World Development Report 1992* published by the World Bank was also sustainable development. It noted:

> *Economic development and sound environmental management are complementary aspects of the same agenda. Without adequate environmental protection, development will be undermined; without development, environmental protection will fail (World Bank, 1992).*

In the report, the World Bank suggested a range of policy and market measures to ensure environmental values and costs were properly reflected in the economic activities (World Bank, 1992; see also Pearce, Markandya, and Barbier, 1989; Ekins, 2000). A number of studies indicated that the cost of environmental degradation was very high even for the economy (Cairncross, 1991; Panayotou, 1993; Pearce and Warford, 1993). Considerable attention was then given to increasing the environmental efficiency of economic activities (Jacobs, 1991; Stagl, 1999).

The concept of sustainable development came to define the environment and development narratives of the 1990s. It got the support of governments, NGOs, and even businesses (see Schmidheiny, 1992). The World Summit on Sustainable Development held in Johannesburg in 2002 demonstrated the continuing dominance of this concept in the new millennium. The main output of this summit, *Johannesburg Plan of Implementation*, reiterated the global commitment to sustainable development (United Nations Department of Economic and Social Affairs [UNDESA], 2002) That a link between environment and development had been firmly established was demonstrated when the United Nations announced the Millennium Development Goals. "Environmental Sustainability" was included as one of the eight global *development* goals.[8] In the 21st century, environmental issues came to "affect virtually all aspects of development policy" (Woodhouse, 2002, p. 136).

It is clear from the above account that the genealogy of the philosophy of CBNRM can be traced to the marriage between the environment and development narratives. The international experience with CBNRM approaches in the forestry sector is discussed next.

1A.3 Experience with Community-Based Approaches in the Forestry Sector

Most CBNRM initiatives are embodiment of the *win-win* solution promised under sustainable development. In the forestry sector, these could be broadly categorized as either CBC or CBFM depending on whether the starting point is conservation or livelihoods. Although the focus of this dissertation is a CBFM project, it is important to understand the wider context of community involvement in forestry, which includes both CBC and CBFM. The key feature of these initiatives is the involvement of local people, who protect or manage the resource while satisfying their livelihood needs. Pretty and Guijt (1992, p. 22) call this "primary environmental care." The reasons for growing emphasis on the involvement of local people are varied, ranging from pragmatic motives such as their proximity to and impact on the resource to more ideological concerns such as protection of their rights and culture (Brown, 1999). In the past two decades, considerable field experience has been accumulated with both CBC and CBFM initiatives. Key aspects of this experience are discussed below.

1A.3.1 Experience with Community-Based Conservation

Three main strategies have been employed under CBC: 1) compensation (or substitution); 2) promotion of alternative livelihood opportunities; and 3) creation of local people's direct stake in conservation (Brandon and Wells, 1992; MacKinnon, 1998; Wilshusen, Brechin, Fortwangler, West, 2003; Turner, 2004a). While the first

[8] Source: http://www.un.org/millenniumgoals/ (accessed 12.11.2010).

two approaches support preservation, the third reflects a conceptual shift from preservation to sustainable use (Western and Wright, 1994; Brandon, Redford, Sanderson, 1998; Hutton and Leader-Williams, 2003). This approach often also reflects neo-liberal thinking because of greater emphasis on the role of markets. It has, therefore, been termed as “new conservation” (Hulme and Murphree, 1999).

Compensation or substitution is a strategy followed to offset loss (or opportunity cost) incurred by local people when they are denied access to forest resources (Wells, Brandon, Hannah, 1992). This loss could be substantial relative to household income (Ferraro, 2002). Field experience indicates that although compensation or substitution limits local people’s economic loss, it often does not cover their entire opportunity cost. For example, while cash and material benefits did help in improving relations between park authorities and the local people in the Lake Mburo National Park in Uganda, these were considered minute as compared to the “value of cultivation and grazing potentials denied” (Hulme and Infield, 2001, p. 127).

Further, even the limited compensation or substitution benefits that are provided are also often poorly targeted (Bell, 1987). In any case, many resource extraction practices (e.g., hunting) have a strong cultural value in addition to their economic value and thus cannot be easily compensated or substituted (Kleymeyer, 1994; Johnson, 2004). The experience of the Ujirani Mwema program in the Tarangire National Park in Tanzania also bears this out (Kangwana and Mako, 2001). Thus, this strategy may not succeed in its main objective of eliminating local people’s antagonism toward conservation measures. The other key challenges in implementing this strategy lie in addressing practical questions such as “*who* should benefit, by *how much*, and for *how long*” (Wells *et al*., 1992, p. 30, emphasis in original).

The second strategy of promoting livelihood alternatives has been mainly implemented through integrated conservation and development projects (ICDPs), which attempt to reconcile “management of protected areas with the social and economic needs of local people” (Wells *et al*., 1992, p. ix). The objective is to reduce local people’s dependence on destructive practices in the conservation area by promoting a range of alternative livelihoods (see Dugelby and Libby, 1998 for an illustrative list). The underlying assumption is that once alternative livelihood options are available, local people will voluntarily refrain from exploiting forest resources that are of conservation interest (Wells *et al*., 1992). Another assumption is that reduction in poverty will reduce pressure on forests (Brandon, 1998).

The experience with this strategy has been mixed (McShane, 2003). A review of early experience of 23 projects in Africa, Asia, and Latin America indicated that although there was generally a positive impact on local livelihoods, it did not always translate into improved conservation (Wells *et al*., 1992). One reason for this was that most projects had a short time horizon of a few years while most livelihood enhancement strategies (e.g., soil conservation or agroforestry) needed a much longer duration to start making a substantive impact (Stocking and Perkin, 1992). Further, the projects addressed only local livelihoods, though in reality non-local

aspects such as migrant work constituted an important component of the livelihood strategies of many rural households (Turner, 2004a). Another reason was that conservation attitudes as well as behaviors of people were not affected by economic factors alone but by a combination of economic, social, and cultural factors (Holmes, 2003; Bernard and Kumalo, 2004). The key reason, however, was that major threats to forests and biodiversity often did not arise locally.[9] Wells *et al*. (1992, p. xi) noted:

> *ICDPs cannot address the underlying threats to biological diversity. Many of the factors leading to the erosion of biodiversity and the degradation of protected natural ecosystems in developing countries originate far from park boundaries.*

The implementation experience indicated a few other issues with this strategy as well, such as reduced focus on conservation and adverse conservation impact of certain development interventions. The field experience of the East Usambaras Agricultural Development and Environmental Conservation Project in Tanzania showed that a disproportionately large amount of project time was spent on development activities, thus taking the project's attention away from conservation. Further, some activities such as road improvement increased illegal logging (Stocking and Perkin, 1992).

The experience of projects such as the Luangwa Integrated Resource Development Project in Zambia highlighted the difficulty of integrating conservation and development objectives (Wainwright and Wehrmeyer, 1998; see also Adams *et al*., 2004). Even in cases where such projects were relatively successful, sustaining the effort after the completion of the project remained a major challenge. Barrett and Arcese (1995) have raised a number of conceptual issues regarding the ICDP approach. Their key argument is that there is likely to be a mismatch between human needs and benefits that could be made available through natural resources such as wildlife. For example, human needs are likely to be greater in drought years but that is also the time wildlife would need maximum protection. Further, the needs are likely to grow as human population increases. It is not unusual for the project itself to act as a "development pole" that attracts migrants and increases resource demand (Brandon and Wells, 1992; Wilshusen *et al*., 2003).

Apart from project-related issues, long-term outcomes of ICDPs are also dependent on larger political and economic forces at play. This was vividly demonstrated in case of a CBC project based on Tiwai Island (Moa River) in Sierra Leone. The project was established after protracted negotiations with the local people but the site had to be abandoned when civil war erupted in the project area (Oates, 1999). There was a similar experience in the Amboseli National Park in Kenya, where a

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[9] Perverse subsidies are among major threats (Myers, 1998).

development program under implementation with the Maasai people collapsed due to various national-level issues (Western, 1994). Overall, the experience with the livelihood promotion strategy does not seem to be very encouraging, especially in terms of conservation outcomes. Some authors have called for decoupling of development and conservation goals (Sanderson and Redford, 2004).

The third strategy focuses on creating local people's direct stake in the resource by promoting sustainable use, both extractive (e.g., sport hunting) and non-extractive (e.g., tourism). The role of market is generally emphasized and the neo-liberal argument of forest and wildlife having to *pay its way* often underpins this strategy (see Western, 1994; Kangwana and Mako, 2001).

Zimbabwe's Communal Areas Management Program for Indigenous Resources (CAMPFIRE) is one of the most well-known sustainable use programs in the world. Major legal reforms were undertaken in the 1980s to allow sharing of wildlife revenue with rural district councils (RDCs) (Metcalfe, 1994; Murombedzi, 1999). During 1989-2001, CAMPFIRE generated over USD 20 million for the participating communities, 89 percent of which came from sport hunting (Frost and Bond, 2006). Although this revenue figure looks impressive, an analysis of data up to 1996 showed that the median benefit per household was only USD 19.4 in 1989, which further declined to USD 4.49 in 1996.[10] Thus, actual benefit at the household level was meager and a fraction of the total household income (Bond, 2001). To put it in perspective, it was less than the value of a goat even in most promising wards (Magome and Fabricius, 2004).

Several important lessons emerged from the CAMPFIRE experience. It was shown that such programs could help in extending conservation beyond the boundaries of protected areas. Due to implementation of CAMPFIRE, Zimbabwe's conservation area increased from around 12 percent (protected area network) to 33 percent by the turn of the century (Duffy, 2000). However, it also became clear that significant wildlife revenue could only be generated in a few areas where adequate numbers of desirable species were present (Bond, 2001). Further, even in such high potential areas (usually with low human population densities), the situation could change rapidly due to migration. For example, Masoka was one of the highest revenue earning wards under CAMPFIRE but it also had a very high inward migration rate (Murombedzi, 1999). Another key lesson was that identifying the appropriate community level was critical. The RDCs, though representing local communities, taxed them at a rate close to 50 percent (Bond, 2001). The results obtained were much better in the Lupande program in Zambia under which wildlife revenue was directly passed on to democratically elected village-level institutions (Child, 2004). A

[10] This decline was due to extension of the program to wards with lower wildlife potential.

major lesson from the program was recognition of the importance of local people's roles. Under CAMPFIRE, though wildlife revenues were shared, the local people did not formally participate in management and had only limited control over benefits generated (Murombedzi, 1999). This was considered the program's biggest weakness:

> *Attempts to foster people's participation in conservation through the distribution of revenues from resource utilization without devolving rights to resources to local people will not necessarily improve local stewardship of resources, regardless of the extent of the revenues that are distributed (Murombedzi, 1999, p. 289).*

A number of other projects and programs based on sustainable use strategy have also been implemented. Their experience provides further insights about the strategy. The efficacy of the strategy was demonstrated in Namibia's conservancy approach (see Nuding, 2002; Nott and Jacobsohn, 2004) that managed to bring down the incidence of illegal hunting. For example, not a single incident of poaching was reported from the Grootberg Conservancy (formed in 1996) during 1999 and 2000 (Nuding, 2002). However, the experience of Zambia's Administrative Management Design (ADMADE) program underlined the need for careful analysis of outcomes. In this case, rather than eliminating unauthorized hunting, the program only shifted hunting pressure to smaller (less intensively monitored) animals (Gibson and Marks, 1995). The experience of such programs also indicated that it is important to consider not just benefits but also costs imposed by wildlife to understand its overall economic impact on local people (Emerton, 2001; Turner, 2004a). Further, projects such as the Tchumo Tchato in Mozambique have shown economics is not the only factor that determines local people's interaction with the resource. Other factors such as cultural practices, social status, and community identity are also important (Gibson and Marks, 1995; Johnson, 2004).

A number of insights regarding the practical implementation aspects are also available. These relate to the potential conflict between traditional leaders (chiefs) and new community institutions created under CBC projects and programs (Child, 2004; Nott and Jacobsohn, 2004; Cousins and Kepe, 2005; see also Hara, 2004); difficulty in building the capacity of local community groups to undertake entrepreneurial activities (Boggs, 2004); and inadequate time horizon of donor-funded projects (Johnson, 2004).

Some more basic issues with the sustainable use strategy have also been brought out. Murombedzi (2003) has argued that this strategy actually limits local people's access to communal lands and reinforces colonial racial and class patterns of resource use. Berkes (2004) has discussed some basic ecological challenges (such as non-linearity). Hutton and Leader-Williams (2003) have shown that some resources (e.g., crocodiles) have greater potential for sustainable use than others. The experience with the conservation of big leaf mahogany (*Swietenia macrophylla*) in South America has indicated that the strategy may not work at all for some resources (Gullison, 1998).

Overall, the experience with this strategy has also been mixed, indicating that there may not be a single silver bullet that will work in all contexts. The outcomes depend on a range of factors, including politics at different levels (see Magome and Murombedzi, 2003).

1A.3.2 Experience with Community-Based Forest Management

The main focus of early CBFM programs in the 1970s was on meeting fuelwood and fodder needs of local people. Their objectives were twofold: 1) meeting subsistence needs of people; and 2) relieving pressure on forests to arrest or reverse degradation. Major CBFM programs were launched in different countries with this philosophy. These included the collective woodlots program in South Korea, village forestry program in Thailand, village afforestation program in Tanzania, community forestry program in the Nepal hills, and social forestry program in India. Subsequently, the focus broadened to include a range of forest goods and services, especially non-timber forest products (NTFPs), to tackle poverty (Arnold, 2001). This shift was based on the realization that a range of "everyday" forest resources such wild foods and medicines were critical for livelihoods of the local people (Shackleton and Shackleton, 2004).

CBFM spread rapidly in the 1980s and 1990s as it got support from donor agencies, NGOs, community rights activists, and many national policymakers. For example, the World Bank invested USD 830 million in various CBFM projects in India (Kumar, Saxena, Alagh, Mitra, 2000). Overall, it is estimated that the World Bank's lending for community-based projects increased from USD 325 million in 1996 to around USD 2 billion in 2003 (Mansuri and Rao, 2004).[11]

The spread of CBFM was considerably facilitated by the decentralization/devolution[12] programs undertaken in many countries (Agrawal and Ribot, 1999). The experience with decentralized forest management varied considerably depending on the local context. For example, in Bolivia, while decentralization of forest management to municipalities created new opportunities for local people, the actual impact depended on factors such as local power relations and importance of forests in the local economy (Pacheco, 2005). In Nepal, development of the concept of *forest user group* helped in focusing attention on actual users of forests (see Springate-Baginski and Blaikie, 2007).[13] In Cameroon, while decentralization over forest management

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[11] If one includes the lending for an enabling environment, the increase was from USD 3 billion (1996) to USD 7 billion (2003). These figures are for all community-based projects and not just forestry projects.

[12] Fisher (2000) makes a distinction between decentralization and devolution. Decentralization is defined as relocating administrative functions away from a central location. Devolution is defined as relocating power away from a central focal point.

[13] See also special joint issue of the *Rural Development Forestry Network* and the *Journal of Forest and Livelihood*, 3 (1), 2003.

led to positive outcomes such as empowerment of hitherto marginalized groups such as Baka pygmies, there were some negative outcomes as well, such as capture of village committees by local elites (Oyono, 2005). The results of the forest decentralization program in China (modeled on the *household responsibility system* tried earlier in agriculture) were not very encouraging due to problems such as uncertain tenure and unclear benefit sharing arrangements (Xu and Ribot, 2005). Similarly, in post-socialist Mongolia although reforms led to reemergence of traditional *khot ail* groups as the primary unit of social organization, these failed to become self-governing associations due to prevailing economic environment (Mearns, 2005). In the case of Indonesia, sudden decentralization without adequate accountability measures actually had a negative impact on both forests and local people (Resosudarmo, 2005). The mixed experience of decentralization has led to calls for "democratic decentralization" (Ribot, 2003; see also Agrawal and Ostrom, 2001), the impetus for which comes "from below" (Larson, 2005).

The field experience of CBFM projects and programs has highlighted the approach's potential as well as key challenges. In many cases, extractive reserves established to allow local communities to sustainably exploit renewable resources such as NTFPs have shown good results in terms of livelihood and resource outcomes (Egler, 2002). The experience of projects such as the green and black iguana management project in Nicaragua indicates that apart from improving resource management and livelihoods, these can also lead to an enhanced sense of security among participating communities (Rivera and Edwards, 1998).

It has, however, been argued that such successes are more likely in smaller rather than larger patches of forest (Rudel, 2006). Other studies have highlighted the challenges involved in commercialization of forest resources such as NTFPs (Newton *et al*., 2006; Belcher and Schreckenberg, 2007), which is influenced by a range of factors (Ruiz-Pérez *et al*., 2004). A bigger challenge is sustainability of the effort after the project ends (see, for example, Rivera and Edwards, 1998; Christie, Buhat, Garces, White, 2003). Security of tenure is considered an important pre-condition for sustainability (see Lindsay, 2000). Although many countries have undertaken significant tenure reforms (see, for example, Lynch and Talbott, 1995), community tenure is not always secure. In many cases, governments retain control over the resource and only management responsibilities (and costs) are transferred to local communities (Meshack, Adhikari, Doggart, Lovett, 2006). This can result in unilateral adverse decisions by the government. For example, in Mexico a community-managed forest (*ejido*) was declared as a part of a protected area (Sanderson and Bird, 1998; see also Christie *et al*., 2003 for adverse impact of such unilateral decisions on a community-based coastal resources management project). In addition to tenure, the role played by institutions is also considered critical for sustainability of CBFM (Murphree, 1994; Cleaver, 1999).

The field experience has highlighted some other issues as well, such as the difficulty in engaging with certain community groups like pastoralists (see, for example, Collett, 1987) and of working with communities experiencing rapid change. For example, a project in Lesotho attempted to build on traditional Basotho range

management systems but found it extremely challenging due to changes in the wider job market and growing lawlessness (Turner, 2004b). This experience also underlined the dangers of assuming traditional or customary practices to be static (see also Zerner, 1994 for an Indonesian example). These not only continually evolve but in many cases have been deeply influenced and refashioned by colonial interventions (Woodhouse, Bernstein, Hume, 2000). Another example of the changing nature of traditional/customary practices was seen in a co-management project in Australia where the aboriginal people had taken to hunting the feral (exotic) water buffalo (Hill and Press, 1994).

Although many commentators consider CBFM to be a promising approach (see, for example, Mayers and Bass, 1999), others have raised basic questions regarding its efficacy for poverty alleviation. The experience of several CBFM projects has been unsatisfactory in this regard (Sunderlin, 2006). Studies have shown that the relatively wealthy are often the heaviest users of forests though the poor usually derive a greater proportion of their overall needs (Byron and Arnold, 1999; Heltberg, 2001; Adhikari, 2005). Due to improvements in agriculture, the importance of forests during stress periods has also been reduced in many areas (Byron and Arnold, 1999). Wunder (2001) has questioned the links between tropical forest conservation and poverty alleviation, at both national and local levels. He argues that in most settings, natural forests have little comparative advantage over other potential land uses, and deforestation (e.g., for agriculture) may actually be an important avenue for local communities to move out of poverty. Similar doubts have also been raised about the potential of wildlife resources for alleviating poverty (Hulme and Murphree, 2001).

Redford, Levy, Sanderson, and Sherbinin (2008) have gone the furthest and argued that the global poverty alleviation objective cannot be met by focusing on wild places such as natural forests as very few poor people live in areas that they classified as somewhat wild (0.2 percent) or extremely wild (0.03 percent). In any case, forestry activities may not always lead to poverty alleviation since many activities have poor economic potential and people undertake these only because they lack better alternatives. Further, these activities may be susceptible to changes in market conditions, e.g., availability of substitutes (Byron and Arnold, 1999).

1A.4 Ongoing Debates

The experience with CBC and CBFM approaches indicates that both have been a mixed bag with some positive and some disappointing outcomes. As discussed above, several conceptual issues with both approaches have also been raised. In addition, there are ongoing debates on even more fundamental issues of direct

relevance to CBNRM. Two such issues are community and participation, which are briefly discussed below.

1A.4.1 Community

One of the biggest criticisms of CBNRM approaches is their naïve assumption about the existence of a clearly bound, homogenous, and static community[14] with few problems in self-regulation (Leach, Mearns, Scoones, 1997a, 1997b; Barrow and Murphree, 2001), a community that is believed to have an interest as well as capability for managing natural resources sustainably and equitably if sufficiently mobilized (Agrawal and Gibson, 1999; Cleaver, 1999, 2001; Woodhouse *et al*., 2000; Belsky, 2003)—especially if the state gets out of the way (Meynen and Doornbos, 2005). According to Little (1994, p. 357), it is a "commonly misused term that can invoke a false sense of "tradition," homogeneity, and consensus."

Community is a concept that is notoriously difficult to define (Western and Wright, 1994; Brown, Malla, Schrechenberg, Springate-Baginski, 2002a; Outhwaite, 2003). Often different formulations such as a small spatial unit, homogenous social structure, and common interests and shared norms are used to define a community (Agrawal and Gibson, 1999). These are often conflated adding to the confusion. In reality, communities are much more dynamic and internally differentiated and as much characterized by conflict as with cohesion (Leach *et al*., 1997b; Cleaver, 1999; Magome and Fabricius, 2004). Communities are also constantly changing and often reconstitute themselves (Vira and Jeffery, 2001; Berkes, 2004). In fact, many local people could be recent migrants (Oates, 1999).

The difficulty of using the concept in practice was demonstrated in a CBC project around the Lake Mburo National Park in Uganda. Eventually all residents of parishes bordering the park (over 80,000 people) were included in the program, though many of them did not have much to do with the park (Hulme and Infield, 2001). Similar problems have been reported from the community forestry program in Cameroon (Brown and Schreckenberg, 2001). The problems of inequitable sharing of costs and benefits within groups involved in CBFM programs have been well documented (see Sarin, 1996; Malla, 2000; Agarwal, 2001; Post and Snel, 2003; Meshack *et al*., 2006). Although some authors have claimed that idealized representations of consensual communities serve the strategic purpose of countering other dominant narratives (Li, 1996), it is increasingly being seen as highly problematic.

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[14] Agrawal and Gibson (1999, p. 640) call it a "mythic community'.

1A.4.2 Participation

Participation is another key concept underpinning CBNRM that has been subject to much criticism (see, for example, Cooke and Kothari, 2001; Hickey and Mohan, 2004). Although the value of local participation is recognized (see, for example, O'Riordan and Stoll-Kleemann, 2002), it is argued that often its radical roots are forgotten and it is reduced to a managerial exercise (Cleaver, 2001) executed in a formulaic manner (Hailey, 2001). Participation can take different forms, ranging from information sharing to empowerment (Vira and Jeffery, 2001). To understand the nature of participation, one needs to ask "who participates, for what purposes and on what terms" (Barrow and Murphree, 2001, p. 28). It has been argued that in many CBNRM projects, participation remains at a superficial level (Little, 1994), something that needs to be changed (Mohan, 2001). However, others have argued that although local participation is desirable on moral grounds, it is not always necessary to promote agendas of the politically powerful (Brockington, 2004).

All these issues have led to vigorous debates on CBC/CBFM. Some commentators have argued for a renewed focus on conservation (Sanderson and Redford, 2003) and people-free conservation areas:

> *…to place on the shoulders of relatively powerless forest dwellers the burden of stopping economically, politically, and socially powerful forces driving deforestation is at best unfair and at worst dangerous (Redford and Sanderson, 2000, p. 1363; see also Redford, 1991).*

Other commentators have argued for keeping forests under state control (Terborgh, 2000) and increasing the outlay for conservation (James, Gaston, Balmford, 2000; see also Balmford and Whitten, 2003). A few have argued in favor of direct payments for conservation rather than making indirect investments through CBC/CBFM (Ferraro, 2001; Ferraro and Kiss, 2002).

This, in turn, has led to counter critiques of this "resurgent protection paradigm" (Wilshusen, Brechin, Fortwangler, West, 2002; Brechin, Wilshusen, Fortwangler, West, 2002; Chapin, 2004) on moral and practical grounds. Some commentators have stressed the importance of CBC/CBFM in combating resource degradation (Chapela, 2000; Nepstad *et al*., 2006) and in supporting community forestry enterprises (Antinori and Bray, 2005). Chapela (2000, p. 129) argued that "any possibility of an ecologically sustainable future will originate in small, community-based initiatives."

Others have supported CBC/CBFM from the perspective of rights of local communities (Colchester, 2000) or due to the need for an alliance between conservationists and local people (Chicchón, 2000). Some commentators have advocated for a network of community-managed areas such as extractive and indigenous reserves using arguments that (1) these provide essential services without which strict protected areas cannot survive for long (Schwartzman, Nepstad, Moreira, 2000), and (2) willing support of indigenous peoples for conservation is critical as they now have control over millions of hectares of biodiverse forests such as those in the Amazon basin (Schwartzman, Moreira, Nepstad, 2000).

The ongoing debates over CBC/CBFM are not only relevant for the forestry sector but also beyond it as forestry (especially tropical forestry) is increasingly seen as an important entry point for wider governance reforms (Brown, Schreckenberg, Shepherd, Wells, 2002b).

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1B EVOLVING POLICY NARRATIVES IN INDIAN FORESTRY: FROM COLONIAL TIMES TO THE PRESENT[15]

1B.1 Introduction

This paper presents a historically-sensitive analysis of national policy narratives, with a focus on the role of wastelands and afforestation. The exploration of these narratives will help in placing current emphasis on climate change and ecosystem approach to forest management within a historical context.

Although several accounts of pre-colonial land tenures and related policies are available (see, for example, Baden-Powell 1892; BISR 1984; Agarwala 1985a; Lal 1989; Gadgil and Thapar 1990; Gadgil and Berkes 1991; Kautilya 1992; Puri 1992; Chakravarti 2010; Chatterjee 2010; Moosvi 2010), the analysis begins with the colonial period as it is considered to be 'an important watershed in the ecological history of India' (Guha and Gadgil 1989, 142; see also Guha 2010). Many concepts and policies introduced during this period continue to shape perceptions and programs to this day. In fact, as elaborated below, many legislations enacted during the colonial period still provide the legal framework for management of forest lands in the country. Due to close linkages between wastelands and forest lands, narratives related to them need to be considered together.

This paper is divided into six sections, each of which presents a key phase in the evolution of policy narratives. These are: 1) colonial, 2) post-independence, 3) social forestry, 4) rural development forestry, 5) watershed development and Joint Forest Management (JFM), and 6) climate change.

1B.2 Colonial Period

The concept of wastelands originated in the colonial period. The term *wasteland* conjures up an image of a desolate and barren area[16]. However, this is not what the colonial administrators had in mind when they classified a significant proportion of the country as wastelands. They used the term in its older legal sense which meant, 'a piece of such land not in any man's occupation, but lying common'[17]. The takeover of these lands was justified by citing practices of erstwhile Indian rulers:

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[15] Extracted from Saigal 2012.

[16] Source: *The Chambers Dictionary*, 2003, Chambers Harrap Publishers Ltd., Edinburgh.

[17] Source: The Shorter Oxford English Dictionary on Historical Principles, 1967, Clarendon Press, Oxford.

> *The old Rajahs claimed all areas which were not actually brought under cultivation, but any person who required waste land for the purposes of cultivation could obtain it without difficulty on agreeing to pay the assessment in force. The rest of the waste land had always been recognised as the property of the rulers, and from them was inherited by the British Government by right of conquest (Stebbing 1923, 465).*

The government asserted its ownership by enacting laws such as the Waste Land (Claims) Act of 1863[18] (Baden-Powell 1892) and the Forest Acts of 1865 and 1878[19] (Singh 1986; Guha 1990; Gadgil and Guha 1992). Although these laws mentioned local claims or rights, it was made clear that the government was the owner of these lands and only certain '*servitudes* or rights of user' were claimable by private persons for compensation before the government could exercise complete control over them (Baden-Powell 1892, 238, emphasis in original).

Although wastelands and forestlands are now considered very different categories of land, they had similar origins and share a close history. In fact, forestlands were often created from wastelands[20] and the government was even cautioned by senior administrators to exercise 'great care in the disposal of *wastelands containing forests'* (Agarwala 1985a, 32, emphasis added)[21]. It is also important to note that all lands declared as forest lands were not forested, as is evident from the following extract from the forest policy of 1894[22]:

> *The fourth class of forests referred to are pastures and grazing grounds proper, which are usually forests only in name. It is often convenient, indeed, to declare them forests under the Act, in order to obtain a statutory settlement of the rights…(Paragraph 12, emphasis added).*

Although, the main purpose of classification of certain lands as wastelands and forestlands was to assert government control, the government did not want control just for its own sake. The key motivation was revenue (Singh 1986). At that time, land revenue was one of the main sources of state income (Vani 2002)[23]:

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[18] This Act, in its amended form, is still in force. Available online at http://punjabrevenue.nic.in/waste_act.htm (accessed 27.02.2010).

[19] The Act was further amended in 1927 and, in its amended form, still provides the basis of forest administration in India (Singh 1986). Available online at http://www.envfor.nic.in/legis/forest/forest4.html (accessed 26.02.2010).

[20] See, for example, Section 3 of the Indian Forest Act, 1927.

[21] Agarwala indicates the extract to be from a letter dated 01.11.1864 from the Governor-General to the Secretary of State for India requesting enactment of the Indian Forest Act.

[22] Circular No. 22-F dated 19.10.1894.

[23] See also http://agcensus.nic.in/ACI2.html (accessed 10.08.2009).

> *The State derives its principal revenue from the land...The 'land-tax' in England is only one item, and not a very large one, among a host of other taxes...In India the land-revenue is a totally different thing (Baden-Powell 1892, 25).*

The actual identification of wastelands and forest lands took place through the process of *settlement*, a term applied to the method of assessing the land revenue demand (Ray 1984). Extensive land survey and settlement operations were carried out throughout the country to streamline the land revenue collection system [Government of India (GoI) 1880; Ludden 1999][24]. These operations resulted in creation of detailed village records and often demarcation of cultivated lands and wastelands/forest lands on maps.

Revenue considerations played such an important role in government decisions and policies, that financial benefit-cost ratio of settlement operations was closely monitored and no new settlements were carried out in areas where additional revenue generation was doubtful:

> *The Government of India, therefore, ruled that no new re-settlement operations should be undertaken, unless it could be shewn either that the proceeding would result in an adequate increase of revenue, or that such special circumstances existed as would justify a large outlay without any corresponding revenue gain (GoI 1880, 36).*

As land revenue was only collected from agriculture land, the policy was to allow extension of agriculture into both wastelands and forest lands. The following extracts from government documents make the policy in this regard clear:

> *It follows that reclamation of waste lands under the ryotwari system involves an immediate gain of revenue to the Government, while under the zamindari system the gain is deferred till the next revision of settlement (GoI 1880, 8).*
>
> *It should also be remembered that, subject to certain conditions to be referred to presently, the claims of cultivation are stronger than the claims of forest preservation… Accordingly, wherever an effective demand for culturable land exists and can only be supplied from forest areas, the land should ordinarily be relinquished without hesitation… (The Forest Policy, 1894, Paragraph 6)*[25].

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[24] There were two major types of land revenue settlements: *ryotwari* and *zamindari*. The latter was also called *mahalwar* or *mauzawar* (GoI 1880).

[25] This was influenced by a report submitted by Dr J.A. Voelcker, a Consultant Chemist to the Royal Agricultural Society, in 1893 on improvement of Indian agriculture (GoI 1976a; Gadgil and Guha 1992; see Voelcker 1893). Dr Voelcker was asked to advise the government on improving agricultural output in 1889 after the great famine of 1876-78 (GoI 1976a).

The government initially decided to sell the remaining wastelands to generate further revenue but, later changed its policy to leasing of wastelands when it was felt, that the latter approach would yield higher revenue (Baden-Powell 1892). The government drew up rules for the sale or lease of wastelands in the 1860s (GoI 1904; Shiva 1991; Vani 2002). Although the rules allowed extension of cultivation by local people, the largest chunks were offered to European settlers to establish plantations:

> *The second class of rules, though open to persons of any nationality, are intended chiefly to induce European enterprise to establish and develop plantations of such staples as tea, coffee, cinchona, which do not come within the scope of ordinary native agriculture (GoI 1904).*

It is clear, that the colonial concept of wastelands was not based on the biological productivity or ecological status of the land. Rather than being degraded lands, it is quite likely that these were ecologically the most important lands. For example, vast tracts of so-called wastelands were actually located in densely forested districts (Shiva 1991). The following account provided by a former Editor of *The Englishman* newspaper of Calcutta (now Kolkata) is most illuminating regarding the actual condition of so-called wastelands:

> *...[wastelands] harbour the foes of man, affording safe retreats to the tiger, the bear, and the leopard, where rank vegetation decaying under the tropical sun, impregnates the passing breath of heaven with those foul exhalations, the fruitful source of deadly fevers, and still more fatal cholera and dysentery... (Saunders 1863, 10).*

Apart from the environmental services being provided by wastelands, it is also likely that they played an important role in the subsistence economy of local people. It has been argued that the takeover of these lands by the government contributed to numerous famines faced by India during the colonial period (Satya 2004; see also Davis 2001).

Although identification and demarcation of wastelands and forest lands is now considered to be linked to reclamation and conservation efforts, it was certainly not the case during the colonial period[26]. In fact, lands left in their natural state were

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[26] There were, however, some localised conservation efforts during the colonial period. The examples include establishment of tree plantations (mostly economically important species), especially in South India (Lal 1989; MoEF 1999); ravine reclamation efforts in the 1880s in Uttar Pradesh (Khan 1987; Sharma and Shukla 1990); enactment of a law in Punjab in 1900 to control erosion by mountain torrents (Sharma and Shukla 1990); establishment of a committee for reclamation of *usar* (alkaline) lands in Uttar Pradesh in 1930 (Sharma and Shukla 1990); appointment of a Land Management Officer in Uttar Pradesh in 1937 (BISR 1984); and promotion of contour bunding through Bombay Land Improvement Act, 1942 (Srivastava 2000a). The Royal Commission on Agriculture (1928) had suggested many measures for protecting soils from

viewed rather negatively. For example, it was proposed that wastelands offered for sale should be divided into two classes and a different price be charged for each class. The two suggested classes were, those which are '*encumbered* with jungle', and those which are 'not' (Saunders 1863, 14, emphasis added).

Quite often, heavy extraction, rather than conservation, followed the declaration of certain lands as wastelands or forest lands. Early interest in forests stemmed from strategic needs, especially the need for Indian teak for shipbuilding as oak forests in England had been exhausted (Stebbing 1922). The need for timber dramatically increased after the advent of railways in India in 1853 (Gadgil and Guha 1992)[27]. To satisfy the demands of the railways, large tracts of lands were declared forest lands and managed for timber (Stebbing 1923) or fuelwood (Agarwala 1985a).

In addition to the demands of the imperial navy and railways, further heavy extraction was carried out during both World Wars (Gadgil and Guha 1992). Interestingly, the Forest Department always generated surplus for the government (Stebbing 1926)[28]. A former senior forest official noted:

> *Perhaps no single factor in the progress of Forest Administration in India is so striking as the continuous rise in the revenue from the forests since the first introduction of conservancy some sixty years ago (Stebbing 1926, 617).*

It is clear from the above account that the focus during the colonial period was on control of land, revenue and extraction. However, the policy narratives changed when India gained independence in 1947.

1B.3 Post-Independence Period

After Independence, one of the top priorities of the new government was achievement of self-sufficiency in food production. The country had suffered a food crisis during World War-II and there was a famine in Bengal. To cope with the difficult food situation, the colonial central government started paying more attention to food production, a subject that had been dealt primarily by the provinces in the previous two decades. A Department of Food was created in 1942 and in the same year, a Food Production Conference was convened. This led to a number of steps to increase food (and fodder) production and subsequently led to the *Grow More Food* campaign. The campaign was further strengthened after the reports of the Food grains Policy Committee (1943), the Famine Inquiry Commission (1945), and the

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erosion though most of its recommendations could not be implemented due to the ensuing economic depression (GoI 1976a).

[27] See Indian Railways website http://www.indianrailways.gov.in/ (accessed 21.03.2010).

[28] Based on data for 1869-70 to 1924-25.

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Reconstruction Committee of Council (set up in 1943). A *Statement of Agriculture and Food Policy in India* was issued in January 1946 (GoI 1976a).

After Independence, food production was made the top-most priority of the government. Simultaneously, there was a growing concern with the loss of key cotton and jute production areas following partition of the country. As a result, an *Integrated Production Programme* was launched in June 1950, 'to win freedom from foreign bread and achieving progressive self-sufficiency' (GoI 1976a, 143). The main thrust was on increasing area under agriculture by extending cultivation in wastelands and forest lands. The chapter on *Land Policy* in the country's First Five Year Plan (FYP) issued in 1951 noted that, 'increase of agricultural production represents the highest priority in planning over the next few years' (Planning Commission 1951, Chapter 12, Paragraph 2).

A committee was set up in 1948[29] to standardize land use classes in the country. The Committee suggested a nine-fold classification superseding the existing five-fold classification and included new categories such as *Culturable Wasteland*[30] (see also Sharma 1990; Puri 1992). Another committee[31] was set up to identify suitable wastelands in blocks of 100 hectares or more. The Committee conducted a survey in 12 states and identified around 640,000 hectares of wastelands suitable for cultivation (GoI 1976b). Further surveys were subsequently carried out to locate wastelands in blocks ranging from 5 to 100 hectares as well and around 2.3 million hectares of such wastelands were identified (GoI 1976b). To speed up the land development process, the administration relied on heavy machinery, and a specially established agency – Central Tractor Organization – was entrusted this task (GoI 1976a).

A significant proportion of identified wastelands was distributed to farmers for agriculture. The figures compiled by the Ministry of Rural Development (MoRD) indicate that as much as 6.2 million hectares of government wastelands were distributed till 2008 (MoRD 2008)[32]. Since the area under agriculture increased sharply in the 1950s and 1960s (but has remained more or less constant since then), it is reasonable to assume that the bulk of distribution occurred in the first two decades after independence. In addition, around 2.6 million hectares of forest lands

[29] Technical Committee on Coordination of Agricultural Statistics.

[30] Source: http://www.krishiworld.com/html/land_utilisation1.html (accessed 20.09.2009).

[31] Wasteland Survey and Reclamation Committee.

[32] Papola (2010) has provided an updated estimate of distribution of 5.39 million hectares of ceiling surplus land.

were also brought under agriculture[33] (MoEF 1998a), bringing the total area diverted for agriculture to 8.8 million hectares.

Although the main objective of land distribution was to increase food production, it was not the only reason. Land distribution was also an important element of the social reform process, as explained by MoRD:

> *Distribution of Governments' Wasteland has been one of the key Strategies of land reforms; it has been the accepted policy that wasteland at the disposal of the Government should be distributed amongst eligible rural poor (MoRD 2001, 94).*

The reform aspect becomes more apparent if one considers the land distribution program as a whole. In addition to wastelands and forest lands, the government also re-distributed a significant area of land *already under agriculture*. This included 2.18 million hectares of ceiling surplus land[34] and 0.88 million hectares of *Bhoodan* land[35]. In addition, 0.17 million hectares of alienated lands were reinstated to Scheduled Tribes (MoRD 2004). In all these cases, the key purpose was social reform and justice rather than increasing food production.

Another reform policy was government acquisition of estates of erstwhile landlords. This resulted in a sharp increase in forest land in the country from 39.94 million hectares at the time of Independence to 75.16 million hectares by 1986-87 (Lal 1989). However, not only was this acquisition based on old settlement records rather than actual status of the lands (GoI 1976c), but also – more importantly – there was large-scale felling on lands that actually had forests. The landlords felled and sold trees to realize as much profit as possible before handing over the control of the land to the government (Planning Commission 1951; MoEF 1999; Banerjee 2010). As a result, in the words of a top forest official, 'we added area [to forest lands] but lost forests'.

Another development that took place during this period had a more direct and profound impact on these narratives. The country adopted a target of bringing one-third of its area under tree and forest cover. Although one of the sub-committees of the Reconstruction Committee of Council had suggested that the provinces should

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[33] Between 1951 and 1980.

[34] This land was acquired by the government from other landowners by imposing a statutory ceiling on agricultural land holdings.

[35] Bhoodan literally means 'a gift of land'. It was a reform movement launched in the 1951 by Vinoba Bhave. See http://www.mkgandhi-sarvodaya.org/bhoodan.htm (accessed 22.03.2010).

strive for a 20 percent to 25 percent forest cover (GoI 1976a), it was the National Forest Policy issued in 1952[36] that formally set the one-third target:

> *…India, as a whole, should aim at maintaining one-third of its total land area under forests. As an insurance against denudation, a much larger percentage of the land – about 60 per cent – should be kept under forests for their protective functions in the Himalayas, the Deccan, and other mountainous tracts liable to erosion. In the plains, where the ground is flat and erosion is normally not a serious factor, the proportion to be attained should be placed at 20 percent (National Forest Policy, 1952, Paragraph 19).*

Considering the importance of this decision (assigning one-third area of a country to one land use has to be considered a major decision), it may be worthwhile to examine the source of this one-third figure. Interestingly, this decision was taken after noticing 'close parallelism between a high proportion of forest area and the general prosperity of a region' (MoEF 1998b, 139) and the role model was Europe:

> *Viewed against its temperate climate, even distribution of rain-fall, and its industrial bias, Europe provides a valuable guide for the proportion of forests that we might well adopt. In India, where we have to reckon with an oppressive tropical sun, desiccating hot winds, periodic monsoons, steep mountain slopes, a lower forest productivity, and a predominantly agricultural population, a proportion somewhat higher than that of Europe would appear to be indicated. From practical considerations, however, we might, for the present, be content with a considerably lower percentage. We should aim at increasing the over-all percentage of area under forest to a minimum of 33.3 (MoEF 1998b, 139).*

Although the one-third area fugure provided the long-term national goal, in the immediate decades following the country's independence, large areas of forest lands had to ve diverted due to development imperative. In addition to 2.6 million hectares of forest lands provided for agriculture, another 1.7 million hectares of forest lands were diverted for industrial and economic development projects such as river valley projects, industrial sites, and for roads and transmission lines between 1951 and 1980 (MoEF 1998a). Although some efforts at combating land degradation were started[37], the focus was clearly on economic development and industrialization. In

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[36] Ministry of Food and Agriculture Resolution No. 13-1/52-F dated 12.05.1952.

[37] These included *inter alia* launch of *Vana Mahotsav* (festival of forests) in 1950 to encourage tree plantations (Sagreiya 1967); focus on soil conservation by the Damodar Valley Corporation, which influenced soil conservation efforts in the country through establishment of the Soil Conservation Society of India, which, in turn, played a role in creation of the Soil and Water Conservation Division in the Ministry of Agriculture (Srivastava 2000a; Subramaniyan 2000); initiation of a scheme for Soil Conservation in the Catchment of River Valley Projects during the Third FYP (Planning Commission 1988); setting up of a Committee on Natural Resources by the Planning Commission in 1963 (Sharma and Shukla 1990); initiation of a

fact, the ultimate objective of many conservation efforts was also often to safeguard industrial or agricultural interests such as prevention of silting of dams or shifting the use of cow dung from fuel to manure.

Although the 1952 forest policy document listed ‘vital national needs’, which included everything from conservation to supply of subsistence products to local communities, the emphasis was on meeting industrial rather than subsistence needs:

> *The accident of a village being situated close to the forest does not prejudice the right of the country as a whole to receive the benefits of a national asset (National Forest Policy 1952, Paragraph 7).*

The focus becomes clearer if one examines the programs pursued during this period. In the 1950s, the paper industry was provided bamboo from forests at a nominal price (Gadgil and Guha 1992). At the time of formulation of the country’s Third FYP (1961-1966), it was estimated that by 1975, there was likely to be a shortage of 4 million tonnes of industrial wood and 100 million tonnes of fuelwood (Planning Commission 1961). Yet, 88 percent of government investment on plantations went into industrial plantations (see Table 2.1).

Table 2.1: Comparison of selected forest development schemes from the First to the Fourth Five Year Plans (INR million)

Scheme	**First Plan (1951-56)**	**Second Plan (1956-61)**	**Third Plan (1961-66)**	**Annual Plans (1966-69)**	**Fourth Plan (1969-74)**
Economic plantations for industrial and commercial uses	11.191	48.688	116.316	93.404	201.499
Farm forestry-*cum*-fuelwood plantations	-	-	10.954	15.193	36.125

Source: GoI 1976c (1 USD = 30.6 INR in 1992)

During this period, external technical and material assistance was also available for industrial forestry. During the Third FYP, a *Pre-Investment Survey of Forest Resources and Industries* was launched with assistance from the United Nations. The objective was to:

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ravine reclamation scheme in 1967 through constitution of the Central Ravine Reclamation Board (Srivastava 2000a); and programmes to reclaim waterlogged and saline-alkaline lands (GoI 1976b).

facilitate formulation of a long-term programme for forestry development including planting of forest area with quick growing species; development of communications, and assessment of the economic prospects of forest based industries (GoI 1976a, 178).

Several logging training centers were also established with external support (GoI 1976c). It was noted in the Fourth FYP Document (1969-1974) that '[a] vigorous programme of economic plantations for industrial and commercial uses was pursued during 1961-69' (Planning Commission 1969, Chapter 8).

In addition to being seen as a source for industrial raw material, the forests continued to be seen as a source of revenue for the government, with relatively less focus on subsistence needs of local communities (see, for example, Gadgil 1991 a,b,c).

It is clear from the above account that the key focus areas in the post-Independence period were food, social reforms, and industrial development and wastelands/forest lands were utilized primarily for these purposes. Initially, bulk of tree plantations established were restricted to forest lands, but the situation changed with the advent of social forestry in the 1970s.

1B.4 Social Forestry

Two key developments in the 1970s shaped the narratives surrounding wastelands and afforestation. The first was the energy crisis (see, for example, Ikenberry 1986; Barsky and Kilian 2004) caused by a sharp increase in the price of oil[38]. The second was the publication of the report of the National Commission on Agriculture (NCA).

The energy crisis of the 1970s helped to focus the world's attention on energy-related issues. In this context, the issue of deforestation and growing fuelwood shortage in the Global South – with attendant ecological and humanitarian consequences – also got into limelight. This came to be known as the 'other energy crisis' (Eckholm 1975). The Indian energy planners also emphasized the need to focus on fuelwood (Planning Commission 1979).

NCA covered a vast array of subjects and made several recommendations related to forestry. However, its main focus was on promoting *production forestry*, which meant commercial forestry operations to be financed through banks. It suggested that local communities' subsistence needs should be met from outside the forest lands. This helped to launch a plantation program, which came to be known as *social forestry*.

[38] Often referred to as the 'oil shock'.

The following extracts from the NCA report help in understanding the thinking behind NCA's recommendations:

> *Although the forest area is a little less than half of the cultivated area, the contribution of the forestry sector to the Net Domestic Product (NDP) is very small and is not commensurate with its potential. The contribution of forestry and logging in 1972-73 was 1.5 per cent at 1960-61 prices. As noticed in the advanced countries in the world, forestry should be able to do better (GoI 1976c, 1).*
>
> *It is clear that any strategy for forest development must take into account the goods and services that the forests should provide…Production of industrial wood would have to be the raison d'être for the existence of forests. Actually, it is in this value that many other values that have been claimed or stressed for forests so far can be absorbed (GoI 1976c, 32-33).*
>
> *…by taking up the [social forestry] programme…it would be possible to meet the requirement of fuelwood, fodder, small timber… at the same time these programmes would remove a serious impediment in the practice of production forestry (GoI 1976c, 120).*

The NCA report greatly influenced the government policy regarding both forest lands and wastelands. The focus on forestlands shifted to production forestry and on wastelands to social forestry[39]:

> *The primary objective in the Fifth Plan [1974-1979] is to take up a dynamic programme of production forestry, aiming at clearfelling and creating large scale man-made forests with the help of institutional financing (GoI 1976c, 15).*
>
> *There is an urgent need for attaining self-sufficiency in fodder, fuel, small timber and wood for pulp. In this context, country's wasteland or unutilised land offers great scope. We, therefore, feel that the reclamation of wasteland may be planned to meet the above demands of national importance (GoI 1976b, 205).*

NCA suggested that about 48 million hectares of forestland should be dedicated to production forestry and state-owned companies or corporations should be set up to attract institutional finance (GoI 1976c)[40]. Accordingly, 26 Forest Development

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[39] The achievement of food self-sufficiency due to 'green revolution' also perhaps played a role in the shift in focus from food to fuel and fodder (see, for example, Randhawa 1974; Papola 2010).

[40] Another stated reason was elimination of private forest contractors (Banerjee 2010).

Corporations (FDCs) were set up in different states (GoI 1990)[41]. FDCs focused on raising plantations or converting mixed natural forests to commercial plantations (FSI 1999; Saxena 1991). Often 'good quality mixed forests were felled to get better sites for raising plantations of chosen species, which in most cases was teak' (MoEF 1999, 86).

Apart from negative environmental consequences, this adversely affected several forest-dependent local communities and even led to conflict (see, for example, Anderson and Huber 1988). A government review report published in 1990 indicated that although FDCs controlled over 1.2 million hectares of plantations[42], their performance was far from satisfactory in terms of survival, yield, and quality (GoI 1990). Most FDCs were incurring losses and had failed to attract adequate institutional finance, the reason they were created in the first place (GoI 1990). In spite of forestry being a priority sector, a mere 0.8% of the NABARD's[43] cumulative disbursement had gone into forestry (Haque 1996a)[44]. They faced numerous operational challenges as well (GoI 1990; Haque 1996b).

Regarding social forestry, NCA suggested two main programs: 1) *farm forestry* on agriculture farms, especially as boundary plantations, and 2) *extension forestry* on government wastelands, village common lands, and strip lands available along roads, railway tracks, and canals (GoI 1976c).

From the mid-1970s onwards, social forestry became the main focus of forest policy in India. It also got considerable support from international funding agencies. As a result, a large number of externally-aided social forestry projects were started in the country in the late 1970s and 1980s. These were mainly implemented by the State Forest Departments (SFDs), which got involved in large-scale tree planting outside forest lands for the first time (Planning Commission 2007a).

This led to a spurt in plantation activity in the country. While the total extent of tree plantations established till 1974 was 2.11 million hectares, over 1.44 million hectares of plantations were raised between 1974 and 1980, and as much as 4.65 million between 1980 and 1985 (see Table 2.2).

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[41] 1990 figure. Some states, *viz*. Orissa, Karnataka, and Tamil Nadu, had more than one FDC each (GoI 1990).

[42] This included 966,538 hectares of new plantations of commercial tree species such as teak, eucalyptus, bamboo, pine and casuarina, 18,774 hectares of cash crop plantations such as red oil palm, rubber, cashew, tea, cardamom, coffee and lavender, and 251,174 hectares of existing plantations acquired from the Forest Departments (GoI 1990).

[43] National Bank for Agriculture and Rural Development – main financial institution for agriculture, forestry and rural development projects.

[44] Up to 31.03.1995.

Table 2.2: Area covered under afforestation and financial outlay (1951-1985)[45]

Plan Period	Area Covered (Lakh Hectare)	Outlay (INR Crore)
First (1951-56)	0.52	1.28
Second (1956-61)	3.11	6.86
Third (1961-66)	5.83	21.13
Post Third (1966-69)	4.53	23.02
Fourth (1969-74)	7.14	44.34
Fifth (1974-79)	12.21	107.28
Annual (1979-80)	2.22	37.10
Sixth (1980-85)	46.5	926.01

Source: MoEF 1998a

Yet, in spite of the substantial area coverage under plantations, social forestry was not very successful in meeting its primary objective, i.e. meeting local fuelwood and fodder needs from outside the state forest lands.

Under the extension forestry program, the Forest Department usually established a plantation and then handed it over to the local *panchayat* after a few years. The program faced several problems[46]: 1) limited involvement of the local community beyond wage employment; 2) it was difficult to find vacant lands due to widespread encroachment or existing subsistence use; 3) the local *panchayat* was often dominated by the village elite and did not represent the interests of the poor, who were the main stakeholders by virtue of their dependence on wasteland/common land; 4) fast-growing non-browsable exotic species were preferred defeating the very purpose of the program; and 5) the *panchayats* often harvested the plantations soon after taking their charge, sold produce outside the village, and did not reinvest money into new plantations thereby ending the program after just one cycle.

[45] 1 lakh = 100,000; 1 crore = 10 million.

[46] See Pathak 1994; Vira 1995; Mishra 1997; Köhlin 1998.

Farm forestry was more successful in terms of number of trees planted. It seems that its success was not anticipated as the government agencies' initial focus was on wastelands' / common lands' plantations and farm forestry targets were kept at modest levels (Saxena and Ballabh 1995). However, farmers, especially those with large holdings in commercial agriculture areas, took to tree planting in a big way. In Uttar Pradesh, for example, while only 11 percent of the target for community self-help woodlots could be achieved, farm forestry exceeded its target by as much as 3,430 percent (Gadgil and Guha 1992).

However, instead of planting fuelwood and fodder trees for meeting local needs, farmers mainly planted short rotation trees (especially eucalyptus) for the commercial and industrial market (Adiseshiah 1989; Pathak 1994; Saxena and Ballabh 1995). Although a large number of trees were planted by farmers within a short span of time, the success of farm forestry was short-lived. By the mid-1980s, farmers started abandoning it as they did not get the anticipated returns from trees (Saxena and Ballabh 1995).

The following extract from a government report sums up the overall with social forestry:

> [*Social forestry] programme was undertaken largely departmentally and could not establish the required linkage with the communities and instead, served mainly to urban and commercial uses through the widespread promotion of fast growing tree species (Planning Commission 2007a, 34).*

While the period between the early 1970s and mid-1980s was defined by the focus on energy, forest corporations and the eucalyptus wave under farm forestry, there were other key developments during this period as well, that had a major impact on the wastelands and afforestation narratives in subsequent years.

1B.5 Rural Development Forestry

Although production and social forestry were the dominant features of the 1970s and the early 1980s, another key concern emerged during the period, *viz*. environment. A number of important initiatives were launched during the early- and mid-1970s. These included the establishment of the National Committee on Environmental Planning and Coordination (1972) (Planning Commission 2007a), enactment of The Indian Wildlife (Protection) Act (1972), launch of the Project Tiger (1973)[47], and enactment of The Water (Prevention and Control of Pollution) Act (1974)[48].

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[47] Source: http://projecttiger.nic.in/ (accessed 26.03.2010).

[48] Source: http://moef.nic.in/modules/rules-and-regulations/water-pollution/ (accessed 27.03.2010).

The importance of environmental issues steadily increased over the period and it had a direct bearing on the subsequent policy narratives. The need for a national land use policy – in spite of 'Land' being on the State List – was first highlighted through a paper titled *A Charter for the Land*, which was written by a senior official in 1972 (MoRD 2001). The paper reportedly influenced the then Prime Minister, who expressed great concern over the matter (Vohra 1986). The states were subsequently requested (in 1974) to set up State Land Use Boards [National Wasteland Development Board (NWDB) 1986a]. Similarly, there was concern over deforestation and the subject 'Forests' was moved from the State List to the Concurrent List in 1976[49]. The central government subsequently issued guidelines for forest management that *inter alia* suggested a ban on tree felling over the altitude of 1,000 meters. In 1980, the central government enacted the Forest (Conservation) Act to control diversion of forest land for non-forest use (FSI 1987). In the same year, a separate Department of Environment was also established at the Centre (MoEF 1986). The growing importance of environment issues was also reflected in the inclusion of a separate chapter on environment in the Sixth FYP (1980-1985) (Planning Commission 1980).

The concern for environment increased significantly in the 1980s. In 1981, The Air (Prevention and Control of Pollution) Act[50] was enacted and the National Eco-development Board (NAEB) was established (MoEF 1986). A couple of reports during the period highlighted the need for urgent action to improve land and forest management. The first was the report of the National Commission on Floods which indicated that the area prone to periodic flooding had doubled between 1971 and 1981, with huge attendant economic loss (Singh et al. 1986; Puri 1992). The second was the report of the National Remote Sensing Agency (NRSA) (1983) that indicated that India lost forests at an average annual rate of 1.3 million hectares between 1972-75 and 1980-82 (NWDB 1986a; FSI 1987; Puri 1992).

The civil society response to these concerns came in the form of an NGO – Society for Promotion of Wastelands Development – that was established in 1982 under the chairpersonship of an eminent scientist Dr. M.S. Swaminathan. The Society played an important role in highlighting degradation of land and forest resources and promoted a people-centered approach for their development (Eswaran 2001). This people-centered approach was also endorsed by United Nations Environment Programme (UNEP) (Tolba 1982).

A key turning point came in the mid-1980s when a number of major environment-related initiatives were launched. These included setting up of MoEF, establishment

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[49] Source: http://lawmin.nic.in (accessed 26.03.2010).

[50] Source: http://moef.nic.in/modules/rules-and-regulations/air-pollution/ (accessed 27.03.2010).

of the National Wastelands Development Board (NWDB), launching of a massive program to clean River Ganges, enactment of a comprehensive Environment (Protection) Act, and adopting a new conservation and people-oriented National Forest Policy[51, 52]. In 1987, the Central Board of Forestry even recommended that extraction of timber from forests should be stopped and states should be compensated for their revenue loss[53]. The thrust given to conservation issues in the mid- and late-1980s is also reflected in the record number of protected areas constituted during this period.

A massive plantation program was launched in 1985. In his address to the nation on 05.01.1985, the then Prime Minister announced:

> *Continuing deforestation has brought us face to face with a major ecological and socio-economic crisis. The trend must be halted. I propose immediately to set up a national wastelands development board with the object of bringing 5 million hectares of land every year under fuelwood and fodder plantations. We shall develop a people's movement for afforestation (NWDB 1986a, 13).*

These goals were subsequently also reflected in the National Forest Policy announced in 1988[54]. It laid emphasis on afforestation through a 'massive people's movement' and reiterated the national goal of having a minimum one-third of the total area of the country under forest and tree cover.

The magnitude of the afforestation effort suggested by the then Prime Minister can be gauged from the fact that it translated into planting of 16,842 trees every year, in each and every village of India[55]. Another notable feature of the announcement was the emphasis on people's movement to achieve the target.

There was considerable interest in environment and forestry issues among the country's top leaders and policy makers. The newly set up National Land Use and Wastelands Development Council was chaired by the Prime Minister (NWDB 1986a)[56].

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[51] See http://moef.nic.in/index.php (accessed 27.03.2010).

[52] An Island Development Authority was also set up in 1986 with the Prime Minister as its Chairperson for ecologically sound development of the Andaman and Nicobar and Lakshadweep Islands (Planning Commission 1992).

[53] Source: Report of Matthai Committee constituted by MoEF in 1989.

[54] MoEF Resolution No. 3-1/86-FP dated 07.12.1988. Available online at http://moef.nic.in/downloads/about-the-ministry/introduction-nfp.pdf (accessed 27.03.2010).

[55] Assuming 2,000 trees per hectare. According to the census 2001, there were 593,731 inhabited villages in India. Source: http://www.censusindia.gov.in/ (accessed 27.03.2010).

[56] It had two bodies under it – National Land Use and Conservation Board in the Ministry of Agriculture and Rural Development and NWDB in MoEF.

After NWDB was established, one of the first tasks it undertook was to define and estimate the extent of wastelands. As there was a plethora of definitions[57], NWDB decided to appoint a Technical Task Force for the purpose (Technical Task Group 1985). The definition suggested by this group was further refined and the following was agreed:

> *Wastelands for the purpose of this document mean degraded land which can be brought under vegetative cover, with reasonable effort, and which is currently under-utilised and land which is deteriorating for lack of appropriate water and soil management or on account of natural causes (NWDB n.d., 2).*

This new definition represented an important shift as wastelands were defined in ecological terms, rather than in terms of their revenue or agriculture potential, or legal status. The next step was estimation of wastelands. Again, there was a plethora of estimates (see Srivastava 2000b). The most quoted figure was 175 million hectares that had been estimated by NCA. The NWDB considered this figure to be an overestimate as NCA had possibly included all lands needing attention as wastelands (NWDB 1986b)[58]. Therefore, NWDB requested NRSA to take up a *National Wastelands Identification Project* in 1986 (NWDB n.d.). This was again a departure from the past as wastelands were to be directly identified through remote sensing rather than through collation of data collected by local officials. This exercise led to a revised estimate of 55.4 million hectares of wastelands (NWDB 1986c). The estimate of wastelands in the country dropped significantly from 53 percent (as estimated by NCA) to around 16 percent of the geographical area. These wastelands were classified under a new 13-fold classification (MoRD and NRSA 2005).

While devising its strategy, NWDB decided to focus on fuelwood and fodder since these two produce had been identified as critical to address the issues of both deforestation and subsistence needs (see Advisory Board on Energy 1985; NWDB 1986b, 1986d). This was also in line with the changing thinking about the role of common lands and development interventions. A seminal study in the mid-1980s (Jodha 1986) had shown the extent of dependence of the rural poor on common lands and that a program focusing on these lands could be used to address poverty.

The NWDB projected its wastelands reclamation program as a poverty alleviation effort. Its chairperson stated that ‘India’s poverty is closely connected with its increasing land degradation’ (Chowdhry 1989, 5). The key document prepared by NWDB outlining its strategy noted:

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[57] See, for example, Bhumbla and Khare n.d.; Mohammad 1990; Sharma 1990; Bagchi and Philip 1993.

[58] NCA had classified as much as 62 percent of cultivated lands as wastelands. The NCA figure was re-assessed by the Ministry of Agriculture as well (see Singh 1989).

> "Half of India, the poorer half depends for its subsistence on the common lands, the uncultivated half of India. Over the years, these lands – forest lands, grazing lands and other common lands – have become highly degraded leading to deforestation and ecological degradation on one hand, and poverty, unemployment and impoverishment of quality of life and drudgery of women and children on the other hand. Unless this vicious circle of ecological degradation and poverty is broken, there is no hope either of achieving ecological balance or improving the situation of the rural poor" (NWDB 1986a, 13).

Once the land degradation-poverty connection was made, a large amount of rural development funds became available for plantations. Up to 25 percent of funds of the flagship rural employment schemes were reserved for afforestation (Planning Commission 1988)[59]. The importance attached to wastelands' development during the period can be discerned from the amount of funds allocated to it (see Table 2.3).

Table 2.3: Breakdown by area of funds of the Ministry of Environment and Forests (1987-88 to 1990-91) (INR million)

Year	**1987-88**	**1988-89**	**1989-90**	**1990-91**	**1991-92**
Area					
Wastelands Development	603.3	600.0	684.0	800.0	1215.0
Ganga Action Plan	455.0	570.0	603.0	620.0	546.0
Environment / Ecology and Environment	307.0	360.4	321.0	308.3	379.7
Forestry & Wildlife	276.9	290.9	289.8	364.3	523.7
Source	MoEF 1988	MoEF 1989	MoEF 1990	MoEF 1991	MoEF 1992

The NWDB tried out various institutional mechanisms to promote local people's involvement in forestry. The key ideas it adopted included grants to voluntary agencies, promotion of decentralized people's nurseries, provision of margin money for plantation projects financed through banks, tree *pattas*, and tree growers' cooperatives. Although there had been a greater emphasis on fuelwood as

[59] Although the actual proportion of funds made available was somewhat less than the target, these still constituted the bulk of funds available for tree plantation during this period (Planning Commission 1988).

compared to fodder since the social forestry era[60], fodder plantations assumed greater importance after the severe drought of 1987 (Planning Commission 1988)[61].

Although NWDB could not achieve its ambitious target, it did promote plantations on a massive scale. The total cumulative area of plantations in the country up to 1985 was 8.21 million hectares. And just between 1985 and 1992, as much as 11.99 million hectares of new plantations were established (MoEF 1998a). This period also saw a tremendous interest in the issue of wastelands in the country, as reflected in numerous meetings and publications (see, for example, VIKSAT and SPWD 1984; Agarwala 1985b; Bandyopadhyay et al. 1985; Hegde and Adhyankar 1986; Singh et al. 1986; Yadav 1986, 1990; Khan 1987; FRI 1988; Shankarnarayan 1988; CSIR 1990; Puri 1992)[62].

1B.6 Watershed, Joint Forest Management, Panchayats and Beyond

A key development took place in 1994 when a government committee[63] recommended that all major land development schemes should be implemented on a watershed basis[64]. The Committee based its recommendations partly on cases (e.g., Ralegaon Siddhi and Mittemari) where the watershed approach had reversed the degradation process. The adoption of the Committee's recommendations by the government led to the emergence of a strong policy narrative on watershed development. Since then, watershed became the main unit for land development program in the country. As watershed development was seen primarily as a strategy for protecting livelihoods of people living in ecologically fragile areas (MoRAE 1996; Rao 2000), up to 50 percent of funds under rural employment schemes were reserved for watershed development projects (MoRAE 1999). A common set of guidelines were issued in 1995 for all relevant schemes, which were revised in 2001 and 2003[65]. A large number of watershed development projects (usually covering 500 hectares each) were implemented in the country. These projects focused on government wastelands and village common lands though forestlands and private lands were not excluded. The main emphasis in these projects was on soil and

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[60] For example, a Rural Fuelwood Plantation Scheme had been under implementation in 157 districts since the Sixth FYP (MoEF 1988).

[61] For example, a new scheme of Silvipasture Farms was launched in 1987-88 (Planning Commission 1988).

[62] *Wastelands News* – quarterly publication of the Society for Promotion of Wastelands Development – also carried a large number of articles on wastelands-related issues and provided a platform for debate.

[63] Technical Committee on DPAP and DDP constituted under the Chairpersonship of Prof. C.H. Hanumantha Rao.

[64] Although there had been earlier calls for adopting watershed approach (e.g., MoRD Task Force under Dr. M.S. Swaminathan in 1982), it was only after the report of the technical committee chaired by Prof C.H. Hanumantha Rao that it became the dominant approach.

[65] See http://www.dolr.nic.in/fguidelines.htm (08.06.2009).

moisture conservation and rural livelihoods, and afforestation was just one of several components[66]. In 2005, another committee reviewed the watershed program (MoRD 2008) and suggested its further strengthening and expansion (DoLR 2006). Accordingly, the National Rain-fed Area Authority was established in 2006 to enable convergence of different programs (Planning Commission 2007b). Subsequently, the Integrated Watershed Management Programme was launched by MoRD under a new set of guidelines issued in 2008 (MoRD 2008). The sheer scale of the watershed program in the country can be gauged from the fact that as much as 50.899 million hectares had been covered by the end of the Tenth FYP (Planning Commission 2007b).

While the focus on non-forest lands was shifting towards watershed management, a major change was occurring on forest lands as well. A new program called JFM emerged in 1990[67]. Its main objective was regeneration of degraded forests by forging a partnership between the SFDs and local communities. The communities were offered greater access and a share in produce in return for protection and management of a designated forest patch. The program generated huge interest among NGOs and donors, as well and a number of externally-aided projects – with participatory forestry as a significant component – were launched[68].

The National Afforestation and Ecodevelopment Board (NAEB) was established witin MoEF, which became the national focal point for the JFM program. Towards the end of the 1990s, there was a renewed focus on achieving one-third forest and tree cover in the country. The National Forestry Action Programme, completed in 1999, laid great stress on meeting this target (MoEF 1999). The target was reiterated in *The Coimbatore Charter on Environment and Forests* agreed at a conference of central and state forest ministers and senior officials[69]. Subsequently, the target was included in the Tenth FYP (2002-07), which also laid down a timetable for achieving it, that is 25 percent by 2007 and 33 percent by 2012 (Planning Commission 2002a; see also Planning Commission 2001; Planning Commission 2003a)[70]. The Tenth FYP also proposed 'universalization of JFM', which meant initiation of JFM in all forest-fringe villages (Planning Commission 2006b, Paragraph 3.7.13). To meet these objectives, NAEB launched the National Afforestation Programme in 2002-03

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[66] See http://www.dolr.nic.in/fguidelines.htm (08.06.2009).

[67] However, some of the early experiments on which it was based (most notably Arabari and Sukomajri) were initiated in the 1970s (Sarin 1996b; Banerjee 2010).

[68] The community involvement in and around protected areas was also attempted, especially through the *ecodevelopment* programme (WWF India 1999).

[69] See http://www.envfor.nic.in/ (accessed 07.06.2009).

[70] The target was also mentioned in the National Environment Policy and the Report of the National Forest Commission, both of which were finalised in 2006 (see NFC 2006).

by merging some of the existing schemes. This program was implemented through JFM committees (Planning Commission 2006a)[71]. It also restructured the existing Grants-in-Aid scheme and renamed it as Grants-in-Aid for Greening India[72]. The importance of JFM in the 1990s and early 2000s can be gauged from the fact that over 100,000 JFM groups were organized and 22 million hectares of forest land (30 percent of the total area) was under JFM by 2006.

Along with watershed development and JFM, another key development took place in the 1990s. Through a Constitutional amendment in 1992[73], significant powers were devolved to *panchayats*. A new schedule (Eleventh Schedule) was added to the Constitution and a number of matters were entrusted to them. These *inter alia* included land improvement, soil conservation, watershed development, social forestry and farm forestry, and fuel and fodder. As a result, considerable emphasis was laid on the involvement of *panchayats*, especially in the watershed development program, and to a lesser extent, also in the JFM program[74].

The new millennium brought a sharper focus on rights-based approaches, reflected most notably in the enactment of the Forest Rights Act, 2006. A high-level committee constituted jointly by the Ministry of Environment and Forests and the Ministry of Tribal Affairs recommended that JFM areas should be managed as community resources under Section 3(1)(i) of this Act (MoEF and MoTA 2010). Similarly, there was also a renewed focus on Panchayats (Extension to Scheduled Areas) Act, 1996 that gave extensive rights over natural resources to local people in Schedule V areas (tribal areas). In addition, there was considerable emphasis on improving NTFP governance and rehabilitation and resettlement packages for people affected by various projects[75].

Although afforestation remained important, issues of ‘quality’ began gaining entry into policy narratives too, with a particular emphasis on ecosystem services. The following two extracts from the Eleventh FYP and its Mid-Term Appraisal illustrate this shift:

> *The target of 33 percent forest and tree cover reflects the tree component without accounting for other vibrant non-tree natural biomes...recognition of*

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[71] Initially launched as a pilot scheme in 2000-01 under the title *Samnavit Gram Vanikaran Samridhi Yojana* (Integrated Village Afforestation and Development Scheme). The JFM committees were organised into groups called Forest Development Agencies for implementing the scheme.

[72] See www.forests.tn.nic.in/PublicUtilities/graphics/NAEBGuidelines.pdf (accessed 29.03.2010).

[73] The Constitution (Seventy-third) Amendment Act, 1992. Source: http://indiacode.nic.in/coiweb/amend/amend73.htm (accessed 30.03.2010).

[74] The role of *panchayats* was particularly emphasised in the *Hariyali* watershed guidelines issued in 2003 (MoRD 2004).

[75] This concern was also reflected in the draft National Land Acquisition and Rehabilitation & Resettlement Bill, 2011 (Source: http://rural.nic.in/ (accessed 05.08.2011)).

biodiversity characteristics and ecological services rendered by habitats like grasslands, natural desert ecosystems, alpine, and riparian habitats suggests that several biomes, even if devoid of tree component, can be recognized as 'green cover' and accounted so (Planning Commission 2007b, Paragraph 9.1.18).

There is a need to change our mindset away from a 'quantity' focus towards a 'quality' focus. We should not merely focus on increasing the area under forest and tree cover, as we have traditionally done, but instead focus on increasing the quality of our forest and tree cover (Planning Commission 2010, Paragraph 22.4).

The concept of *payment for ecosystem services* also became prominent policy narratives towards the end of the first decade of the new millennium. The following is an extract from the statement issued by a conference of Chief Ministers of Himalayan states:

They will work to ensure that financial incentives are provided for natural resources, which capture the cost of ecosystem services, carbon sequestration as well as land and livelihood opportunities (Extract from the Shimla Declaration on Sustainable Himalayan Development, Shimla, 30.10. 2009).

One development that affected the afforestation narrative significantly was creation of the Compensatory Afforestation Fund Management and Planning Authority (CAMPA) on the orders of the Supreme Court of India[76]. This body was entrusted with the responsibility of managing funds obtained from the diversion of forest lands[77] for afforestation and forest development purposes. A large amount of funds accumulated with CAMPA within a few years[78] and exceeded the regular central budgetary provisions for forestry[79]. The afforestation narrative was also affected by a growing interest, especially from the early 2000s onwards, in raising bio-fuel plantations, especially of *Jatropha curcas* and *Pongamia pinnata* (Planning Commission 2003b; MoRD 2004, 2006, 2008). The stated objectives included 'rehabilitating degraded lands' and reducing the country's huge oil import bill (Planning Commission 2003b, ix). In addition, the *India Vision 2020* document issued

[76] The process for establishing CAMPA started with an Interim Order of the Supreme Court of India in an ongoing case in 2002, which was followed up with several other orders as well. Formal constitution through MoEF Order No. S.O. 525(E) dated 23.04.2004. The higher judiciary started to exert a significant influence on forestry policies from the mid-1990s onwards (Banerjee 2010), especially through a particular case popularly referred to as the Godavarman case or forest case (WP No. 202 of 1995).

[77] These funds are collected from industrial, commercial, or development projects that use forest lands.

[78] The total fund size had reached INR 112 billion by 2009 (MoEF 2009b).

[79] Source: Presentation made by MoEF to the Prime Minister's Council on Climate Change, 22.02.2011.

in 2002 also contemplated energy plantations to generate as much as 100,000 megawatts of power (Planning Commission 2002b). However, interest in these plantations subsequently waned somewhat due to poor productivity and land availability.

1B.7 Climate Change

For some years now, policy narratives have shifted considerably towards the issue of climate change. In 2008, the Prime Minister announced a national action plan to combat climate change and launched the *National Mission for a Green India* (MoEF 2010) – one of the eight missions announced by him (GoI 2008).

Mitigation of climate change emerged as an important objective of raising tree plantations:

> *Due to this [plantations], the carbon stocks in Indian forests have increased over the last 20 years…(GoI 2008, 18; see also Ravindranath et al. 2008; Kohli and Menon 2011a,b).*

It seems that policy narratives are going to be focused on climate change for some time. In the National Mission for a Green India, JFM has been presented as a key strategy to combat climate change (MoEF 2010). Even Indian forest-based industry has started projecting the carbon sequestration potential of industrial plantations (FICCI 2007). A booklet issued by MoEF in August 2009, in the run up to the climate change meeting at Copenhagen, noted:

> *India's forests serve as a major sink of CO_2... Clearly, India's forest and tree cover is serving as a major mode of carbon mitigation for India and the world (MoEF 2009, 5).*

The National Mission for a Green India has kept a target for increasing forest/tree cover by 5 million hectares and improving quality of such cover on another 5 million hectares. The focus likely to be on climate change issues in the coming years (MoEF 2010). As the Mission also emphasizes on JFM (though with greater links to *panchayats*), it is likely to see renewed interest among the policy makers and practioners alike. There is also likely to be a emphasis on leveraging public investment under rural development initiatives such MGNREGA[80] and the National Rural Livelihoods Mission.

1B.8 Conclusion

Different policy narratives have shaped India's policy and physical landscape for around 150 years. These narratives have continuously evolved in accordance with

[80] Mahatma Gandhi National Rural Employment Guarantee Act, 2005.

the perceived national needs and priorities such as revenue, food, fuel and fodder, combating deforestation and poverty, and climate change. The power of these narratives is reflected through the policies and programs they have spawned.

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LECTURE 2: THE FOREST AS AN ECOSYSTEM

This lecture covers the following:

- Traditional forest management objective and impacts
- Principles of sustainable forest management
- Evolution of EAFM
- Principles of an ecosystem approach (CBD)

2 SUSTAINABLE FOREST MANAGEMENT AND ECOSYSTEM APPROACH TO FOREST MANAGEMENT

2.1 Introduction

Forests are one of the most important components of the terrestrial environmental system. The United Nations General Assembly declared 2011 as the International Year of Forests to raise awareness on sustainable management, conservation, and sustainable development of all types of forests and to further highlight the important role of forests for people. An international study conducted in 2010, “The Economics of Ecosystem and Biodiversity” popularly known as TEEB, has been an attempt to demonstrate the economic value of biodiversity and ecosystems, and their services, and integrate into everyday decision making. It concluded that human activity has significant and escalating impact on the biodiversity of the world ecosystems and reduces both their resilience and biocapacity. The report referred to natural systems as humanity’s “life-support system,” providing essential ecosystem services.

The scientific management of forests in India has a long history of more than 150 years. It started in early 1860s with the appointment of Sir Dietrich Brandis as the first Inspector General of Forests of India in 1864 and promulgation of first Indian Forest Act in 1865. The Act was subsequently replaced by a more comprehensive legislation in 1878 that facilitated the acquisition of forests and their management in a more organized manner. The earlier part of the 1950s witnessed the consolidation of ex-princely and zamidari forests and industrial plantations. In 1972, the *Arabari* experiment on joint forest management (JFM) in Sal forests of West Bengal paved the way for the involvement of local communities in the management of forests by promising them jobs on the plantation and rights to non-timber forest products (NTFP) collection. However, it was an isolated case. JFM in India was formally institutionalized in 1990 with the issuance of guidelines by the Government of India.

With the passage of time, the concepts and systems of forest management have changed considerably to address the contemporary issues and related policies. Recently, there has been a paradigm shift in the objectives of forest management. The present day focus is on adopting a people-centric approach for sustainable management of forests (SMF) with an ecosystem approach to forest management (EAFM).

2.2 Dominant Considerations in Forest Management

The dominant considerations in forest management over a period of time can be summarized as below.

TABLE 2.1: FOREST MANAGEMENT CONCERNS OVER TIME

1850–1900	Consolidation of forests, production of timber for defense, railways and constructions, agricultural expansion, and hunting reserves
1900–1947	Regulated production of timber for commercial and social needs, revenue to government, grazing
1947–1960	Consolidation of ex-princely and ex-zamindari forests, revenue maximization, and industrial plantation
1961–1980	Revenue maximization, afforestation, enhancement of forest productivity
1980–1990	Ecological considerations, social and farm forestry, protection of natural forests
1990–2000	Sustainable development, people's participation in forestry, and tribal development
2000-onward	Sustainable forest management, criteria and indicators (C&I) approach, livelihood, biodiversity conservation, ecosystem approach, economics of ecosystem services, and forest valuation

2.3 Status of Forest Resources in India

India is one of the 17 mega-biodiverse countries (Conservation International, 1998). As per the latest estimate of the India State of Forest Report (India-SFR, 2013), the forests constitute 21.23 percent (697,898 km^2) of total geographical area of the country. The forests have been classified into (i) very dense forest (canopy density of 70 percent and above), (ii) moderately dense forest (canopy density between 40 percent and 70 percent), and (iii) open forest (tree canopy density of more than 10 percent but less than 40 percent). In terms of density classes, area covered under very dense forest (VDF) is 83,502 km^2 (2.54 percent), under moderately dense forest (MDF) is 318,745 km^2 (9.70 percent), and open forest (OF) is 295,651 km^2 (8.99 percent). The area under VDF, MDF, and OF also includes mangrove cover (4,629 km^2) of the corresponding density classes (FSI, 2013).

India's population has grown from 361 million in 1951 to 1.21 billion in 2011, with decadal growth rate of 17.4 percent over 2001 (provisional census data from 2011). The per capita availability forest has thus declined considerably from 0.08 ha in 2001 to a minimal figure of 0.06 ha in 2011, which is one of the lowest in the world.

2.4 National Policy in Forest Management

The owner defines the priorities in the management of a resource. In India, virtually all forests are owned by the state. The priorities of the state are laid down in the National Forest Policies (Lal, 2005). National policies and programs should take into account the relationship, where it exists, between the conservation, management, and sustainable development of forests and all aspects related to production, consumption, and recycling and/or final disposal of forest products (UNCED, 1992). The first National Forest Policy was introduced in 1894. Post-independence the second and third National Forest Policies were introduced in 1952 and 1988, respectively.

The major drawbacks of 1894 Forest Policy were as follows:

- Land use subordinated forestry to agriculture.

- There was inadequate emphasis to protective and regulative services produced by forests.
- Management of forests did not stipulate the principles of sustained yield.
- There was no suggestion of protection of forests from harmful practices of shifting cultivation and excessive grazing.

2.4.1 Shifts in Policies (1894 to 1952)

Post-independence, the second National Policy was introduced in 1952. The second policy witnessed the following shifts from the 1894 policy:

- Management for an increase in forest area and stress on having at least 33 percent of the land area of the country under forest cover,
- Comparison of agriculture to forest as “a foster mother not only to agriculture but other industrial and commercial purposes,” and
- Maximum revenue/benefits to the crown to “general well-being of the people.”

2.4.2 Third National Forest Policy (1988)

The Third National Forest Policy was introduced in 1988. The policy acknowledged the concerns about serious depletion of forests. The major focus in the Third National Forest Policy were enhancement of area under forestry, massive afforestation, scientific management of state forests, the tribal-forest interface, participatory management, alternative avenues of income to discourage shifting cultivation, forest extension, and promotion of forestry research and education.

2.5 Sustainable Development

Sustainable development not only encompasses the environmental consideration but further aims to improve human well-being. *Our Common Future* (also known as the Brundtland Report) states ‘sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” (WCED, 1987). Thus, the sustainable development envisages both economic growth and ecological stability.

Sustainability will vary in the context of ecology, economy, and the social and cultural environment of the country or region. The definition also has to be flexible and innovative; and to be of any use, it has to be less theoretical and more practical (Lal, R.B. 2011).

2.5.1 Doctrine of Sustained Yield

The early working plans written for management of forests prescribed exploitation of forests on a sustained yield basis. The doctrine of sustained yield envisaged that natural resources should be used by a generation in such a manner that its productivity is not diminished and the generation to follow derives equal benefit from it. The principle of sustained yield ordains that silivicultural systems should ensure maintenance of soil fertility and unhampered regeneration of species forming the

crop. The emphasis is on sustainable commodity production. The doctrine in principle implied that harvest from forests should not exceed the increment. The principle would have worked well had the demand on forests, vis-à-vis growing stock, been static. However, with the population growth and increasing demand on forests, the concept of sustained yield had to be replaced by progressive yield and subsequently to sustainable forest management (SFM). This is because over time the benefits derived from forest were no longer limited to timber, fuel wood, and fodder for domestic consumption but included services such as watershed management, recreation, clean environment etc. There was an increase in the number of stakeholders. Socio-cultural and spiritual values of forest, though known earlier, were not truly appreciated. The economics of ecosystem and biodiversity are now better understood.

2.6 Sustainable Forest Management

The concept of SFM has continued to evolve since 1992 through the international forest policy dialogue with Intergovernmental Panel on Forests (IPF), Intergovernmental Forum on Forests (IFF) and United Nations Forum on Forests (UNFF) and through a large number of country-led and eco-regional initiatives aimed at translating the concept into practice. It included the development of criteria and indicators of SFM supported by international organizations such as the Food and Agriculture Organization (FAO), the International Tropical Timber Organization (ITTO), United Nations Environment Programme (UNEP) and other members of the Collaborative Partnership on Forests. SFM encompasses two key elements: economics and ecology. SFM is about balancing conservation, production, and use of forest goods and services and incorporating a broader range of environmental and social objectives. The definition of sustainable forest management given in the Helsinki's Conference of European Ministers in 1993 as "use of forests and forest land in a way and at a rate that maintains their biodiversity, productivity, regeneration capacity and their ecological, economic, and social functions while not causing damage to their ecosystems" indicates that in addition to ecological and economic aspects, social aspects are equally important.

The Food and Agriculture Organization of the UN (FAO) has defined SFM as:

> *"The stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfill, now and in future, relevant ecological, economic and social functions, at local, national and global levels, and that does not cause damage to other ecosystems."*

2.6.1 Sustainable Development vis-à-vis Sustainable Management

Sustainable development comprises three main interrelated goals: (i) to ensure that all society's needs are met; (ii) to ensure that all members of society have their needs met; and (iii) to ensure that all development is sustainable over time in a social, economic, and environmental sense. Sustainable management also

emphasizes (i) more full recognition of the environmental costs of activities and policies, and (ii) better environmental stocktaking.

2.6.2 Joint Forest Management

As envisaged in Third National Forest Policy (1988), JFM was formally launched in 1990s after issuance of guidelines to that effect by the Government of India. It marked an era of participatory forest management in India. It was appreciated that forest management was no more a regulatory function, but a development function. Policing approach was replaced by participatory methods. It was a shift from “top down” to a “bottom up” approach. JFM was found to be a better strategy to manage common property and regenerate degraded forests.

The salient features of JFM in India are as follows:

- Micro-level planning,
- Decentralized and democratic system of rural resource allocation,
- Empowerment of community,
- Sharing of authority & responsibility,
- Social fencing approach,
- Focus on NTFPs,
- Sharing of usufruct,
- Market development,
- Integration of short-term economic gains to long-term sustainability, and
- Recycling of the benefits.

There were mixed responses to the program. In most of the cases, it was quite successful; in some of the cases, it failed to make the desired impact, due to attitudes and ethos of bureaucracy, lack of understanding of socioeconomic and cultural value systems of the local people, inter- and intra-village conflicts; lack of statuary authority to local institutions; inadequate participation of citizens; and coverage of only degraded forests. Despite these shortcomings, JFM was an improvement over the traditional forest management in India, and it promoted an ecosystem approach.

2.6.3 Criteria & Indicators: a Tool for Assessing Sustainability of Forests

The Criteria & Indicator (C&I) approach was developed and further refined for SFM in India. It was developed by Indian Institute of Forest Management (IIFM) following International Tropical Timber Organization (ITTO) definition of SFM commonly known as the Bhopal-India process. It was done to assess the extent to which forests had been managed sustainabaly. In many developed countries, C&I form the basis for measuring progress toward SFM and have been institutionalized in their system of management. However, in most developing countries, the action is limited

for want of necessary information and capabilities in development and implementation of the approach.

Criterion: A criterion may be defined as a standard by which sustainability of forest management can be assessed.

Indicators: Indicators are measurable entities to indicate if a criterion of sustainability is being fulfilled in forestry practices.

The national set of C&I for sustainable management of natural forests in India was issued by the Government of India, Ministry of Environment, Forests and Climate Change in 2014. It has eight criteria and 37 indicators. The C&I based on the principles of ecological integrity, social acceptance, and economic viability have also been incorporated in the National Working Plan Code of 2014. The eight criteria so defined are (i) maintenance/increase environmentally secured forests; (ii) maintenance, conservation and enhancement of biodiversity; (iii) maintenance and enhancement of forest health and vitality; (iv) conservation and maintenance of soil and water resources; (v) maintenance and enhancement of forest resource productivity; (vi) optimization of forest resource utilization; (vii) maintenance and enhancement of social, cultural and spiritual benefits; and (viii) adequacy of policy, legal, and institutional framework. The eiight criteria are supported by 37 indicators to measure the sustainability of a criterion.

2.7 An Ecosystem Approach to Forest Management

An EAFM consists of maximizing the output of some desirable product or service, but deciding upon a mix of products and services that can be obtained without either degrading the structure or impairing the functioning of the ecological system. The ecosystem theory only demands that output of one product or service is maximized to the extent it does not degrade the structure or impair the efficient functioning of the system. (Lal, J.B., 2007). EAFM is about balancing and integrating conservation and use of biological diversity. EAFM maintains a balance between conservation and development where poverty reduction and economic growth are predominant considerations and is a logical progression from SFM.

2.7.1 Evolution

Subsequent to the Rio Summit in 1992, EAFM was primarily developed within the framework of the CBD. However, “ecosystem management” as a concept had been around much before the CBD. The definition of ecosystem approach and a set of 12 principles for its application were developed in an expert group meeting in Malawi in 1995, known as the Malawi Principles. The definition, the principles, and five operational guidance points were adopted by the CBD Conference of the Parties (COP) to CBD in its fifth meeting in 2000. The COP further recognized that:

> *“Application of the ecosystem approach will help to reach a balance of the three objectives of the Convention; conservation, sustainable use and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. It is based on the application of appropriate scientific*

methodologies focused on levels of biological organization which encompass the essential processes, functions and interactions among organisms and their environment. It recognizes that humans, with their cultural diversity, are an integral component of ecosystems."

The principles and concepts common to both sustainable forest management and the ecosystem approach include national sovereignty over resources, duty of care, the polluter pay principle, participation, intergenerational equity, conservation of ecosystem structure and functioning, multiple and sustainable use of resources, need for environmental impact assessment, and equitable benefit sharing (CBD Subsidiary Body for Scientific and Technological Advice, 9th Meeting, July 2003)

Definition: The CBD defines EAFM as "a strategy for the integrated management of land, water, and living resources that promotes conservation and sustainable use in an equitable way."

a. Principles

EAFM's 12 principles as developed by CBD are as follows:

- The objectives of management of land, water, and living resources are a matter of societal choices.
- Management should be decentralized to the lowest appropriate level.
- Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.
- Recognizing potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context.
- Conservation of ecosystem structure and functioning, to maintain ecosystem services, should be a priority target of the ecosystem approach.
- Ecosystem must be managed within the limits of their functioning.
- The ecosystem approach should be undertaken at the appropriate spatial and temporal scales.
- Recognizing the varying temporal scales and lag effects that characterize ecosystem processes, objectives for ecosystem management should be set for long term.
- Management must recognize that change is inevitable.
- The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity.
- The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations, and practices.

- The ecosystem approach should involve all relevant sectors of society and scientific disciplines.

b. Operational Guidance Points

The five operational guidance points are as follows;

1. Focus on the functional relationships and processes within ecosystems.
2. Enhance benefit sharing.
3. Use adaptive management practices.
4. Carry out management actions at the scale appropriate for the issue being addressed, with decentralization to lowest level as appropriate.
5. Ensure inter-sectoral cooperation.

EAFM and SFM are both based on ecosystem functioning. Both express similar goals and ambitions for forest management, focusing on generating and maintaining benefits for both present and future generations (FAO, 2003). In comparison to SFM, EAFM also takes into account the social and institutional dimensions. While the traditional forest management had a sectoral approach, the ecosystem approach, in contrast, integrates all the sectors. SFM is usually centralized whereas EAFM is decentralized to the lowest level, and is concerned both with environmental and social contexts.

2.8 Conclusion

Economic development of any country is mainly based on its resources and entrepreneurial skills. The concepts of forest management have changed over time to meet the demands on forests. There is an urgent need to recognize the increasing role of forests in an expanding economy and a need to meet the present day demands on forests and fulfill India's international commitments on contemporary global issues. The concepts of both SMF and EAFM have a common goal of achieving sustainability of forests for the benefit of present and future generations. It is thus possible to develop synergies between the two. The ecosystem approach can be an effective tool in achieving the sustainable development goal of poverty alleviation and ensuring environmental sustainability.

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MODULE 2: ECOLOGY AND MANAGEMENT

The study of the interaction of life and its abiotic environment is the purview of ecology. Ecology's study of this interaction has led to the recognition that interactions can lead to unpredictable effects at longer spatial and temporal scales. This has in turn informed management strategies such as adaptive management, and the avoidance of irreversible effects in management practice.

This module's first lecture gives the reader an introduction to ecology. Considering the large size and lifespan of forests, the second lecture describes landscape planning, the goal of which is to plan at large spatial and temporal scales. The last lecture describes the importance of soils for forest ecosystem heath, and draws the reader's attention to the irreversibility (from the human perspective) of the degredation and loss of forest soil.

LECTURE 3: FOREST ECOLOGY

This lecture covers the following:

3A Part 1

- Ecosystem concept
- Ecosystem components
- Energy flow
- Nutrient cycle
- Hydrological cycle in forest ecosystem

3B Part 2

- Population and community ecology
- Succession
- Species migration

3A PART 1

3A.1 Introduction

Forests are a valuable natural resource. In addition to timber and non-timber products, forests provide numerous environmental services, such as regulation of droughts and floods, control of soil erosion and sedimentation of downstream water bodies, amelioration of climate, protection against weather damage, ground water recharge, conservation of genetic resources and biological diversity, and generation of recreational benefits and aesthetic values.

The human environment is impacting the natural environment in a myriad of ways. Its manifestations are being felt in the form of global warming and climate change. In recent years, climate change has emerged as a major global issue of common concern. It is likely to affect the poor in developing world the most. Forests affect climate in a variety of ways: as sources of greenhouse gases (GHGs), as reservoirs of potential GHGs (as sinks that sequester GHGs), and through directly influencing energy dynamics on a landscape scale. In addition, climate change influences forests. This is why the forestry sector has been an important area of international climate policy negotiations since the 13th Conference of Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC) held in Bali in 2007.

The need for conservation of forest resources is gaining wide acceptance. Wise management of forests can keep them perpetually productive and useful, whereas neglect and continuous overexploitation can deplete and eventually exterminate them. In addition to the ecological impacts, forest degradation adversely affects the well-being of people living nearby or relying on the forests for their livelihood. Ecology provides the foundation for forest management. It is, therefore, necessary to fully appreciate the role of forests and develop a thorough understanding of relationships of its components based on an ecological approach for rational and responsible forest management both on a temporal and spatial basis.

3A.2 Ecology and the Ecosystem Concept

Ecology is the study of the relationship of organisms or groups of organisms to their environment. Viewed in hierarchical arrangement from large to small, based on the concept of levels of organization, ecology can be subdivided into (i) ecosystem ecology, (ii) community ecology, and (iii) population ecology. Ecology can also be subdivided by habitat type, e.g., marine and terrestrial ecology.

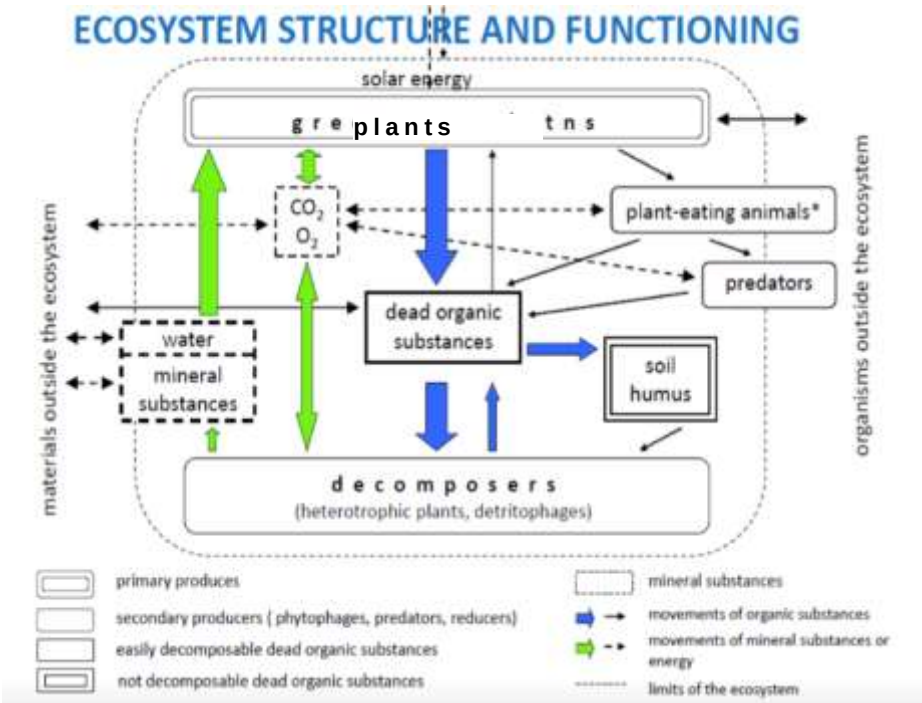
Living organisms and their non-living environment are inseparably linked. A community of species interacting among themselves and with the physical environment is called an ecological system or ecosystem.

During its evolutionary history, the biosphere has differentiated as a function of climate, geological substrate, available genetic information, and the action of living organisms into a complex pattern of interdependent units called ecosystems. Ecosystems are well-exemplified by various types of forests, savanna, grasslands,

and other habitats which make up the landscapes of the globe. The ecosystems, although a part of a larger continuum, are endowed with more or less specific system characteristics. It has been convenient to use ecosystems as basic units while recognizing that they can be grouped together in larger units according to their interactions.

The basic design of the ecosystem is that of a machine capable of intercepting radiant energy from the sun, converting it into chemical energy through photosynthesis and distributing this chemical energy in such a manner as to ensure maintenance of its functional structure. Green plants are instrumental in photosynthesis; herbivores and predators contribute to the distribution of energy and matter; and decomposers permit the breakdown of dead organic matter. The mineral elements locked up in organic matter are then available again to plants. Control mechanisms, often closely related to species diversity, enable ecosystems to maintain, or reestablish (if exposed to disturbance) their functional structure. The schematic representation of the structure and functioning of an ecosystem is shown in Figure 3A.1.

FIGURE 3A.1: ECOSYSTEM STRUCTURE AND FUNCTIONING



Source: Kulhavy et al.*, 2014*

Ecosystems have the following distinguishing characteristics:

- **Structure**: Ecosystems can be conveniently divided in the following components (i) inorganic substances involved in material cycle, (ii) organic compounds that link biotic and abiotic factors, (iii) climate regimes, (iv) producers, (v) macroconsumers or heterotrophs, (vi) microconsumers or saprotrophs.
- **Function**: Based on functions, ecosystems may be conveniently analyzed in terms of the following (i) energy circuits, (ii) food chains, (iii) diversity pattern in

time and space, (iv) nutrient (biogeochemical) cycles, (v) development and evolution, and (vi) control (cybernetics).

- **Complexity**: Complexity results from the high-level of biological integration that is inherent in an ecosystem. All events and conditions in an ecosystem are multiply determined. They are therefore difficult to predict without a considerable knowledge of structure and functional process of the system.
- **Interaction and Interdependency**: Because the interconnectedness of the various living and non-living components of the ecosystems is complete, a change in any factor will result in a subsequent change in almost all the others.
- **Diffused Boundaries**: An individual organism is a tangible entity. It has a clearly defined physical size. Population and communities are also spatially defined entities, although their size may sometimes be rather difficult to define. The ecosystem focuses on structure, functioning complexity, and interaction of the system and not on the geographic boundaries of the system, which makes the boundaries more diffuse.
- **Temporal Change**: Ecosystems are not static, unchanging systems. In addition to the continuous exchanges of matter and energy, the entire structure and function of an ecosystem undergoes change over time.

Two guiding principles of ecosystem management are:

- Current management should not impair or degrade the long-term productivity of the site.
- Ecosystem management should not jeopardize the diversity and viability of native plant and animal populations.

Forest ecology is the application of general ecology to a specific type of ecosystem--the forest. Forest ecology involves studies at the individual, population, community and ecosystem levels, but such studies should always involve the ecosystem concept. Although forest ecology has traditionally been thought of as largely concerned with the community level organization, its full contribution can be realized only if all levels of biological organization within the forest ecosystem are studied.

3A.3 Energy Flow

Energy flow is the transfer of energy from one organism to another in an ecosystem. The study of inputs, storage, and transfer of energy in an ecosystem is called ecological energetics. Distribution and movements of energy are responsible for the productivity of the ecosystem. Energy remains the ultimate determinant of ecosystems and the central thread of ecology.

Based on the sources of energy supply, living organisms have been broadly classified into two major divisions (i) the autotrophic organisms that utilize abiotic sources of energy and are referred as primary producers, and (ii) the heterotrophic organisms that depend on biotic energy. To illustrate energy flow and feeding

relationships in an ecosystem three models are used (i) food chains, (ii) food webs and (iii) food pyramids. Energy transfer sequences are referred to as food chain or trophic chains. The successive stages along a trophic chain are called trophic levels. Ecosystems are complex and so are the trophic chains resulting in a tropic web. The trophic webs can be represented as a series of stages or trophic levels in the transfer of energy in the system and can be summarized in a diagram referred to as an ecological pyramid. There are three types of ecological pyramids (i) pyramid of numbers, (ii) pyramid of biomass, and (iii) energy flow pyramid.

For understanding the ecosystem function, though the pyramid of number and the pyramid of biomass provide useful information, they do not furnish adequate information for long-term ecosystem management. This problem is overcome by the study of the energy flow pyramid. The pyramid of number and pyramid of biomass may be upright or inverted, but the energy flow pyramid is always upright because during the transfer of energy from one trophic level to the next, there is always a loss of energy. At each link in the food chain, 80 to 90 percent of energy transferred is lost as heat. Energy flow pyramids provide information in respect to biomass accumulation in different tropic levels. The combination of all three types of pyramids gives a complete representation of the ecosystem.

The productivity of an ecosystem is determined by the efficiency with which energy enters and is passed through the tropic web. Forestry, like other branches of management is concerned with production, and harvestable quantity of energy. In respect of energy flow, it is worthwhile to examine important terminology. Crop refers to total volume or weight of material that can be removed from a given area over a given period. Standing crop is the weight or volume of material that can be harvested by a particular method from a given area at a particular time. Crop and standing crop are the same at the time of harvest. Yield is the average rate of accumulation of harvestable material: crop divided by the period of crop production. In forest management, yield is the factor of greatest long-term interest because it determines the return on investment—essential information for production forestry.

For crop, standing crop, and yield, ecologists use rather similar terms: production, biomass, and productivity respectively. Production refers to increase in total weight (biomass) or quantity of organic matter material on a given area over a defined period. It refers to crop plus the non-harvested or non-harvestable organic matter produced over the period, plus losses to other population, tropic levels, or ecosystem. Production can be subdivided into gross production and net production. Biomass describes the total weight of organic material in a population, tropic level or an ecosystem in a given area at any point in time. Productivity refers to production per unit area per unit time and is analogous to yield. Foresters are concerned with harvesting net primary production. Forests are one of the more efficient forms of vegetation for converting light energy into plant material especially in inhospitable environments owing to the degree of canopy closure, the effect of light efficiency, and the retention of nighttime respiratory carbon dioxide. Production forestry is largely concerned with manipulating energy flows.

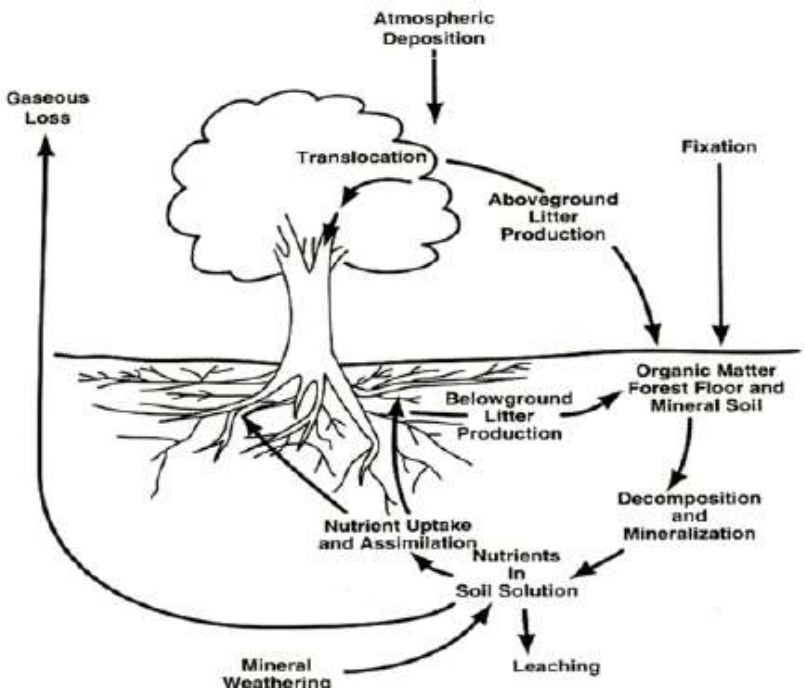
3A.4 Nutrient Cycle

Unlike energy which enters, flows through, and is ultimately lost from an ecosystem, the chemical elements (nutrients) associated with energy flow are returned to the non-living parts of the ecosystem (cycled) and may again be taken up by the plants, may be moved to another ecosystem, or may go in long-term storage.

Nutrients may cycle between living organism and the atmosphere, between organisms and the soil, or within plants and animals. The movements of elements in an ecosystem can broadly be classified in three major categories (i) the geochemical cycle, (ii) the biogeochemical cycle, and (iii) the biochemical cycle. For each cycle, there are two compartments or pools: (i) the reservoir pool (the large, slow moving, generally non-biological component), and (ii) the exchange or cycling pool (a smaller but more active portion that is exchanging [i.e., moving back and forth] rapidly between organisms and their immediate environment) (Figure 3A.2).

Forests have an intrinsic ability to store and recycle nutrients and if undisturbed they may be able to remain in a state of equilibrium. Perturbations in the above state may result in loss of nutrients and degradation of forests cascading into numerous environmental problems. There is growing concern about the exploitation of forests (particularly in the tropics for timber production) or clearing of forests (for shifting cultivation or permanent agriculture). These changes in landscape pose a serious threat of removal of nutrients from the land leaving nutrient-poor soils. It is the biogeochemical efficiency of forests which offers solutions to these problems. Therefore, maintaining the biogeochemical cycle and management of nutrients is of great importance in forestry.

FIGURE 3A.2: NUTRIENT CYCLING



Source: Waring and Running, 1998

3A.5 Hydrological Cycle in the Forest Ecosystem

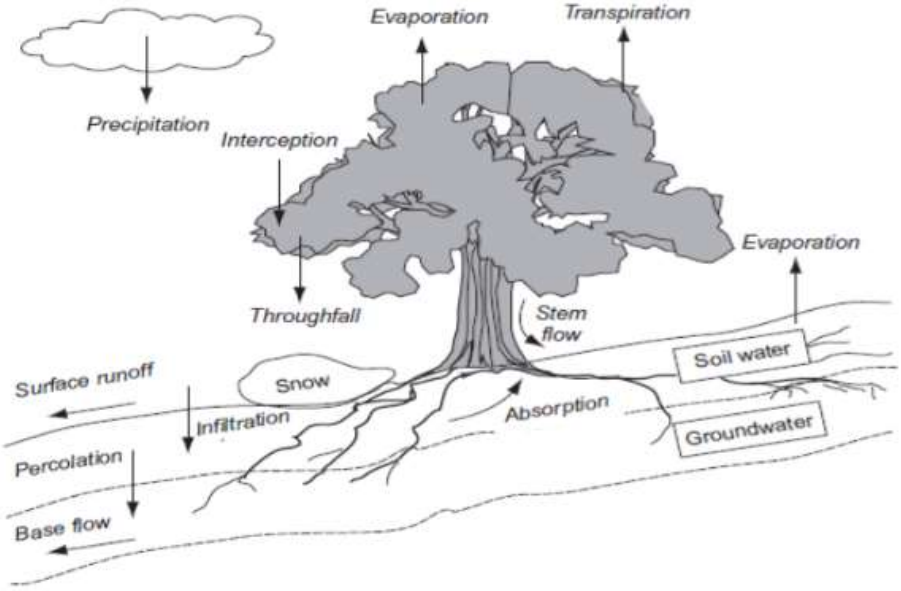
Water is a vital resource and second only to energy in terms of importance for sustenance of life. The water cycle or hydrological cycle describes the continuous movement of water on, above, and below the surface of the earth. The mass of water on earth remains fairly constant over time but its partitioning into major reservoirs of ice, fresh water, saline water and atmospheric water is variable depending on a wide range of climatic variables. The water moves from one reservoir to another such as from river to ocean, or from ocean to atmosphere, by the physical process of evaporation, condensation, precipitation, infiltration, runoff and subsurface flow. The water cycle involves exchange of energy which influences climate.

Water and solar energy are essential for the functioning of the earth system. Since neither is distributed evenly around the globe, the mechanisms by which they are redistributed (the global hydrologic cycle and energy budget) are important. The hydrological cycle also controls the earth's biogeochemical cycles by influencing all biotic processes, dissolving nutrients, and transferring them within and among ecosystems. These nutrients provide the resources that support the growth of organisms. The movement of materials that are dissolved and suspended in water links ecosystems within a landscape.

The hydrological cycle is an important feature of all ecosystems, particularly forests, which generally grow in climates where precipitation provides more water than the vegetation can use or soils can store. The excess water contributes to stream flow which provides for irrigation and urban needs far from the source of precipitation.

Canopies intercept and retain part of the incident precipitation (intercepted water), which is eventually evaporated from the canopy and lost to the atmosphere. The water intercepted by tree crowns is redistributed in the form of through fall—the portion of the incident precipitation which drips from or falls through the canopy, and stem flow—that portion which reaches the soil by flowing down the stem. Once the water reaches the ground, it can either flow laterally over the surface or infiltrates into the soil recharging the groundwater table. Water balance in an ecosystem is shown in Figure 3A.3.

FIGURE 3A.3: WATER BALANCE IN AN ECOSYSTEM



Source: Waring and Running, 1998

Without forest vegetation, most of the water coming in the form of rainfall would be lost to rivers resulting in progressive drying of air and resultant reduction in atmospheric humidity and precipitation besides erosion and flooding in the catchment. Forests are responsible for maintaining the quality and regimen of stream water. It is estimated that the annual average value of ecosystem services of tropical forests in terms of water supply (provisioning) is US$300 per hectare and in terms of water flow regulation (regulatory) is US $19 per hectare. Therefore, forest conservation in many watersheds for its water values may outweigh many tangible gains from other uses for the forest and forest products.

3B PART II

3B.1 Population Ecology

Population is a group of organisms of the same species occupying a common space. Some of the important properties of population are density, natality, mortality, age distribution, biotic potential, dispersion, and growth. A population has “biological attributes” which it shares with its component organisms and it has “group attributes” unique to the group. Among the former, the population has a life history that grows, differentiates, and maintains itself as does the organism. It has a definite organization and structure that can be described. Group attributes which include birth rate, death rate, age ration, and genetic fitness apply only to the population.

Populations provide both advantages and disadvantages to the constituent members. Some of the advantages are protection against the physical environment, reproduction (which is necessary for maintaining the population), genetic diversity (to improve the ability of a population to survive), intraspecific competition (for maintaining a healthy population), and division of labor (to cope with the evolutionary development). Among the disadvantages are intense competition for resources, alteration of environment (which may become unsuitable for the population), transmission of disease, and other factors.

Population growth is an important characteristic of a population. Populations mostly exhibit relatively little change in numbers from year to year. Initially a population may grow at a geometric rate, but this is typically not sustained for long, because as the population grows in numbers so does the negative feedback caused by competition, disease, stress, and other factors. This negative feedback is referred to as environmental resistance. As a population starts increasing, this resistance is low and growth is geometrical. The environmental resistance steadily reduces the rate of population growth unless the resistance becomes so great that no further increase is possible. Such population growth has a sigmoid shape and is called a “logistic growth curve.” The population grows slowly in the beginning followed by a phase of rapid increase which in turn slows down as the numbers approach an upper limit, the carrying capacity.

While producing offspring, species typically follow one of two patterns. The one is to produce large numbers of small offspring, and the other or fewer larger offspring. Where the environment is unfavorable or unstable, risk of mortality is high, or the competition from other organisms is low, the optimum evolutionary strategy is to produce large numbers of small offspring. When the environment is more predictable and uniform with high levels of inter- or intraspecific competition, the strategy is to produce fewer but larger offspring with greater competitive ability. Species (including humans) may exhibit behavioral plasticity, transtioning between these reproductive patterns as the environment changes.

Plants are stationary, easy to enumerate, and their behavior is not as complicated as that of animals. Plants have genetically determined fecundity (potential maximum number of reproductive propagules per plant per year or per generation) and an

environmentally determined fertility (number of reproductive propagules actually produced per plant per year or per generation). The reproductive propagules have a characteristic survivorship curve in any particular environment. There is heavy juvenile mortality with most plant populations.

Tree populations have survivorship curves and age class distributions which may vary greatly between species and the stage of development of the plant community. Light demanding pioneer species tend to have a small number of age classes (i.e., are even aged) that pass up and out of the age-class distribution as the species is eliminated in the course of successional development. Shade tolerant climax species in old growth forests have a more stable age distribution.

Plants compete for limited resources in their environment and their population development and carrying capacity may be determined by factors like light, soil moisture, nutrients, soil fertility, and other factors. Interspecific competition is also an important factor. Shade-intolerant species are outcompeted by shade-tolerant species. Under conditions of low fertility, trees tolerant to low fertility will outcompete nutrient-demanding species.

Timber management is applied population ecology to a great extent. Foresters attempt to establish a population of a particular genotype of a species with the objective of attaining a particular number of mature individuals of a particular size at a particular age. This involves manipulation of age-class structure to achieve a pre-determined age-class distribution, which requires the knowledge of the survivorship curve of that genotype under the particular conditions. Knowledge of percent viability of seeds and percent seedling mortality is a prerequisite for nursery management. Knowing natural mortality rate of trees is helpful to plan intensity and frequency of thinning. Similarly, wildlife management also requires better understanding of population ecology.

3B.2 Community Ecology

Populations do not exist in isolation. A biotic community is a complex assemblage of populations that exist together in an orderly manner in a particular habitat. It is an organized unit to the extent that it has characteristics additional to its individual and population components and functions as a unit through coupled metabolic transformation. This understanding has led to the idea of a community being described as a supraorganism. A community is a living part of the ecosystem.

A community is characterized by a particular species composition, structure, and patterns of change over time, biomass, energy flow, and nutrient cycling. The community has no boundaries, although its geographical extent can be defined by the plant association.

Structure relates to vertical arrangement and spatial organization of the plants. In a forest, vegetation occurs in layers with each layer having distinct characteristics like tree layer, shrub layer, herb layer, etc. The overall growth form of communities is referred as their physiognomy. Foresters divide tree layers into different crown classes (e.g., dominant, codominant, and suppressed) on the basis of the

competitive status of the crown. These are used for both stand description and thinning for overcrowded plantation or natural stands.

Communities vary in their composition according to variations in the physical environment. The variation in physiognomy along such gradients is accompanied by variation in species composition. The sequence of biotic communities along the environment gradient is called a community gradient. If the species are distributed solely based on environmental tolerance along the gradient a continuum of vegetation change results, where there are neither identifiable grouping between layers nor sharp exclusion of species within a layer. Transition areas between two adjacent communities are zones of tension in which the member species of each community compete with those of other community for resources and occupancy of land. These transition zones are called ecotones and can be clearly seen where the adjacent communities have a different physiognomy as well as different species composition (e.g., grassland and forest).

Species avoid competition by evolving different adaptations, tolerances, requirements, behavior and other factors, as no two species that have the same set of characteristics can compete indefinitely. This led to the development of the concept of ecological niche. Niche refers to the functional role of a species in an ecosystem. It also refers to the way in which an organism fits into an ecological position in the world. Forest ecosystems are often divided based solely on the plant community. Diversity of interaction among constituent species is an important aspect of community ecology. Recognition of the importance of interspecific interaction can be helpful in managing these interactions to our advantage. Improved mycorrhizal and symbiotic nitrogen associations offer the possibility of significant increases in tree growth. Community ecology considered in ecosystem contests leads to the concept of ecological niche.

If renewable forest resources are to be sustainably managed, ecologically sound management techniques have to be used. If forest management ignores the effects of the management on the ecological mechanisms of forest productivity and on resource functioning, forest management may be no different from non-renewable resource extraction, like mineral deposits.

3B.3 Ecological Succession

Perhaps one of the most fundamental characteristics of ecosystem is “change.” This change may not be visible on a short-time scale. A combination of changes in weather, climate, individual organisms, and community of organisms results in changes in energy capture, storage of biomass, and nutrient cycling over time. The process of change in ecosystems is called ecological succession and the pattern of ecosystem conditions observed over time in a particular location is called a sere.

The type of vegetation that can develop in an area is ultimately determined by the climate. Changes in structure and composition of the community are accompanied by changes in ecosystem function. Productivity, biomass, and energy exchange between different components of the ecosystem all vary between different seral

stages and between different types of sere. Similarly, nutrient cycling also changes with succession.

Succession is largely discussed in relation to plant succession. However, succession refers to ecosystem events as it is not confined to plant communities but also animal and microbial communities. A better understanding of succession is helpful in land management. Forestry is also concerned with manipulating succession to optimize the availability of certain seral conditions.

3B.4 Migration of Species

Global warming and changing rainfall patterns are reported to have resulted in shifts or extension in species" range northward or to higher altitudes. As the globe warms, species are moving away from rising temperature to places with temperatures that are more suited to them. A well-known example of species moving higher is that of apples in lower Kullu Valley in Himachal Pradesh. With fewer days of freezing weather at 1,500 meters (m), apples are now reported to be flourishing above 2,000 m as revealed by a study done by Nagraj Adve.

A fish, oil sardines, were found on the west coast of India between Kanyakumari to Dakshin Kannada. Today they are found six degrees further north until southern Maharashtra. This shift in the range of species is also taking place in India's rivers. Along the Ganga River, for instance, four species of warm water fish--striped catfish, needlefish, tank goby, and ticto barb--can now be found swimming further north up to Haridwar.

Change in phenology (annual life cycle event), capture the effect of global warming on species. Examination of long-term records of the flowering dates of Rhododendrons since 1893 by scientists at the G. B. Pant Institute in Almora reveals that they are flowering earlier by over 40 days. When timing changes in plants, it creates problems for other species dependent on them for food. When species shift northward or higher, not all species in an ecosystem may move, and the interconnectedness that has evolved over time gets disrupted.

3B.5 Forest Management

The indigenous people and rural people have lived in forests for generations and were greatly dependent on forests for their livelihood and sustenance. People have managed forests for extracting timber and other resources for millennia. The scale of extraction was small enough so as not to damage the ability of forests to recover. Such management practices, while not always ecologically sound, nevertheless did not destroy the regenerative and productive capacity of forests.

Scientific forestry has been practiced for approximately 300 years and throughout much of that time it has been considered by foresters to be sustainable. The forests have been managed according to the principle of sustained yield, with the value of interest being the production of timber. As a consequence, forest management often aimed to increase timber production and economic returns through intervention into natural processes.

Currently, many forests, particularly in the tropical region of the world, are being managed unsustainably. This type of management generally places emphasis on timber harvest of a few valuable species and lacks adequate techniques to conserve sustainability, that is, to preserve ecosystem structure and function and to ensure the regenerative ability of desirable tree species. Sustainable management of forests should take into consideration features that are essential for maintenance of natural forests" structure and function, like conservation of ecosystem biodiversity, nutrient retention and recycling, preservation of soil fertility, hydrological stability, and other factors.

On account of variation in climatic, edaphic, and physiographic factors, Indian forests present a wide spectrum of variability in terms of structure, physiognomy, floristic species and other components. Diversity of vegetation coupled with complexity of socio-economic conditions has led to the evolution of a wide spectrum of management systems. The main silvicultural systems followed in India include selection, shelterwood, clear felling, and coppice systems. Clear felling system is no longer practiced. Currently, the most prevalent system is selection system.

With growing recognition of importance of conservation of forests, the protected area network has increased. There are 93 national parks and 512 wildlife sanctuaries covering 4.9 percent of the geographical area of India (ICFRE, 2011). The annual timber production, which was reported to be 30 million cubic meters (FSI, 1987) has been reduced considerably to around 3 million cubic meters (FSI, 2011). The forest cover has increased from 677,088 square kilometers (FSI, 2005) to 701,673 square kilometers (FSI, 2015). The total growing stock, however, has decreased from 4,740 million cubic meters (FSI, 1995) to 4, 194 million cubic meters (FSI, 2015).

3B.6 The Way Forward

The concept of sustainable development emerged in the context of growing awareness of an imminent ecological crisis. It was defined in Brundtland Report (World Commission on Environment and Development, 1987) as 'sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." The adoption of the Conventional on Biological Diversity (CBD) further reinforced the growing commitment of the world community to sustainable development.

In the context of sustainable forest management in India, the National Forest Policy of 1988 emphasizes maintenance of environmental stability and restoration of ecological balance, and subordinates deriving economic benefits from forests. In the T.N. Godavarman Thirumulpad vs. Government of India case, the Supreme Court of India directed that the forest working shall be carried out strictly in accordance with the working plans approved by the Government of India (1996). The Thirteenth Finance Commission, constituted in 2007, was asked that while making its recommendations, the Commission shall have regard, among other considerations, to the need to manage ecology, environment and climate change consistent with sustainable management. The National Working Plan Code-(2014) has been adopted to address issues of contemporary significance in the management of

forests. It emphasizes that the concept of sustainability is not confined to the productive functions but also environmental functions like soil and water conservation, biodiversity conservation and development, carbon sequestration and mitigation of climate change, and other factors. With this in mind, it is important to adopt an ecosystem approach to forest management so that the ecological integrity of forest ecosystems is maintained and flow of goods and services from forests is available in perpetuity.

3B.7 References and Further Reading

Forest Survey of India. (1987). The State of Forest Report 1987.

LECTURE 4: LANDSCAPE ECOLOGY AND LANDSCAPE PLANNING

This lecture covers the following:

- Planning with a purpose
- Landscape and a forest division as a working plan area
- Principles of landscape ecology
- Landscape-level planning in Green India Mission

Joseph M. Kiesecker

The Nature Conservancy

4 LANDSCAPE ECOLOGY AND WORKING PLAN

4.1 Introduction

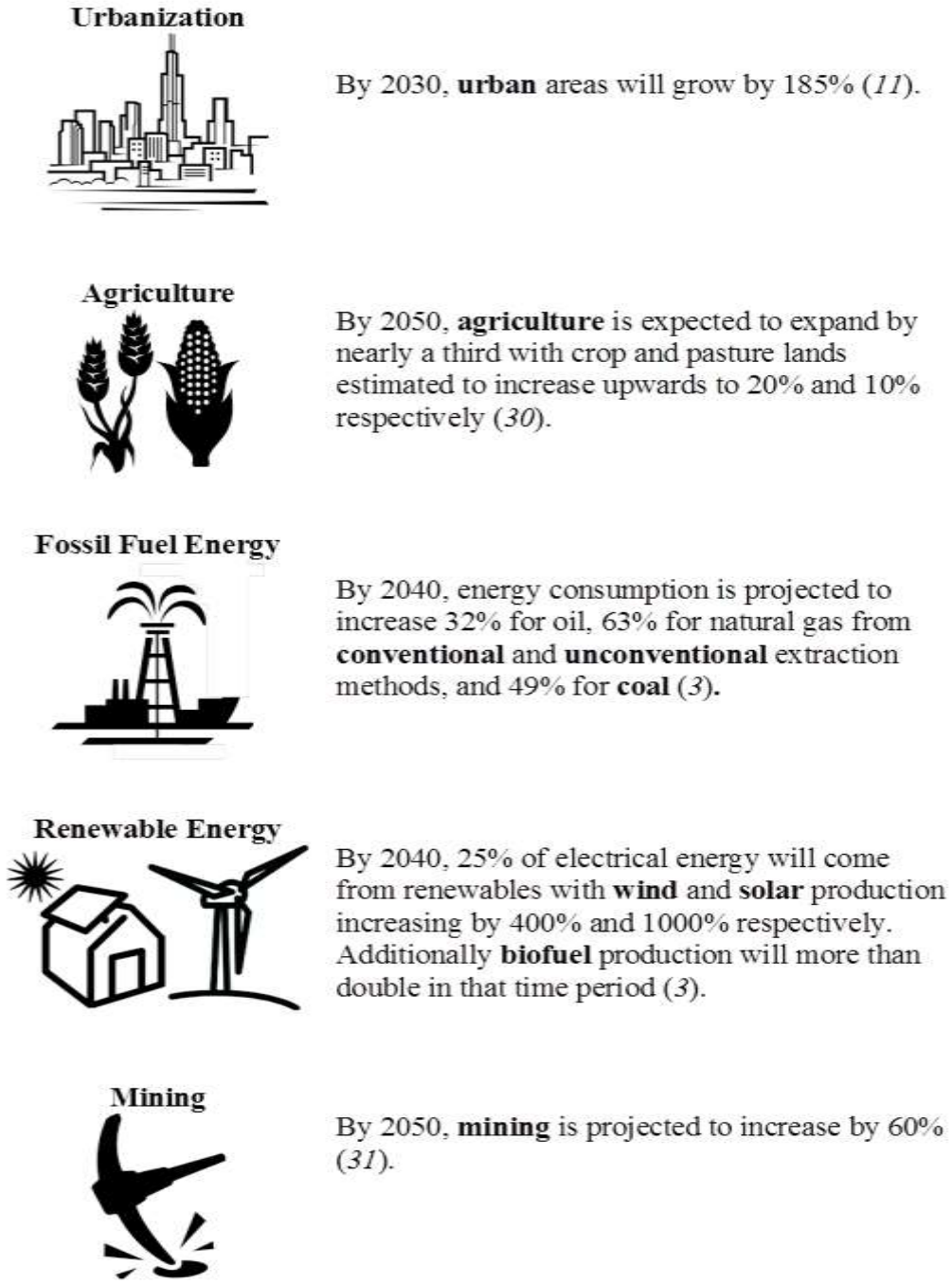
We plan because we have limited resources, and planning helps us make decisions about where and how to deploy those resources. Planning can be a means of settling conflicts among multiple uses and users, as anyone who has participated in a public planning process that involves lands and waters managed by any governmental agency can attest to. Sometimes planning is undertaken to better understand a problem and to begin to develop solutions, while at other times planning is a strategy unto itself to engage stakeholders and raise the profile of conservation. Finally, planning provides for a level of transparency to all involved that not only helps build trust among stakeholders but also allows for critiquing and improving project strategies as they assess the effectiveness of their efforts over time. In the age of the “Anthropocene,” the need to plan becomes more urgent as we approach what some refer to as a tipping point.

4.2 The World at Risk

Population increase, estimated to reach 9.6 billion by 2050, along with gains in personal wealth and expansion of the middle class will continue to promote a rapid pace of development to meet the growing demands for food, water, housing, energy, minerals, and other resources. For example, increasing demand for food and biofuels will result in nearly a billion new hectares of agricultural land by 2050. At the same time, this higher spending power of emerging markets is expected to increase global energy consumption by 56 percent in 2040 and thus increase overall energy sprawl. This pending development will help fuel economic growth, lift people out of poverty, and improve living conditions, e.g., 1.7 billion more people are estimated to gain access to electricity by 2030. Given these expected benefits, development will likely go forward but by how much and where and at what cost to natural systems are unclear.

Proactively identifying areas at risk of conversion and strategically planning to balance development objectives with conservation goals will be critical to achieve any semblance of sustainable development. While previous studies have either characterized the globe based on current conditions or examined the global consequences of future habitat conversion, in particular from sectors such as agriculture and urbanization, no study has examined the potential combined effects of multiple sectors and provides a comprehensive forecast of future global development risk. This cumulative risk is important, because freedom from risk due to one source of development is no guarantee of freedom from risk due to other forms of development. A recent study from Oakleaf et al. (2015) focused on urbanization, agriculture, energy, and mining—the major sources of land conversion —and projected these nine forms of development.

FIGURE 4.1: DEVELOPMENT OF URBANIZATION, AGRICULTURE, FOSSIL FUEL ENERGY, RENEWABLE ENERGY, AND MINING



Oakleaf et al. *(2015)*

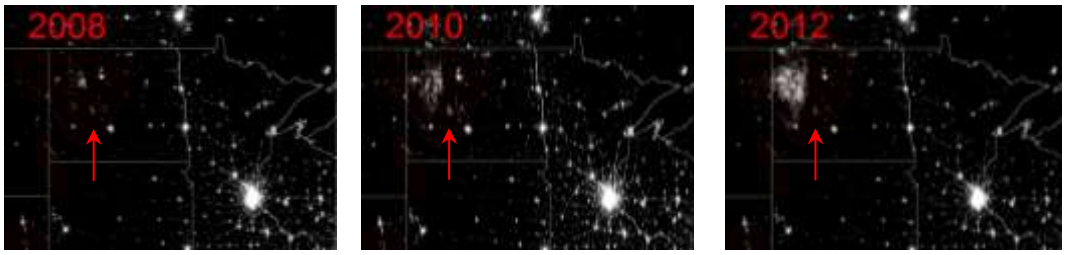
Future resource development potentials for each of these nine sectors were spatially mapped, ranked, and aggregated globally to determine cumulative threat. They then examined patterns of high development risk, defined as the quarter of the globe with the highest cumulative threat scores overlapping natural areas, and examined these at-risk areas within terrestrial biomes, ecoregions, and geopolitical regions to highlight opportunities for proactive conservation action and mitigation planning. Cumulatively, these threats place at risk 20 percent of the remaining global natural lands (19.68 million km^2) and could result in half of the world's biomes becoming >50

percent converted while doubling and tripling the extent of land converted in South America and Africa, respectively. With only 5 percent of the Earth's at-risk natural lands under strict legal protection, estimating and proactively mitigating multi-sector development risk is critical for curtailing significant loss of nature. The size and rate of change today is very different that in the past occurring at a scale that necessitates planning at a comparable scale—a landscape scale.

4.3 Unprecidented Change

Example Temporal Changes: Shale development can transform the landscape in a relatively short time frame in ways that can negatively affect nature and people (Figure 4.2).

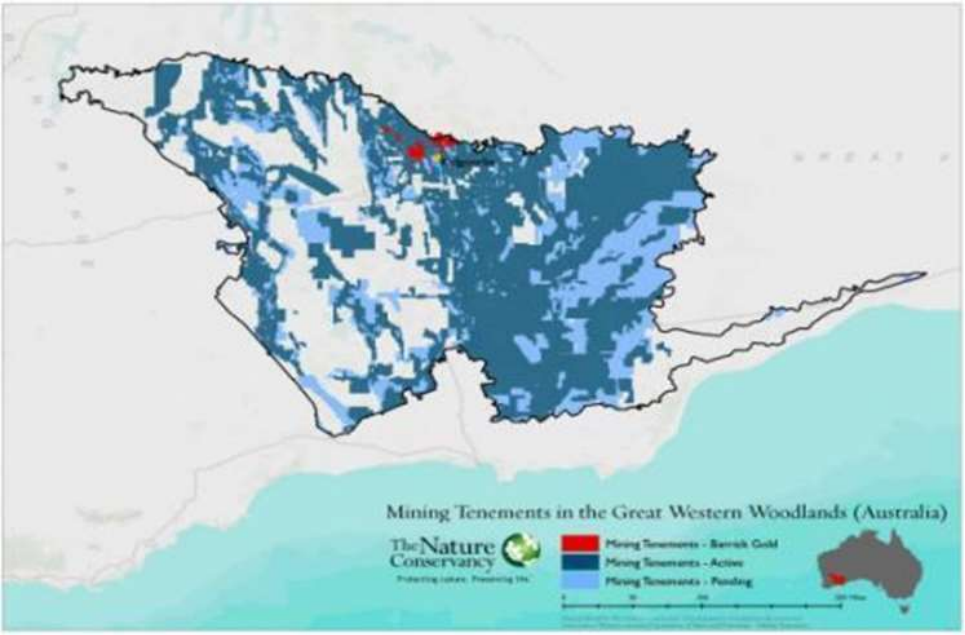
FIGURE 4.2: NIGHTTIME LIGHTS RESULTING FROM GAS FLARES IN THE BAKKEN PLAY OF NORTH DAKOTA



Number of new spudded wells approximately doubled within the two-year intervals from 2008 (n = 555), to 2010 (n = 1,094), to 2012 (n = 1,826) such that in 2012, flares exceeded in size the metropolitan area of Minneapolis-St. Paul, MN (bottom right).

Example Spatial Changes: Mining leases in the Great Western Woodlands of Western Australia illustrate potential spatial scale of land use change that can transform the landscape in ways negatively affecting nature and people (Figure 4.3).

FIGURE 4.3: MINING TENEMENTS IN THE GREAT WESTERN WOODLANDS (AUSTRALIA)



4.4 Introduction to Landscape Ecology

At the heart of most natural resource planning exercises are the science of ecology and the sub-discipline of landscape ecology. Quick reviews of those fields of study are as follows:

4.4.1 What is Ecology?

"...the study of the distribution and abundance of animals" (Andrewartha, 1961)

"...the study of the structure and function of nature" (Odum, 1971)

"...the study of the adaptations of organisms to their environment" (Emlen, 1973)

Collectively, these definitions convey the notion that the environment influences organisms and organisms influence the environment. That we breathe oxygen (generated primarily by photosynthesis) is a striking example of the power of organisms to influence the environment!

4.4.2 What is Landscape Ecology?

Landscape ecology is the study of landscapes—specifically, composition, structure, and function of landscapes. But what is a "landscape?" Multiple definitions of this term are valid. The phenomenon under consideration can affect definition of "landscape," and a landscape is not necessarily defined by its size; rather, "landscape" is defined by an interacting mosaic of elements (e.g., ecosystems) relevant to some phenomenon under consideration (at any scale). Thus, a landscape is just an area of land (at any scale) containing an interesting pattern that affects and is affected by an ecological process of interest. Landscape ecology, then, involves studies of these landscape patterns, interactions among the elements of this pattern, and how these patterns and interactions change over time. In addition, landscape ecology involves application of results of these studies to formulate and solve real-world problems. Landscape ecology is perhaps best distinguished by its focus on: 1) spatial heterogeneity, 2) broader spatial extents than those traditionally studied in ecology, and 3) the role of humans in creating and affecting landscape patterns and processes

4.4.3 Spatial Heterogeneity

Landscape ecology might be defined best by its focus on the following in regard to spatial heterogeneity and pattern: characterization, origin, changes through time, significance, and human management. As such, landscape ecology has five central themes:

- Detecting pattern and the scale at which it is expressed, and summarizing it quantitatively;
- Identifying and describing the agents of pattern formation, which include the one physical abiotic template, demographic responses to this template, and disturbance regimes overlaid on these;

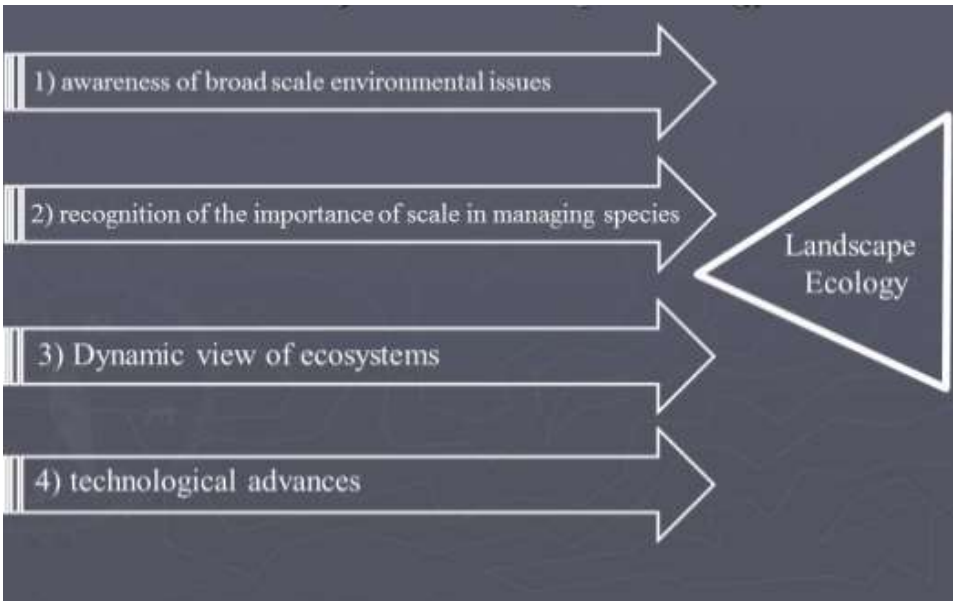
- Characterizing and summarizing quantitatively changes in pattern and process over space and time—that is, dynamics of the landscape. An interest in landscape dynamics necessarily invokes models of some sort, because landscapes are large and they change (usually!) over time scales difficult to embrace empirically;
- Understanding ecological implications of pattern—that is, why this matters to populations, communities, and ecosystems; this is the stuff of conservation biology and ecosystem management; and
- Managing landscapes to achieve human objectives.

FIGURE 4.4: LANDSCAPE ECOLOGY

4.4.4 Broad Spatial Extents

Landscape ecology is distinguished by its focus on broader spatial extents than those traditionally studied in ecology. This stems from the anthropocentric origins of the discipline (see below). Initial impetus for the discipline came from the geographer's aerial view of the environment—for example, patterns in the environment visible on an aerial photograph. The focus on large geographic areas is consistent with how humans typically see the world (through a coarse lens). However, modern landscape ecology does not define, *a priori*, specific scales that may be universally applied; rather, emphasis is on identification of scales that best characterize relationships between spatial heterogeneity and the process of interest.

FIGURE 4.5: GEOGRAPHIC (OBSERVATIONAL) SCALE



4.4.5 The Role of Humans

Landscape ecology is often defined by its focus on the role of humans in creating and affecting landscape patterns and processes. Indeed, landscape ecology is sometimes considered an interdisciplinary science dealing with interrelations between human society and its living environment. Hence, a great deal of landscape ecology deals with “built” environments, where humans are the dominant inducers of landscape change. However, modern landscape ecology, with its emphasis on interplay between spatial heterogeneity and ecological process, considers humans as one of many important agents affecting landscapes, and emphasizes natural, semi-natural, and built landscapes.

4.5 History of Landscape Ecology

Historical roots of Landscape Ecology as a discipline trace to two traditions: the “European School” (also strongly represented in the United States and elsewhere), and the “American School” (also common in Australia and elsewhere).

4.5.1 The European School

- Very long history (almost as old as ecology itself);
- Emphasis on typology and classification, and mostly concerned with “built” systems; and
- More influential in Landscape Architecture, Planning, or Design schools than in Biology departments.

4.5.2 The American School

- Comparatively young, gaining a high profile in the United States only after the early 1980s;

- Launched, for practical purposes, by a workshop at Allerton Park (Risser et al., 1984)—pivotal in specifying what landscape ecology was to be about, including its intellectual domain (what would be considered “interesting”) and “tools of the trade” (officially sanctioned approaches);
- In contrast to the European school, more focus on natural systems (or at least, semi-natural ones such national parks); and
- Much more investment in theory and models, some extremely abstract.

The emergence of landscape ecology as a prominent sub-discipline of ecology in the early 1980s traced to a number of factors:

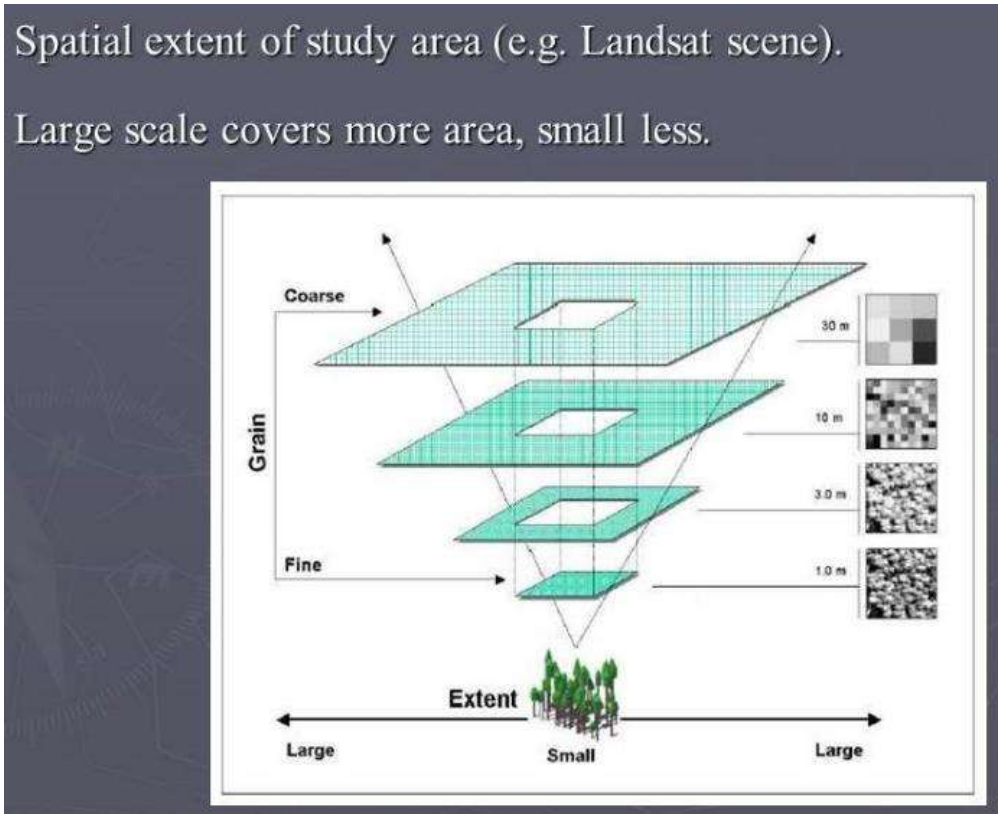
- Growing awareness of broad-scale environmental issues requiring a landscape perspective;
- Increasing recognition of the importance of scale in studying and managing pattern-process relationships;
- Emerging dynamic view of ecosystems/ landscapes; and
- Technological advances in remote sensing, computer hardware, and software.

4.5.3 Broad-scale Environmental Issues

Unrelenting demand for more and more commodities and services from global ecosystems has led to numerous ecological crises. Staggering losses of topsoil each year from many of farmlands demonstrate the exploitation of these ecosystems. Failure of certain tropical humid forests to rebound after clear-cutting dramatically illustrates their vulnerability to radical disturbance. Equally compelling evidence of ecosystem limits is evident in altered flooding regimes, increased suspended loads, chemical contamination, and community structure changes in virtually every temperate river in the world. Degradation of the Earth’s ecosystems is further signaled by the unprecedented decline of thousands of species, many of which have become extinct. Many of these crises have resulted from cumulative impacts of land use changes over broad spatial scales (i.e., landscapes). Basic understanding and management solutions at landscape scales are required to address questions of how to manage populations of native plants and animals over large areas as land use or climate changes, how to mediate effects of habitat fragmentation or loss, how to plan for human settlement in areas that undergo a particular natural disturbance regime, and how to reduce deleterious effects of nonpoint source pollution in aquatic ecosystems.

4.5.4 Concepts of Scale

FIGURE 4.6: SCALES OF MANAGEMENT



Despite early attention to effects of sample area on measurements, such as species-area relationships, the importance of scale was not widely recognized until the 1980s. Recognition that pattern-process relationships vary with scale necessitated that ecologists explicitly consider scale in designing experiments and interpreting results. It became evident that different problems require different scales of study, and that most problems require multiple scales of study. The theory of scale and hierarchy emerged as a framework for dealing with scale. The emergence of scale and hierarchy theory provided a partial theoretical framework for understanding pattern-process relationships, which became the basis for the emergence of landscape ecology as a discipline.

4.5.5 Dynamic Ecosystem View

A major paradigm shift in ecology from the “equilibrium” view of ecosystems to a “dynamic” view occurred in the 1980s. Coupled with the view that ecosystems are dynamic, characterized more by their dynamics than by their tendency toward stable equilibrium, is the notion that ecosystems are not isolated systems and cannot be understood without considering flows of energy and materials across ecosystem boundaries. This view of ecosystems as “open” systems required an understanding of how mosaics of ecosystems interact to effect ecosystem processes, and this led to the emergence of landscape ecology.

4.5.6 Technological Advances

Technological developments particularly important for studying spatial patterns over broad spatial scales have been rapid advances in computing power; availability of remotely sensed data such as satellite images; and development of powerful computer software packages called geographic information systems (GIS) for storing, manipulating, and displaying spatial data. Indeed, uses of computers and computer models are essential to study behavior within landscapes, many of which extend over large distances. Technological advances since the 1980s have made possible the study of landscapes. The American school of landscape ecology, in particular, is heavily invested in uses of these technologies.

4.6 The Importance of Landscape Ecology to Resource Managers

Landscape ecology (or a landscape perspective) with its focus on spatial patterns is important to resource managers because 1) ecosystem context matters, 2) ecosystem function depends on the interplay of pattern and process, and 3) human activities can dramatically alter landscape context and the relationship between patterns and processes. Resource managers have a stewardship responsibility to understand and manage these impacts; more pragmatically, resource managers have a policy and legal mandate to include a landscape perspective in resource management decisions.

4.6.1 Ecosystem Context

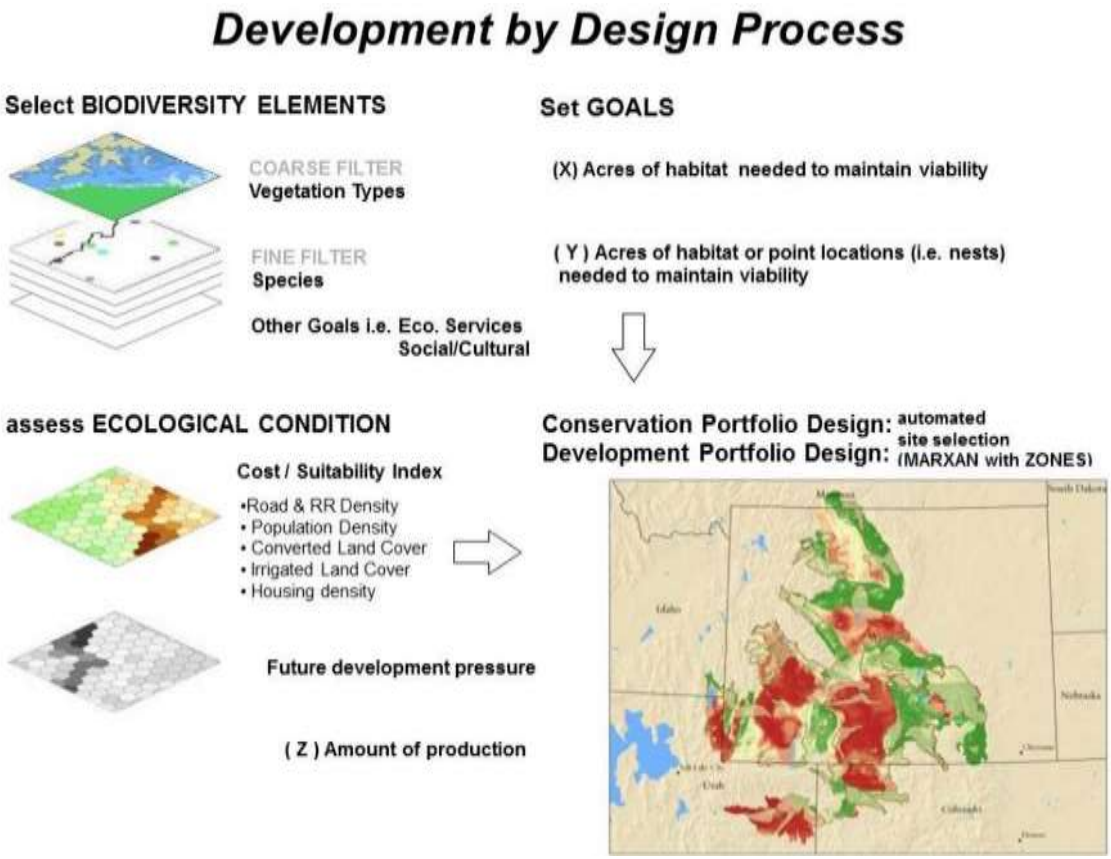
Landscape ecology is founded on the principle that ecosystem composition, structure, and function partially depend on the spatial (and temporal) context of the ecosystem (i.e., its landscape context)—that what we observe ecologically at any particular location is affected by what is around that location. This shift in perspective from the site to the site embedded in a landscape context has profound implications for resource management. Let's consider a couple of examples:

- *Metapopulations:* depend on the number and spatial arrangement of habitat patches, whereby probability that a habitat patch is occupied at any time depends at least partially on its proximity to other habitat patches. Focusing management on the individual site without consideration of its landscape context can lead to disastrous consequences for a population.
- *Forest succession*: neighborhood effects can be important in successional response following a disturbance. For example, edge effects that modify distribution of energy and water, and composition of plant species in the immediate neighborhood (which can influence relative abundance of propagules) can strongly influence succession in forest gaps and in larger openings (e.g., via wave-form succession).
- Ignoring these effects can lead to undesirable outcomes, including an unwanted shift in species composition or an inadequate recovery of vegetation altogether.

4.6.2 Ecosystem Function

Landscape ecology is also founded on the principle that spatial patterns affect ecological processes, which in turn affect spatial patterns. This interplay of spatial pattern and process is in fact the overarching focus of landscape ecology. While arguably, “ecology” has always sought to explain the relationship between pattern and process, “landscape” ecology has shifted the focus to pattern-process relationships over broad spatial extents and has emphasized the role of humans in creating and affecting these relationships. This shift has profound implications for resource managers.

FIGURE 4.7: DEVELOPMENT BY DESIGN PROCESS



Let’s consider a couple of examples:

Habitat fragmentation: Disruption of habitat connectivity is a major impact of human activities on plant and animal populations, and one of the leading causes of the biodiversity crisis. Anthropogenic landscape elements (e.g., roads, developed land, dams) can function as impediments to movement of organisms across the landscape, and cumulative impacts of these impediments over broad spatial extents can be devastating.

Alteration of disturbance regimes: Disruption of natural disturbance regimes has long-lasting ecological and socioeconomic impacts. For example, disruption of fuel mass and continuity of human land use practices over broad spatial extents can dramatically alter fire regimes in fire-dependent ecosystems, leading to shifts in

species distributions and community structure, and serious socio-economic consequences (e.g., catastrophic fires resulting in loss of life and property).

4.6.3 Human Activities, Landscape Context, and the Relationship between Patterns and Processes

Finally, human activities can dramatically alter the landscape context and the relationship between patterns and processes. More pragmatically, inclusion of a landscape perspective in resource management decisions is a policy and legal mandate. In the United States, all federal land management agencies have formally adopted "ecosystem management" as the overarching resource management paradigm, and a landscape perspective (and all that it subsumes) is is essential to the ecosystem management approach. More specifically and more tangibly, a landscape perspective plays a critical role in the 2005 Forest Service Planning Rule (36 Code of Federal Regulations [CFR] Part 219) and subsequent regulations to implement that rule. This is similar to India's National Working Plan Code 2014.

Examples:

- Spotted owl (Stirx occidentalis),
- Salt marsh sparrow (Melsopiza melodia), and
- Sage Grouse (Centrocercus urophasianus).

4.7 Types of Planning Efforts

Planning for nature comes in many shapes and sizes. Conservation planning is difficult to define because it can be applied to many situations. Groves and Game (2015) define "*conservation planning as "a systematic process that is primarily focused on identifying, developing and implementing strategies to conserve specific features of biological diversity, the ecological process that sustains this diversity, and the ecosystem services that are provided by it.*" Here we will examine a few examples of different planning exercises to illustrate the types of issues that can be addressed, and in future lectures we will provide more detail as to the process of creating a conservation plan.

4.7.1 Systematic Conservation Planning

Systematic Conservation Planning or Landscape-level Conservation Planning is the process of locating, configuring, and maintaining areas that are managed to maintain viability of biodiversity and other natural features. A conservation portfolio (composed of priority sites), the end product of conservation planning, is made up of a selected set of areas that represent the full distribution and diversity of these systems. Plans often optimize the design of the portfolio to meet the minimum viability needs of each biological target, but in a way that minimizes the area required. Thus, even though areas outside of the portfolio have not been selected, they may still help to meet biodiversity goals. The key feature of a conservation plan is the clear articulation of a biodiversity vision that incorporates the full range of biological features, how they are currently distributed, and what minimum viability

needs each biological target requires to persist in the long term. The creation of this vision and the implementation of the conservation strategy depend on the active involvement of host governments, experts from many disciplines, development organizations, and local residents. The ultimate goal is a peer-reviewed conservation strategy with specific action plans that are widely embraced and implemented by stakeholders. Although typically used to identify and establish a comprehensive and biologically representative set of nature reserves there are numerous application these approach can play in India. For example it can be used to help identify values particular forest management plans should, focus on it can also be used to guide the Green India Mission by identifying areas were restoration should targeted or renewable energy should be prioritized.

4.7.2 Development Planning

There's no form of energy that doesn"t have an impact on our planet. It just depends on the impact. For traditional fossil fuels, the impact is CO2 emissions and pollution. And while renewable sources are a cleaner alternative, they present a different set of challenges given the amount of land used to produce the power we need. Wind and solar farms, for example, can have severe impacts on wildlife and their habitats. Using a science-based planning approach called Development by Design (DbD) one can offer solutions for developers, government policy-makers and regulators that avoid and minimize harm to critical habitats and mitigate or offset impacts. Adapting this approach Kiesecker et al. (2009) outlined a common-sense approach to renewable energy development by recommending siting wind energy in areas across the United States already impacted by human activities—like agriculture or oil and gas development. In these areas wind development would likely have few additional impacts on natural areas and wildlife. The study considers onshore wind energy development, which is projected to expand extensively in the Great Plains and Rocky Mountain West of the U.S. The Department of Energy's (DoE) goal to develop 20 percent of the nation's energy from renewable sources by 2030 translates into 12 million acres of land and 11,000 miles of additional transmission lines. In scientific terms, that 20 percent equates to 241 gigawatts of wind energy—enough to power 64 million homes across the U.S. All of it can be achieved in places already impacted by human activities reducing conflicts and facilitating the development of wind.

4.7.3 Multi-Objective Planning

Designing landscapes that can meet human needs, while maintaining functioning ecosystems, is essential for long-term sustainability. To achieve this goal, we must better understand the nature of the trade-offs and thresholds in the provision of ecosystem services and economic returns. Using commercial sugarcane expansion in a watershed in the threatened Brazilian Cerrado as a case study, Kennedy et al. (2016) applied integrated spatially-explicit economic and biophysical models to jointly optimize agriculture (sugarcane production and cattle ranching), biodiversity (bird and mammal species), and freshwater quality (nitrogen, phosphorus, and sediment retention) in the Cerrado biome in Brazil. The Brazilian Cerrado biome is a global biodiversity hotspot: It is the world's most diverse tropical savannah, but has lost

more than 50 percent of its area in recent years due to agricultural conversion. With less than 2.2 percent under federal or state protected areas, the vast majority of remaining natural vegetation is on private lands and is regulated by the FC, which currently has low compliance in the biome. This policy intends to provide no net loss of habitat and ecosystem services by stipulating that a minimum portion of natural vegetation be maintained on individual properties. The study generated production possibility frontiers that map efficient combinations of agricultural land and natural habitat under varying ecosystem services preferences. They found opportunities to improve both agricultural production and environmental quality relative to the current landscape. Significant trade-offs between biodiversity and water quality exist when land use targets a single goal but these trade-offs can be minimized through multi-objective planning. Further, we demonstrate that landscape-level planning can greatly improve the performance of the Forest Code relative to traditional farm-level planning. These findings suggest that through joint planning for economic and environmental goals at a landscape-scale, Brazil's agricultural sector can expand production and meet regulatory requirements, while maintaining biodiversity and ecosystem service provision.

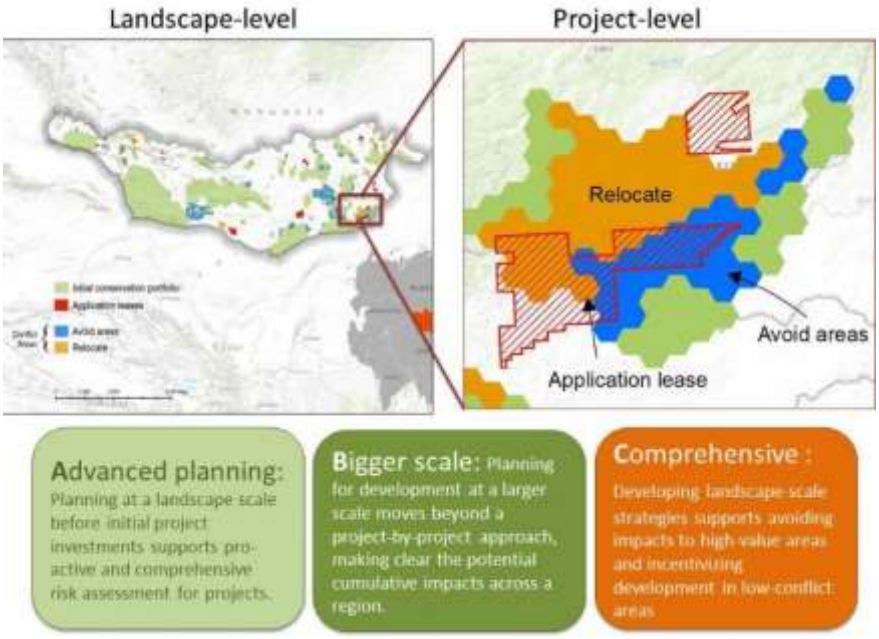
4.8 Planning in Line with the Scale of Threats and Challenges

Achieving sustainable development will require new thinking about how we meet the demands of a growing global population while also addressing increasing pressure on lands, waters, and the climate. Investments in development projects for food, water, energy, minerals, and infrastructure can help fuel economic growth, improve quality of life, and lift people out of poverty. But these investments can also bring environmental impacts and social conflict. As each project is developed, cumulative impacts contribute to a footprint. This can degrade landscape health, such as the provision of water security, and negatively affect communities, nature, and the economy. To take a more pro-active approach to sustainable development, there is an urgent need to transform development planning. We must move beyond what can be achieved by site-level planning for individual projects to consider development scenarios at a larger scale and assess the integrated opportunities for achieving better economic, social, and environmental outcomes.

This will require development planning:

- At a landscape scale;
- In advance of major project decisions; and
- For a more comprehensive set of values, functions, and goals.

FIGURE 4.8: LANDSCAPE-SCALE PLANNING



Landscape-scale planning (LSP) can benefit governments, businesses and communities by supporting more informed development decisions. It promotes comprehensive risk management and offers greater predictability and transparency to businesses and communities. This can reduce conflicts, delays, and costs. In addition, LSP may help in identifying new development options for shared facilities among two or more operators, or broader opportunities for integrated development corridors. Planning at this larger scale also informs strategies for long-term landscape resilience, such as ensuring functional watersheds for clean drinking water, connected habitat for species, and buffers against climate effects. In this way, LSP can support progress on global sustainability initiatives including many of the Sustainable Development Goals. Despite its abundant applications for sustainable development, LSP is not common practice. Government policies and institutions are often not set up to perform or fund LSP. Companies and financial institutions tend to be focused on their specific projects and investments. As a result, development planning often proceeds in a more ad hoc project-by-project manner, potentially missing opportunities for larger-scale integrated development solutions.

Transforming development planning will take collective leadership from government, industry, development agencies, and financial institutions. While technological advances are rapidly building our power to execute LSP at a reasonable speed and cost, accelerating LSP adoption also requires policy and institutional changes to break down planning silos, public-private collaboration to advance LSP initiatives, and increased resources for developing the blueprints we need for sustainable development.

4.9 Defining Landscape-Scale Planning: Framework and Process

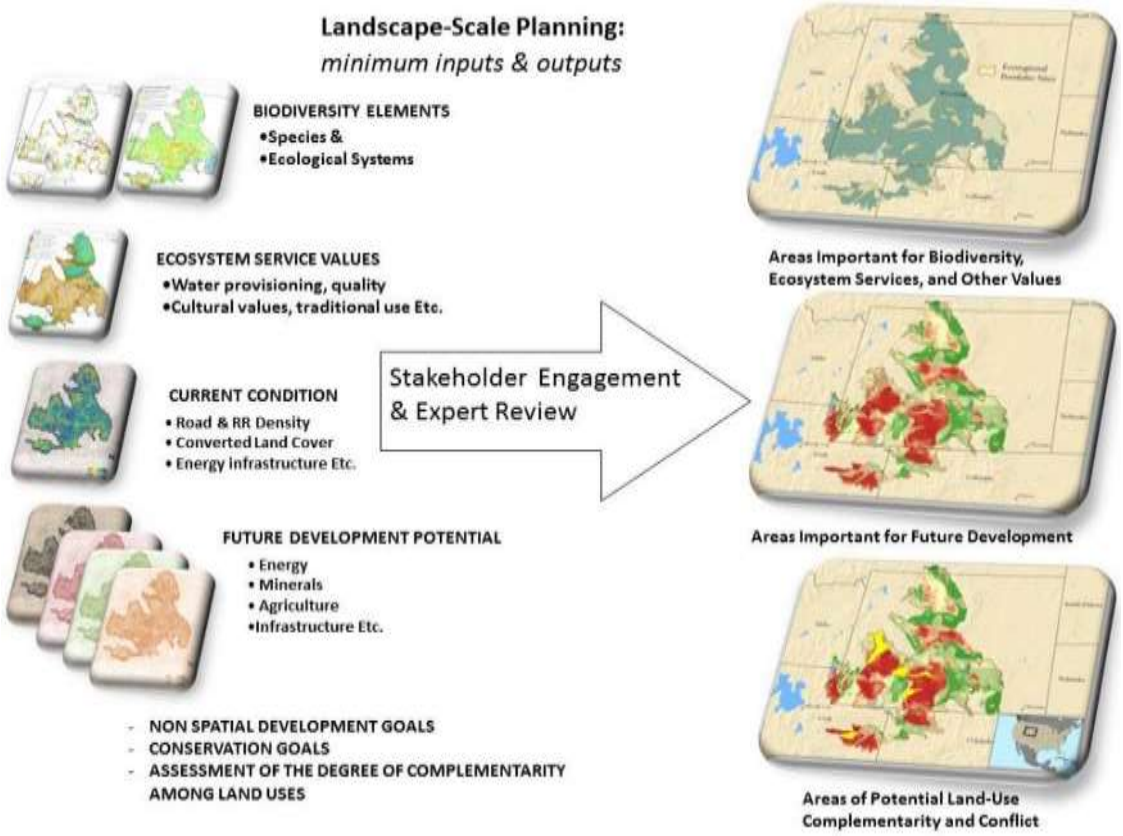
LSP is an approach for harmonizing multiple goals within the same geographic area, which may be defined by eco-regional, watershed, or jurisdictional boundaries.34

LSP expands the planning vision to larger spatial and temporal scales to manage landscapes for economic development, biodiversity and ecosystem services, food security, social and cultural values, and other key objectives. This helps place individual project plans and land units within their larger economic, social, and ecological context to better inform land-use decisions. The approach is proactive in helping stakeholders to find common interests, understand trade-offs, and work cooperatively toward more optimal solutions. LSP draws directly on the disciplines of conservation planning and landscape ecology, both of which emerged some years after environmental impact assessment processes were first established in the 1970s. Early conservation planning focused solely on ways to accomplish biodiversity conservation goals. This involved developing a conservation plan that incorporates the full range of biological and other natural features, their distribution, and what their minimum viability needs are to persist in the long term.

LSP expands the conservation planning process to integrate additional landscape values, such as water provisioning, carbon sequestration, cultural values, and other ecosystem services, and considers how projected future development and its cumulative impacts could affect goals for landscape health. It is important to note that LSP is not intended to replace project-level environmental and social impact assessment (ESIA). Rather LSP can serve as a complement to ESIA by highlighting priority areas and resources (i.e., species, ecological systems, and ecosystem services) that should be the focus of detailed ESIA studies and data collection. In addition, while there is some overlap conceptually with sectoral or strategic ESIA, LSP differs by taking a spatially explicit and target-driven approach. This helps inform how future land uses may complement or conflict with one another, and provides a basis for understanding trade-offs among landscape values and associated economic, social, and environmental goals.

The commonly accepted process for LSP involves (a) setting landscape goals; (b) identifying the optimal locations and configuration for maintaining landscape resources and functions, including the viability of biodiversity and other natural features; (c) projecting future development and associated long-term cumulative land use changes; (d) assessing potential complementary and conflicting landscape values and goals; (e) identifying a portfolio of priority areas for maintaining landscape health; and (f) providing decision-support tools to promote achievement of multiple landscape goals. Carrying out this process requires, at minimum, a set of data inputs to address questions regarding areas for maintaining biodiversity and ecosystems services, current landscape conditions, future development potential and goals, and possible conflicts between drivers of land use change and landscape goals.

FIGURE 4.9: LANDSCAPE-SCALE PLANNING



Data Needs: In most cases LSP can be developed with available data through a process that takes approximately one to three years, depending on the extent of stakeholder engagement and review, landscape complexity and issues, and the plan's level of detail. General data needs for LSP correspond to the inputs in the figure above, with specific data needs (geology, soil, water, biodiversity, social, future development, etc.) dependent on the LSP context and goals. Typically not all desired data on the landscape and its resources will be available. This is the case around the world, regardless of the financial and human resources available to the team carrying out the planning process. With the advent of many low cost remotely sensed data products, even where only minimal field data are available, it is possible to develop a landscape-scale plan that can help inform development and conservation decisions. Incomplete data should not be an impediment; landscape-scape plans can be developed noting where there are data needs and uncertainties, and allowing for updating as these data are acquired over time.

Projecting Future Land Use: Information to support projections of future development activity can be gathered from a variety of sources, including governmental resource management plans, forest management plans, long-range or metropolitan transportation plans, and community growth plans. Predictive modeling approaches can be used where plans do not exist or do not provide details on the distribution of potential development. A wealth of predictive modeling techniques has been used in recent years to predict changes in land cover and residential development, and to predict anticipated agricultural and energy development. These predictive modeling tools can be used to describe landscape-scale development

scenarios, helping inform decision makers and the public about patterns of anticipated development and potential impacts.

Tools. Numerous tools for LSP are available to facilitate: 1) gathering and distributing relevant data (e.g., regional databases that support queries and downloads), 2) conducting analyses and modeling (e.g., vulnerability assessments), 3) visualizing data and analysis/modeling results (including current and potential future conditions), and 4) integrating information into planning for conservation, land use, and land management. Although an exhaustive list of tools is beyond the scope of this paper, a good starting point for understanding the scope of tools available is a recent review by NatureServe on LSP tools for natural resource managers.

Stakeholder Engagement: LSP requires a stakeholder engagement process, public participation, and a planning team to develop the plan. Whereas some stakeholder groups have identifiable representatives (e.g., government, industry), for others it may not be clear. Critically, this can often be the case for the people living in the landscape subject to the planning exercise. While a review of stakeholder engagement processes is beyond the scope of this paper, there are well-established techniques for gathering stakeholder input on a wide range of values. These examples include land use planning applications for biodiversity conservation, energy development and multiple-use of public lands in both developed and developing countries.

4.10 Seeing the Big Picture: Advancements in Science, Policy, and Practice

Smarter land-use planning will be essential for a sustainable future—to achieve development goals at a time of deepening environmental concern about water-stress, forest loss, land conversion, species decline, and climate change. To meet this challenge, a combination of technical advancements, policy improvements, and experience in implementation is providing new ways to plan for development at larger scales. Below we highlight progress in the science, policy, and application of LSP to illustrate the growing momentum and capabilities.

4.10.1 Technical Advances

The combination of innovation and technological advances helps practitioners view the world differently and use information and data in new ways. This drives transformation. We are in the midst of a geospatial revolution that is supporting such change. Dramatic advancements in remote sensing, geographic information software, and spatial modeling capabilities make development planning at a landscape scale possible in ways not imaginable when conventional environmental planning processes were first developed in the 1970s. These advancements support knowledge integration, forecasting and decision-support models, and monitoring frameworks that promote more synergistic solutions for sustainable development. Advances in remote sensing are having the most significant impact on LSP. Remotely sensed data are relatively cheap, provide up-to-date information over large geographical areas, and in some cases may be the most practical way to construct

base maps for inaccessible regions. The first Landsat satellite was launched in 1972, ushering in a new era in remote sensing, and allowing users today to access over 40 years of data that is both free and easy to use. Landsat sensors focus on the reflectance characteristics of vegetation, greatly enhancing our understanding of the dynamics of vegetation and its function in the terrestrial ecosystem. The Landsat program shows the power and potential of remote sensing data for development planning. Today it is one of many sources for remotely sensed data. In addition to new sources of data, practitioners now have new ways of using spatial data to address key questions for development planning and its potential environmental impacts. For example, the explosion of new GIS software modeling tools (e.g., Maxent, Random Forest) supports predictive models for estimating future distribution patterns of resources (i.e., species) and extrapolating predictions to areas where data has yet to be collected.

New tools also allow for the rapid assessment of: habitat quality for biodiversity, habitat connectivity, and optimal configurations of habitat to achieve conservation goals. In addition, with growing recognition of the importance of ecosystem services and climate change adaptation, new tools and approaches have been developed to estimate how land-use changes may affect service values and for identifying areas with greater resilience to climate effects.

While this is by no means an exhaustive review of tools and technology available to support LSP, it illustrates current planning capabilities for establishing baselines, estimating future development patterns, and assessing how resources may respond to future impacts. These advances are helping to extend development planning from the traditional site-based focus to a broader landscape approach, and doing so in a way that can reduce costs and improve outcomes for economic development, landscape health, communities, and climate (Table 1).

4.11 Advanced Landscape-Level Planning: Getting Ahead of Problems Before They Start

Scenarios analysis has become a widespread approach in pursuit of sustainable development. However, it is used infrequently, at least in any formal way, in environmental impact assessment (EIA). This is surprising because EIA is a process designed specifically for exploring options for more-sustainable (i.e., less environmentally damaging) futures. Similarly predictive modeling techniques have been applied in recent years to project land cover changes and residential development and to predict potential species habitat, but comparable techniques are rarely used to model anticipated energy development and proactively quantify environmental impacts.

TABLE 4.1: SELECTED STUDIES: IMPROVING OUTCOMES FOR DEVELOPMENT, COMMUNITIES AND ENVIRONMENT THROUGH LSP

Study	Context	Findings	Benefits of Landscape-Scale Planning
Optimizing sugarcane development for business and conservation	Kennedy et al. (2015) modeled sugarcane expansion scenarios in the Brazilian Cerrado and quantified the benefits of implementing Brazil's Forest Code at a landscape-level compared to parcel-level compliance.	Compared to a parcel-level approach, landscape-level mitigation reduces business costs by -4.5% (totaling $19-35 million) while supporting more species, storing more carbon, and improving water quality.	Landscape-level mitigation costs less and generates greater benefits for people and nature than traditional, site-based impact mitigation.
Energy development and cumulative watershed impacts	Evans and Kiesecker (2014) created probability surfaces for wind and shale gas development potential and modeled future energy build-out scenarios for the Central Appalachians region of the US to quantify potential impacts on surface drinking water .	The cumulative impacts of up to 106,004 new wells and 10,798 wind turbines could impact 447, 134 ha of forest, causing surface disturbance and fragmentation that affects biodiversity values and the quality of surface water resources for 22 million people.	Taking a forward-looking landscape-scale approach shows the potential cumulative impacts of energy development, informs decisions for avoiding and mitigating impacts, and identifies opportunities for achieving energy and conservation goals.
Dependency of hydropower on forested watershed	Stickler et al. (2013) applied land use, hydrological, and climate models to assess potential effects of deforestation on river discharge and energy generation for the Bela Monte complex in the eastern Amazon.	Under business-as-usual projections of cumulative forest loss to 2050 (40%), simulated power generation declined to only 25% of maximum plant output and 60% of the industry's projections.	Assessing an energy project's dependence on forests in the region can support a more integrated assessment of options and their economic, social and environmental benefits and costs.
Ecosystem service losses for communities due to road development	Mandie et al. (2015) applied the 'service-shed" concept- an area providing an ecosystem service to a specific beneficiary - to assess how a proposed Peruvian Amazon road may negatively affect ecosystem services for indigenous communities.	Sites with the highest levels of ecosystem function across the landscape under analysis are not the sites most valuable for the provision of ecosystem services to people affected by road development.	Taking a service-shed approach reduced average unmitigated impacts to drinking water quality more than four-fold for sediment, 16-fold for nitrogen and 38-fold for phosphorus loads, compared to methods relying on cological processes alone.
Climate impacts due to higher carbon emissions caused by forest fragmentation	Putz et al. (2014) integrated results from remote sensing and forest modeling to estimate the loss of biomass at forest edges and the potential additional contribution to higher emissions of carbon dioxide (beyond current deforestation estimates) for tropical rainforests in Brazil and globally.	The remaining Brazilian Atlantic forest has 245, 173 mainly small fragments with a mean fragment size of 64 ha. Fragmentation has contributed 69 Tg C emissions over 10 years. Globally, fragmentation of tropical forest areas results in up to a fifth more carbon dioxide emitted (0.2 billion tonnes).	The fragmentation effect on carbon emissions decreases considerably with greater forest patch sizes (i.e., less forest edge per hectare of forest). Landscape-scale planning can support larger forest patch sizes and connectivity to reduce emissions caused by degrading edge effects.

4.12 Examples of Advanced Landscape-Level Planning

4.12.1 Oil and Gas Development in Central Appalachians of the United States

Global demand for energy has increased by more than 50 percent in the last half-century, and a similar increase is projected by 2030. Energy production to meet growing demand has resulted in impacts to human health and well-being as well as increased habitat fragmentation and stress on biological diversity worldwide. In the United States, directives for renewable energy, energy security and technological advancements such as horizontal drilling in conjunction with hydraulic fracturing have spurred a rapid increase in alternative and unconventional energy production over the last decade (Evans and Kiesecker, 2013). Energy development is poised to continue its upward trajectory, with over 200,000 km^2 of new land projected to be developed in the U.S. alone by 2035. Development of ""unconventional"" gas dispersed in shale will be key, as the potential resource may be large. In addition to shale gas, the U.S. Department of Energy's goals are to produce 20 percent of its electricity from terrestrial wind energy development (241 gigawatts of on-shore wind) by 2030 (Kiesecker et al., 2011; Evans and Kiesecker, 2013). In light of this new energy future, understanding and mitigating the impacts of energy development will be one of the major challenges in the coming decades.

The Marcellus shale gas play covers approximately 160,934 km^2 across eight states and contains both some of the largest technically recoverable shale gas resources is the U.S. and headwater watersheds that provide drinking water for over 22 million people in several of the largest U.S. metropolitan areas (e.g., New York City, Washington DC, Philadelphia & Pittsburgh). Land use change from shale gas and wind development is known to increase land clearing, impervious surface and increase deforestation. Aquatic ecosystems are particularly vulnerable to land use change such as deforestation and change in impervious surface. Deforestation and increases in impervious surface influence sediment, hydrologic, and nutrient regimes, which in turn influence aquatic biota and ecological processes in fresh waters. Because sediment represents one of the most significant controlling variables on stream morphology and hydrology, deforestation and increases in impervious surface will be an important driver in stream health, integrity of headwater watersheds, and quality of drinking water. It is therefore essential to understand patterns of future deforestation and changes in impervious surface resulting from energy development.

To address this issue Evans and Kiesecker (2013) created probability surfaces representing development potential of wind and shale gas for portions of six states in the Central Appalachians. We used these predictions and published projections to model future energy build-out scenarios to quantify future potential impacts on surface drinking water. Our analysis predicts up to 106,004 new wells and 10,798 new wind turbines resulting up to 535,023 ha of impervious surface (3 percent of the study area) and upward of 447, 134 ha of impacted forest (2 percent of the study area). In light of this new energy future, mitigating the impacts of energy development will be one of the major challenges in the coming decades.

4.12.2 Wind and Wildlife in Kansas

Depending on siting, wind energy may cause adverse impacts on wildlife, resulting in direct mortality to birds and bats, as well as habitat loss and fragmentation (Kiesecker et al. 2011; Obermeyer et al. 2011). Although direct habitat losses from turbine footings and roads typically entail less than five percent of a wind energy project area, the habitat values of adjacent lands may be significantly diminished. Fragmentation is widely acknowledged to be detrimental to both the integrity of ecological systems and the long-term viability of associated wildlife (Margules and Pressey, 2000), and may act synergistically with climate change and other factors to magnify deleterious effects to species and ecosystems by limiting the ability of species to adapt or migrate.

Wind development projects may also result in fragmentation on a more local scale. At the 150-MW Elk River Wind Project near Beaumont, Kansas, nearly 30 km of new, improved roads were built across native tallgrass prairie to service the facility. Roads effectively fragment the habitat, restricting movement for many animals, possibly leading to population level impacts and genetic effects. Edges of habitat caused by roads may also create an avenue for predators and invasive weeds and may affect fire behavior. While some bird species seem minimally affected by the presence of wind turbines, certain waterfowl, shorebird, and songbird species are known to avoid them.

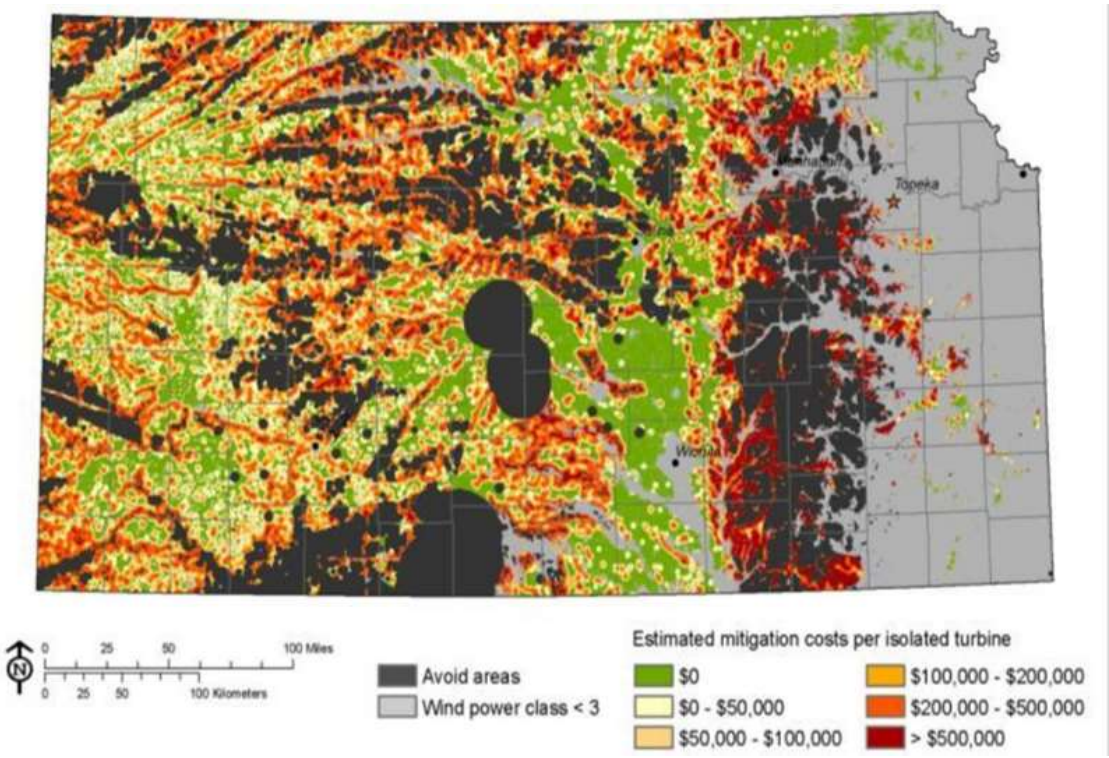
Grassland and shrubland-nesting birds are of particular concern, because these species are sensitive to human infrastructure and activity and may be evolutionarily disposed to avoid nesting and brood-rearing activities near vertical structures such as wind turbines. Ongoing population declines for greater and lesser prairie-chickens and the intersection of their remaining distribution with some of the continent’s prime wind generation regions compound the concern.

The DOE estimates that it will require about 5 million ha of land and nearly 18,000 km of new transmission lines in order for the U.S. to generate 20 percent of its electricity from wind. Given the distribution of wind resources across the continental United States, certain states, such as Kansas, are likely to experience a disproportionate amount of development. According to DOE, however, wind energy production will require only about 3 percent of the land area with commercially viable wind resources in the continental U.S. This should allow ample opportunity to site wind energy development away from important and sensitive habitats.

Regulatory agencies often require that developers follow the mitigation hierarchy, which requires developers to avoid and minimize site impacts before utilizing offsets for negative impacts. We use a landscape-level approach to mitigation, referred to as ““Development by Design”,” which provides a quantitative approach to development that achieves no net loss for wildlife. Although the term ““mitigation”“ has sometimes been used to refer only to the payments designed to offset or compensate for impacts, we restrict the use of ““mitigation”“ to refer to the whole mitigation hierarchy sequence, which starts with avoidance of impacts. In the final step of the mitigation hierarchy, mitigation payments are required to offset or compensate for remaining

impacts that cannot be avoided or minimized. We refer to this final step of the mitigation hierarchy as ""compensatory mitigation"" or ""offsets.""

FIGURE 4.10: MITIGATION COSTS PER WIND TURBINE



The Development by Design approach to landscape-scale mitigation offers three distinct advantages over traditional project-by-project approaches: 1) it allows consideration of the cumulative impacts of current and projected development projects; 2) it provides a regional context to better determine which step of the mitigation hierarchy should be applied (i.e., avoidance versus offsets); and 3) it adds flexibility for choosing offsets to maximize conservation benefits by targeting the most threatened habitats or species. This method allows for mitigation funding to be pooled and allocated toward the highest conservation priorities, resulting in a higher conservation return on investment. This should lead to reduced development costs and improved conservation outcomes compared to project-by-project approaches to offset impacts.

Obermeyer et al. (2011) applied Development by Design to wind energy development in Kansas. This framework identifies areas where impacts to important habitats cannot be offset and, therefore, should be avoided. The framework also provides a method to identify areas where development may proceed without significant ecological concerns, as well as areas where ecological impacts will be significant, but can be offset. Importantly, this approach provides a mechanism to quantify expenditures necessary for offsets where they are appropriate.

Fortunately, risks to wildlife from wind energy may be alleviated through proper siting and mitigation offsets. Obermeyer et al. (2011) identified areas in Kansas where wind development is incompatible with conservation, areas where wind development

may proceed but with compensatory mitigation for impacts, and areas where development could proceed without the need for compensatory mitigation. They demonstrated that approximately 10.3 million ha in Kansas (48 percent of the state). has the potential to provide 478 GW of installed capacity while still meeting conservation goals. Of this total, approximately 2.7 million ha would require no compensatory mitigation and could produce up to 125 GW of installed capacity. This is 1,648 percent higher than the level of wind development needed in Kansas by 2030 if the United States is to get 20 percent of its electricity from wind.

4.13 Key References

TABLE 4.2: REFERENCES INCLUDE HOTLINKS THAT PROVIDE DIRECT ACCESS TO REPORTS

Topic	Readings/Support Materials
Why Plan? **Types of Plans:** • Systematic Conservation Planning • Natural Resources Management Planning • Land Use Planning • Multiple Objective Planning • Climate Adaptation Planning • Strategic Conservation Planning (CAP) site based	Groves et al., 2003; Groves and Game, 2015; The Geography of Hope] Redford et al., 2003; McShane et al., 2011; Steiner et al., 2013; Rosckstrom et al., 2009; Oakleaf et al., 2015 Margules and Pressey, 2000; Pressey and Bothrill, 2008 U.S. Department of Agriculture; Marsh, 2010; ECO-Logical; EPA Smart Growth Kiesecker et al., 2010; Kennedy et al., In Press ; Goldman-Benner et al., 2012; Game et al., 2011 Conservation Measures Partnership
Planning with Purpose—Ensuring Plan Results are in line with key decisions • Situational Analysis • Theory of Change • Proactive/Scenario Mapping • Strategy Mapping • Development by Design	Prendergast et al., 1999; Knight et al., 2008; Hulme, 2014; Fisher and Dills, 2012 Conservation Measures Partnership; Salafsky, 2008; Margoluis et al., 2013; Vogel, 2013 Duinker and Greig, 2007; Evans and Kiesecker, 2014; Copeland et al., 2009; Pocewicz et al., 2008; Pontius and Malanson, 2005; Theobold, 1998 Development by Design; Kiesecker et al., 2009; Kiesecker et al., 2010; Saenz et al., 2013; Heiner et al., 2013; Kiesecker et

Topic	Readings/Support Materials
	al., 2013
The Importance of Stakeholder Engagement in Landscape Planning • Stakeholder Mapping & Coordination • Selecting Conservation Targets **Coarse filter / fine filter strategy** Coarse filter = ecosystems • capture broad, regional patterns of biodiversity • biotic + physical components • data: vegetation, landforms, geology, climate • coarse but regionally consistent Fine filter: • rare & threatened species, special habitats • data: surveys, specimens, expert knowledge • locally accurate, sampling bias EXAMPLE: Mongolia • major steppe types • wetlands • landforms EXAMPLE: Australia Great Western Woodlands **Fine Filter: species** selection - many possible criteria • Threatened, endangered and imperiled species (various listings, global, regional, national, or combination. • Endemic Species are those with distributions restricted • Disjunct populations • Species life-stage: breeding habitat, migratory habitat other criteria (surrogates) • keystone: ecosystem structure and function • umbrella • species aggregations	Reed et al., 2009; Golder and Gawler, 2005 Groves et al., 2003, Hunter, 1988, 1991; The Geography of Hope; Comer et al., 2003; Andersen et al., 1999; Rodriguez et al., 2011; Keith et al., 2013 Heiner et al., 2011; 2013 Kiesecker et al., 2012; Fitzsimons et al., 2014 IUCN, 2001; Rabinowitz, 1981 Estes et al., 2011; Verissimo et al., 2011
Topic 4. Setting Conservation Goals Making Objectives Measureable: Targets and Attributes Challenges - viability info and research is often lacking Use PVA, where available Common criteria: • abundance (how much is enough?) ecosystems and 30 percent goal Spp/area curve (Island biogeography) patch size/Minimum Dynamic Area • species T/E status (risk) rangewide distributions goals endemic, limited, disjunct, widespread, peripheral • distribution	Guisan ad Zimmermann, 2000; Tear et al., 2005; Carwardine et al., 2009; Wilhere, 2008; Diamond and May, 1976; Desmet and Cowling, 2004; Dobson, 1996; He and Hubbell, 2011 Tear et al., 2005; Carwardine et al., 2009 Benitez-Lopez et al., 2010; Hebblewhite, 2008; Leidholdt, 2008;Trombulak and Frissell, 2000

Topic	Readings/Support Materials
stratification = genetic variation redundancy (epizootics, extreme events) • configuration (connectivity) Importance of Transparency: being objective and transparent, set measures, link to policy goals Assessing Viability of Conservation Targets goal = maximize difficult to measure or quantify • but tools and methods to estimate and rank relative disturbance/condition • populations or patches: size, condition, landscape context • Spatial models of disturbance • cumulative impacts • rank occurrences, • landscape pattern	
Topic 6. Selecting and Designing a Portfolio of Conservation Sites Being clear about the purpose? • not just protected areas - strategies • avoidance & protection • critical habitat and mitigation (steer development) • management / restoration • management-specific activities i.e., restoration • seasonal protected areas Portfolio design criteria—based on goals • representation • condition • connectivity - spatial configuration • SLOSS: larger patches are better • spatial—optimize area/cost Spatial framework, planning units • parcels • uniform planning units (hexagons) • catchments (watersheds, HUCs) • hybrid approaches spatial optimization MARXAN other tools: zonation Conflict between portfolio and development identify and resolve Topic 7. Predictive and Species distribution modeling **1) Types of predictive models in natural resource planning** a. Events b. Species distribution c. Occurrence or density d. Anthropogenic development e. Landuse change **2) Types and availability of data** a. Point occurrence (presence only) b. Point presence/absence c. Sampling continuous process d. Power testing (capturing sample variation)	Kiesecker et al., 2009; 2010; 2011; Bull et al., 2013; Margules and Pressey, 2000; Carwardine et al., 2008 Ball and Possingham, 2000; Moilanen et al., 2012; Kiesecker et al., 2010; Heiner et al., 2013; Grantham et al., 2013 Kiesecker et al., 2009; Copeland et al., 2009; Evans and Kiesecker, 2013; Obermeyer et al., 2011; Pocewitz et al., 2008; Theobald and Hobbs, 1998; 2000

Topic	Readings/Support Materials
e. Survey designs f. Leveraging currently available data g. Open access public data sources h. Simulating data **3) Types and suitability of models** a. Simple is good but, often not possible b. How to choose a suitable model c. Autocorrelation and pseudoreplication d. Parametric e. Nonparametric **4) Model evaluation and validation** a. Significance testing b. Sensitivity testing c. Evaluating assumptions d. Cross-validation and Bootstrap techniques **5) Model projection approaches** a. Maximum build-out scenarios b. Build-out scenarios for specific time periods c. Landcover transition projection models d. Climate projections **6) Case studies** a. Gradient modeling of conifer species b. Oil and Gas buildout modeling in the Marcellus shale play Projecting Future Development Scenarios (preadapt portfolio to possible future environmental or land uses) ***Land use trends:*** • projected population growth • modeling development potential • forest concessions • mineral & petro leases • other natural resources **1) Modeling approaches** a. Maximum Likelihood b. Parametric regression methods c. Nonparametric methods **2) Estimation** a. Nominal (discrete process) b. Continuous (continuous process) c. Probabilistic (binominal or multi-nominal process) d. Per-class multi-model probabilistic 3) **Validation** a. Data withhold b. Dual-phase field data collection c. Cross validation d. The Bootstrap e. Significance testing **4) Case studies** a. Forest succession and structure using lidar b. Modeling habitat associations types using Landsat and abiotic characteristics	
Taking Conservation Action • Linking Conservation actions to Outcomes • Conservation Action Planning Project Completion, Planning for the Future	Conservation Measures Partnership; Healthy Country Planning; Muir, 2010; Hutto and Belote, 2013; McDonald-Madden et al., 2010

Topic	Readings/Support Materials
• Measuring Progress—Assessing Outcomes • Dealing with Uncertainty—Climate Change	

LECTURE 5: FOREST SOILS

This lecture covers the following:

- The importance of soils to an ecosystem approach to forest management
- How soils are formed
- The composition of soil
- The five most important soil properties to an ecosystem approach to forest management and sustainable forest ecosystems

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5 FOREST SOILS

5.1 Why Are Soils so Important to an Ecosystem Approach to Forest Management?

5.1.1 Soils Are Old, and Take a Long Time to Form

Soil formation is very slow, in human terms. It can take hundreds or even thousands of years or more to form an inch of soil, but poor management can result in its loss in a single rainstorm. This means that soils are non-renewable in any reasonable timeframe. Soil loss is of great consequence because the impact will persist for a very long time.

5.1.2 Soils Are the Basis of Life on Land

All terrestrial life depends directly on soils.

5.1.3 Soils Are the Source of Almost All Ecosystem Services

Nearly all ecosystem services depend directly on soils. The intensity and duration of ecosystem services is typically proportional to the quality and health of the soil.

Soils are the great ecosystem service providers on earth. They store and provide water for plants. They prevent floods by transferring water slowly to streams and groundwater. They filter and remediate pollutants. They cycle and recycle nutrients and wastes—transforming them into biologically available forms, storing them away for later use, and preventing them from leaching to ground and surface waters. Soils provide habitat for a vast diversity of life. They take up and release important gases, including oxygen and greenhouse gases (a service referred to as gas regulation). Many of these ecosystem services are being lost through the degradation and loss of soils. The conservation, restoration, and optimization of ecosystem services provided by soils are among the great challenges for humanity in the twenty-first century.

5.1.4 Soils Are Fundamental to Biodiversity

Biodiversity in terrestrial and freshwater aquatics systems also depend fundamentally on soils. Without soils, biodiversity cannot exist. Soil diversity supports biodiversity.

5.1.5 Soils Control Watershed Function

Watershed function is primarily a soil function. Nearly everything that happens in a watershed happens in the soil. Watershed function depends directly on the ability of soils to filter, store, and slowly release added water from rainfall and runoff. Soils play important role to control watershed functions and decrease the incedences of floods and droughts.

5.1.6 Soils Are the Primary “Natural Capital”

Soils are the basis of all productivity in terrestrial and freshwater aquatics systems and therefore the primary “natural capital” of forested and agricultural lands.

5.1.7 Conserving Soil and Keeping it Healthy is the Most Important Aspect of an Ecosystem Approach to Forest Management (EAFM)

Soils take so long to form that damage to them is essentially irreversible in human time scales. An impact that lasts for thousands of years is basically permanent in terms of our values. Healthy, productive, well-conserved soils are the foundation of ecosystems and an important approach to forest management.

5.2 How are Soils Formed?

Soil formation is the combined effect of physical, chemical, biological, and human influenced processes on soil parent material. An example of soil development from bare rock occurs on recent lava flows in warm regions under heavy and very frequent rainfall. In such climates, plants become established very quickly on basaltic lava, even though little organic material is present. The plants are supported by the porous rock becoming filled with nutrient-bearing water; for example, water carries dissolved bird droppings or bat guano. The developing plant roots themselves gradually break up the porous lava and organic matter soon accumulates. Before organic matter can build up, the predominantly porous broken lava in which the plant roots grow can be considered a soil. How the soil “life” cycle proceeds is influenced by at least five classic soil-forming factors that are dynamically intertwined in shaping the way soil is developed. These five factors consist of the following: parent material, regional climate, topography, biotic potential, and the passage of time.

5.2.1 Parent Material

The material from which soils form is called parent material, which can include: primary bedrock; secondary material transported from other locations (for example, colluvium and alluvium deposits that are already present but mixed or altered in other ways); old soil formations; organic material, including peat or alpine humus; and anthropogenic materials, such as landfill or mine waste. Few soils form directly from the underlying rocks they develop on. The soils that do form directly from the breakdown or weathering of rocks are often called “residual soils” and have the same general chemistry as their parent rocks. Most soils are derived from materials that have been transported from other locations by the wind, water, and gravity. Some materials may have moved many kilometers, while others only a few meters. The deeper sections of the soil profile may contain materials that are relatively unchanged from when they were deposited by water, ice, or wind.

Weathering is the first stage in the transformation of parent material into soil material. In soils forming from bedrock, a thick layer of weathered material (known as saprolite) may form. Saprolite is the result of weathering processes that include the following: hydrolysis (the replacement of a mineral’s cat ions with hydrogen ions); chelation from organic compounds; hydration, which consists of the absorption of water by minerals; dissolution by solution, where minerals are dissolved by water; oxidation and reduction; and physical processes that include freezing/thawing or wetting/ drying. The mineralogical and chemical composition of the primary bedrock material, as well as the physical features such as grain size, degree of consolidation,

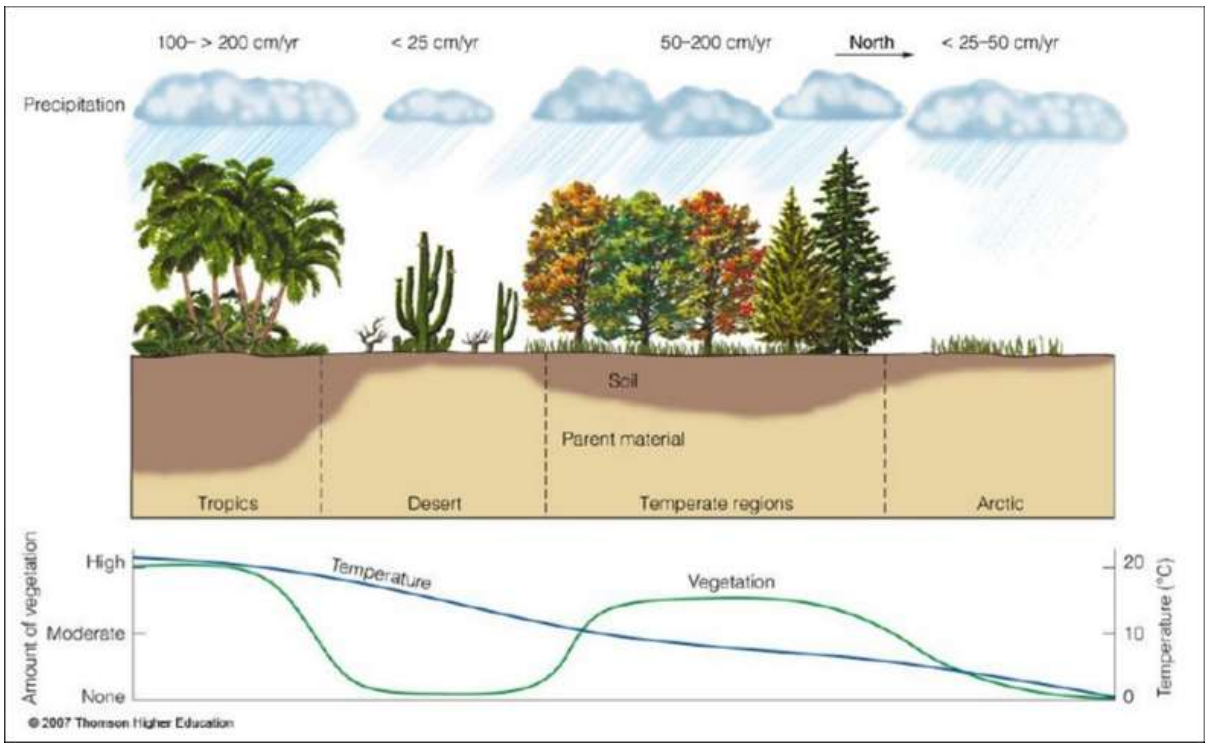
and the rate and type of weathering, transforms the bedrock into different soil materials.

5.2.2 Climate

Soil formation is greatly dependent on the climate. Temperature and moisture affect weathering and leaching. Wind moves sand and other particles from one location to another, especially in arid regions where there is no or little plant cover. The type and amount of precipitation influence soil formation by affecting the movement of ions and particles through the soil, aiding in the development of different soil profiles. Seasonal and daily temperature fluctuations affect the efficiency of water in weathering parent rock material, and soil dynamics. Freezing and thawing is an effective mechanism to break up rocks and other consolidated materials. Temperature and precipitation rates affect biological activity, rates of chemical reactions, and types of vegetation cover. Soils from different climate zones show distinctive characteristics. Warmer, more humid areas tend to have richer and deeper soils than cooler, more arid regions.

The production and accumulation, or degradation, of organic matter and humus is greatly dependent upon climate conditions. Temperature and soil moisture are major factors in the formation, or degradation, of humus and the formation of organic soils. Soils high in organic matter tend to form under wet conditions and in areas where there is enough precipitation to sustain thick vegetation.

FIGURE 5.1: CLIMATE STRONGLY INFLUENCES THE SOILS AND VEGETATION THAT OCCUR IN ANY AREA



Thorston Higher Education, 2006

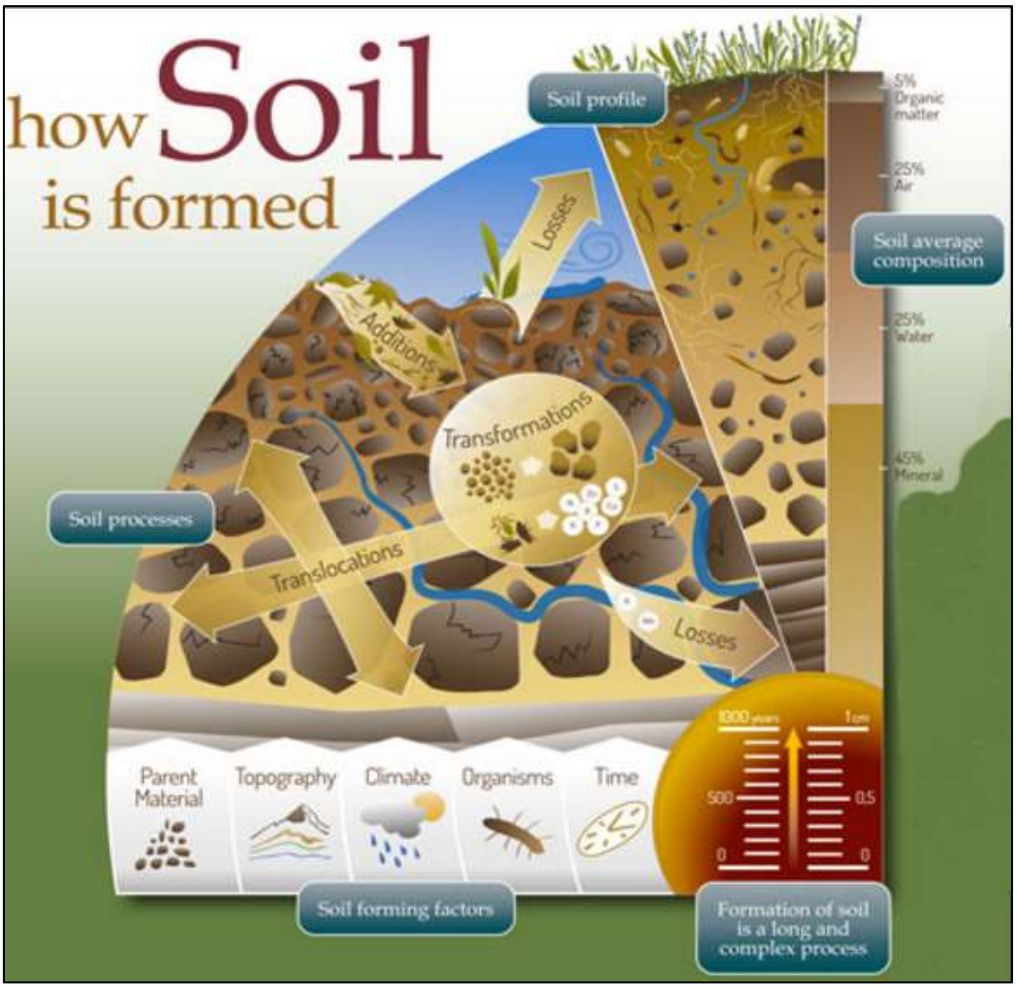
5.2.3 Topography

Slope and surface orientation affect the moisture and temperature of soil and affect the rate of weathering of parent material. Steep slopes facing the sun are warmer. Steep land areas may erode faster than soil formation process or deposition rates, and may add material, causing a net loss of topsoil. Low areas receive deposits from areas upslope, often producing deeper soils. Topography affects erosion and depositional rates; water moves materials from higher, steep elevations to lower, flat locations. Sediments along river banks, on flood plains, and in deltas have different textures, dependent on the rate and duration of water flow. Fast-moving water can move larger material along with fine material, while slow-moving water moves fine material only. Fast-moving water leaves gravel, rocks, and sand. Slow-moving water, including lakes, leaves fine textured material, which forms fine textured sediments such as clay and silt when the water deposits sediments or materials settle in bodies of water like lakes and shallow oceans. Topography also affects the drainage characteristics of soil with ridge systems being shallower, rockier, and more prone to drought than valley bottoms which accumulate both eroded material and water. Where water drainage is impeded, the soil can become water logged and inhibit plant growth.

5.2.4 Living Organisms and Organic Material

Plants, animals, fungi, bacteria, and humans all affect soil formation. Animals and microorganisms mix soils and form burrows and pores, allowing moisture and gases to seep into deeper layers. In the same way, plant roots open channels in the soils, especially plants with deep taproots that can penetrate many meters through the different soil layers and bring up nutrients from deep soil. Plants with fibrous roots that spread out near the soil surface, and have roots that easily decompose, also add organic matter. Micro-organisms, including fungi and bacteria, affect chemical exchanges between roots and soil and act as a reserve of nutrients. Humans can impact soil formation in different ways, such as by removing vegetation cover, which promotes greater erosion; and mixing the different soil layers freely, restarting the soil formation process when less weathered material is mixed with and dilutes more developed upper layers.

FIGURE 5.2: THE INFOGRAPHIC ILLUSTRATION OF SOIL FORMATION



FAO, 2015

Vegetation impacts soils in numerous ways; it can prevent erosion due to rain or surface runoff; it provides shade to soils, keeping them cooler and slowing down the evaporation of soil moisture; or it can cause soils to dry out by transpiration. Plants can form new chemicals that break down or build up soil particles. Vegetation cover is dependent on climate, land form topography, and biological factors. Soil factors, such as soil density, depth, chemistry, and pH; plus temperature, and moisture levels greatly affect the type of plants that can grow in any given location. Dead plants and dropped leaves and stems of plants fall to the surface and decompose on the soil, where organisms feed on them and then mix these dead plants with the upper soil layers. These organic compounds become part of the soil formation process, ultimately shaping the type of soil that is formed.

5.2.5 Time

Time is a significant influence on the interactions of all the factors listed above, as they interplay to develop varying types of soils. Over time, soils evolve features dependent on the other forming factors, and soil formation is a time-responsive process dependent on how the other factors interplay with each other; therefore, such soils are always in a state of development or change. For instance, recently

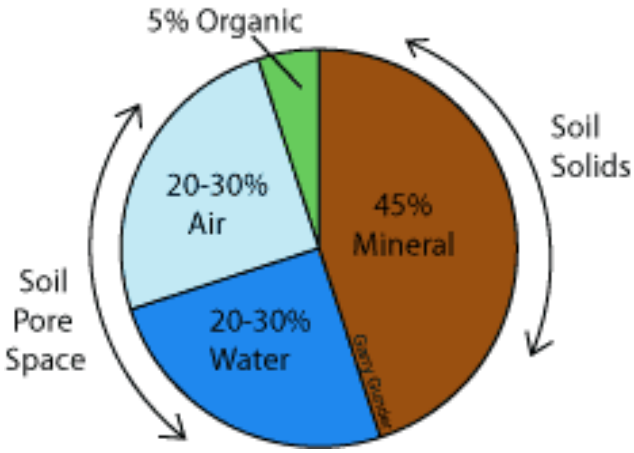
deposited material from a flood exhibits no soil development because there has not been enough time for soil-forming activities. The underlying soil surface and horizons become buried and the time clock resets for these soils. Soil is always changing. The long periods over which change occurs and the multiple influences of change mean that simple soils are rare, resulting in the formation of soil horizons. While soil can achieve relative stability in properties for extended periods of time, the soil life cycle ultimately ends in soil conditions that leave it vulnerable to erosion. Despite the inevitability of soils retrogression and degradation, most soil cycles are long and productive.

Soil-forming factors continue to affect soils during their existence, even on ‘stable” landscapes that are long enduring, some for millions of years. Materials are deposited on top of soils and other materials are blown or washed away from the surface. With additions, removals, and alterations, soils are always subject to new conditions and changes may be slow or rapid, depending on climate, landscape position, and biological activity. Soils are always in a dynamically dependent state of change.

5.3 What Is the Composition of Soil?

As shown in the graph below, soil is made up of mineral, water, air, and organic materials.

FIGURE 5.3: TYPICAL SOIL COMPOSITION



Note that half the soil is not solid, and is porous and is filled with air and/or water. Source: Earthsoils. https://www.earthsoils.com/soil-composition

5.4 What Are the Six Most Important Soil Properties to EAFM and Sustainable Forest Ecosystems?

Below are the six most important soil properties to EAFM and sustainable forest ecosystem:

1. Texture,
2. Depth (thickness),

3. Porosity/Infiltration Capacity,
4. Organic Matter,
5. Soil Cover, and
6. Water-Holding Capacity.

5.4.1 Soil Depth, Porosity/Infiltration Capacity, and Cover: conserving soils in forest management

The loss of topsoil has doomed many civilizations, and this loss has historically been a result of deforestation and subsequent agriculture and grazing. Removing the trees alone does not cause heavy damage if a forest is allowed to grow back. However, if the land is converted to agricultural property or is heavily grazed following deforestation, erosion rates are far greater than soil formation rates and the soil steadily degrades to the point where it is no longer productive. Foresters are often the voice of conservation and look at long-term effects.

India cannot afford to lose its soil productivity. The population is still growing and if soils are degraded, food production will be harder in the future, with more poor, hungry people, and less for everyone. Conservation might require some short-term sacrifices, but in the long term, they are a sound investment in sustaining people and ecosystems.

The primary threat to soil depth is erosion. Erosion is defined as the detachment and movement of soil. Erosion occurs as a natural process; however, the activities of man often accelerate the rate and alter the timing of erosion processes.

5.4.2 Types of Erosion

Wind Erosion is the movement of exposed soil due to wind. This occurs predominantly in arid areas or when drought occurs.

Dry Ravel Erosion is the rolling, bouncing, or sliding of soil downslope. It occurs on or over steepened cut banks of roads or on steep slopes (over 60 percent) following burns. Fires remove vegetation and organic material that was retarding the movement of surface soil. Dry ravel erosion can move a significant amount of soil off of hill slopes into the headwaters of ephemeral channels to be transported downstream as sediment during rain events.

Water Erosion is the movement of soil by the forces of water. This is usually the most active threat and forest soils are most vulnerable to water erosion. Several types of water erosion are listed below.

- Raindrop Splash: individual raindrops hit on exposed soil surfaces, breaking up soil aggregates and displacing soil particles downslope.
- Sheet Erosion: term for soil that has been removed from an area but rivulets or rills are not clearly defined. It is also described as water moving across the soil surface as a sheet, taking soil particles with it. In actuality, the water is moving in micro-rills that are just too small for the eye to see.

- Rill Erosion: conspicuous channels form (approximately 6 - 8 inches deep) where water has excavated the soil.
- Gully Erosion: areas of heavy concentrated flow where water cuts through the soil to depths greater than 8 inches but sometimes 600—1200 inches deep. In India ravaines cover about 100 million hectares. Gullies have defined forms based on the soil types they cut through.
  - V-shaped gullies occur where the subsoil's are more resistant to erosion than the surface soils.
  - U-shaped gullies occur when the subsoil is equally or more erodible than the surface soil.
- Tunnel Erosion or Piping: occurs when subsurface soils erode through soil pores or pipes and the land surface collapses to fill the voids.

5.4.3 Factors Affecting Soil Erosion

The Universal Soil Loss Equation (USLE) or the Revised Universal Soil Loss Equation (RUSLE) is used to predict the rates of erosion, and demonstrates the factors that influence soil erosion rates:

A = RKLSCP

Where:

A= Average soil loss in tons/acre/year

R = Runoff Factor is based on the average 30-minute rainfall intensity for the area

K= Erosivity Factor determines the rate of erosion

L= Slope Length is defined as the distance from the origin of flow (top of the slope) to an area of concentrated flow or deposition. Slope lengths are rarely longer than 4800 feet, micro topography effects water flow and erosivity. Field checking of the length factor is required; GIS measurements of slope length often overestimate the length of slopes.

S= Slope Steepness. Erosion increases with slope gradient much more so than it does with increased slope length. Changes in slope gradients from flatter to steeper slopes are often nick points for erosion. A nick point is considered the place where erosion begins, which is why it is important to place water bars or drainage structures slightly below the change in slope and not at the bottom of the slope.

C=Cropping factor or soil cover. This factor can be anything from a forest or shrub canopy to a grass forb surface cover, or even organic material. It also includes a measure of the surface roughness. Prior land use is also considered in this factor due to the potential for compaction from some previous land uses.

P= Support Practice or Conservation Practice. The erodibility of a site is lowered if conservation practices are employed that slow water movement and facilitate infiltration of water. The following practices are examples: no-till farming; terracing; strip cropping; contour planting; permanent pasture; agroforestry, and row cropping on the contour.

The table below indicates the reasons for soil erosion.

TABLE 5.1: REASONS FOR SOIL EROSION

Erosivity Value	Soil Type	Reason
Low	Heavy clays	Structure resists soil particle detachment
Low	Coarse textured soils (sands)	The high infiltration rates result in low levels of runoff
Low	High organic matter content	Good structure, high infiltration, high permeability, low runoff
Moderate	Medium textured soils (loams, and silt loams)	Moderate runoff potential and soil particles easily detached
High	Silts and very fine ash deposits	Soil surface tends to crust, high runoff rates, particles are easily detached
High	Compacted soils	Low infiltration, high runoff potential

5.5 What Are the Environmental Effects of Soil Erosion?

5.5.1 Potential On-site Environmental Effects

- Loss of topsoil;
- Loss of productivity;
- Low seedling emergence, due to surface sealing or subsoil exposure;
- Exposure of subsoil (less fertile, low infiltration);
- Loss of seed bank;
- Removal of plants;
- Degraded soil structure;
- Changed soil texture (erosion pavement: removal of fine soils leaving only gravel, cobbles, or stones behind); and
- Changes in water-holding capacity, thereby increasing the susceptibility to drought.

5.5.2 Potential Off-site Environmental Effects

- Sediment loading of streams, wetlands, estuaries, mangroves, and coral reefs;
- Decreased water quality;
- Loss of aquatic habitat: filling pools, smothering fish in gravel, smothering corals;
- Increased nutrient loads (phosphorous and nitrogen) in streams, wetlands, and water bodies;
- Filling of lakes, reservoirs, and wetlands;

- Increased flooding and the potential to wash out farms, houses, roads, and bridges downstream; and
- Increased stream bank erosion.

5.6 Soil Porosity, Permeability, and Infiltration Capacity Is a Function of Soil Density

Dense soils have less pore space for water and air, are less porous and permeable, and have lower infiltration rates than open, less dense soils. Management practices that avoid compacting soils or depriving them of organic inputs need to be minimized or avoided to maintain low soil densities.

TABLE 5.2: PERMEABILITY MEASUREMENTS OF SAMPLED LAYERS WITHIN 20 INCHES OF SOIL SURFACE

Site	Bulk Density (g/cm3)	Permeability (cm/hr)
Forest	1.42	38.10
Pasture	1.47	25.25
Single House	1.67	18
Subdivision Lawn (1)	1.79	0.36
Garage Lawn	1.82	0.33
Cleared Woods	1.83	0.33
Subdivision Lawn (2)	2.03	0.08
Athletic field	1.95	0.025
Concrete	2.4	0.00

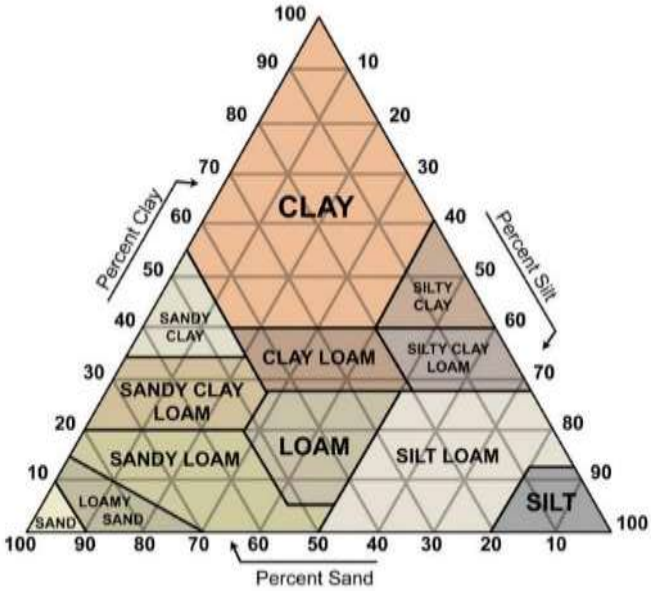
Typical soil densities. Note that forests have the lowest density, and therefore the greatest porosity, permeability, and infiltration capacity.

5.7 What is Soil Water-Holding Capacity?

The ability of soil to hold water is a function of depth, texture, and organic matter. Soil texture is a fundamental soil property. The proportion of sand, silt and clay particles is referred to as the soil texture. Sand sized particles are 1,000-fold larger than clay particles; therefore, the spaces between clays are much smaller than those between sand particles, and clays hold much more water and sands drain quickly. We can use the soil textural triangle to classify soils into textural groups. Soil texture affects a whole range of physical and chemical properties. Soil texture has important implications for soil fertility.

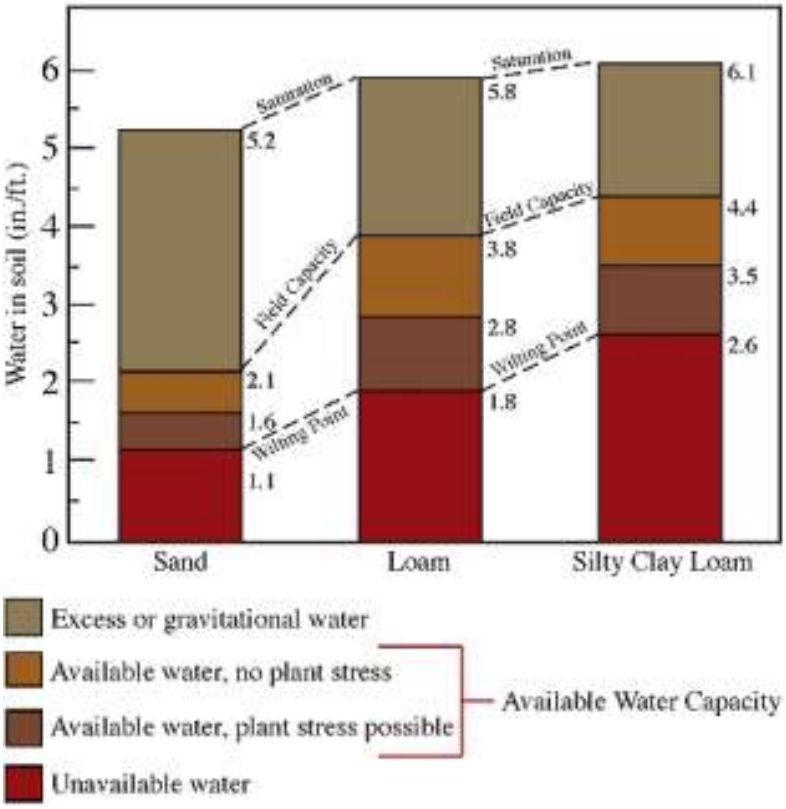
Along with organic matter, soil texture determines the soil's capacity to store and supply water and plant nutrients to trees and other forest vegetation. Texture also strongly influences seedling emergence, root penetration, and drainage.

FIGURE 5.4: THE SOIL TEXTURAL TRIANGLE. SOIL PARTICLE SIZE CLASSES: SAND .02 – 2MM; SILT .002 - .02 MM; CLAY < .002 MM



Source: Science Visualized. http://mucholderthen.tumblr.com/post/47596484105/i-dont-remember-posting-this-but-since-its

FIGURE 5.5: WATER HOLDING CAPACITY OF SOILS



How much water do soils hold? This depends on their texture and depth, as well as their organic matter content. Source: Samuel Roberts Nobel Foundation. http://www.noble.org/ag/soils/soilwaterrelationships

Refer to the Module 3 - Lecture 7: Watershed Management section for definitions of "Green Water," "Blue Water," and "White Water," as these are important concepts in how soils fractionate water.

5.8 Organic Matter is Fundamental to Soil Fertility and Health

Most living things found in soils, including plants, insects, bacteria, and fungi, are dependent on organic matter for nutrients and energy. Soils often have varying degrees of organic compounds in different states of decomposition.

5.8.1 Organic Matter in Soil Aids Structure, Water-Holding Capacity, Nutrient Exchange, and Site Fertility

Fertility consists of the overall properties that describe how well a plant grows and produces, which is essentially a summary of the right physical, biological, and chemical properties of a soil that provide plant growth. In the decomposition of organic matter, fungi, and bacteria produce by-products and end products that associate with mineral particles giving the soil a desirable structure. Such a structure allows water, air, and roots to penetrate more readily than when organic matter is deficient.

When the decomposition of organic matter is nearly complete, a black material called humus is formed. Humus decomposes slowly and, to keep a desirable amount of humus in the soil, it needs to be replenished regularly. Under natural or cultivated conditions, in which crop residues add organic matter to a soil, additional organic matter may not be necessary to maintain desirable amounts of humus. Furthermore, because the amount of humus in a soil is largely regulated by climate, attempts to increase humus by adding more organic matter may not succeed. When humus concentration increases in the soil, the ability to retain nutrients increases. This process is referred to as the exchange capacity of the soil and as it increases, the ability to guard against leaching of nutrients increase, as well as other mineral constituents which influence the soil's physical and chemical properties.

Plant and animal organic matter contain the mineral constituents needed to form new plants or increase plant growth. As the matter decomposes, the mineral constituents become simple chemicals. These simple chemicals are the same as the plant nutrients occurring in the soil (or added to the soil by using fertilizer). As long as they remain a part of the organic matter, they cannot be taken from the soil by plants. The rapid, but incomplete decomposition that occurs soon after organic matter is added to a soil, releases much of the plant nutrients. The rest are released later as humus slowly decomposes. Time has a similar effect on physical properties of soil, the beneficial properties gradually decline over time.

5.9 What is the Concept of Soil Health?

According to FAO (2008). Soil health may be defined as:

> *"The continued capacity of the soil to function as a vital living ecosystem that sustains plants, animals, and humans."*

Soil health can be seen as a function of:

- Continued capacity: this implies rejuvenation and then sustainability.
- A living ecosystem: people need to recognize the ground beneath them is a living ecosystem.
- Soil function: soils need to provide basic functions for food and fiber production to meet human demands.
- Nutrient cycling: soils store, moderate the release of, and cycle nutrients and other elements. During these biogeochemical processes, analogous to the water cycle, nutrients can be transformed into plant-available forms, held in the soil, or even lost to air or water.
- Water relations: soils can regulate the drainage, flow, and storage of water and solutes, which include nitrogen, phosphorus, pesticides, and other nutrients and compounds dissolved in the water. With proper functioning, soil partitions water for groundwater recharge and for use by plants and soil animals.
- Biodiversity and habitat: soils support the growth of a variety of plants, animals, and soil microorganisms, usually by providing a diverse physical, chemical, and biological habitat.
- Filtering and buffering: soils act as a filter to protect the quality of water, air, and other resources. Toxic compounds or excess nutrients can be degraded or otherwise made unavailable to plants and animals.
- Physical stability and support: soils have the ability to maintain their porous structure to allow passage of air and water, withstand erosive forces, and provide a medium for plant roots. Soils also provide anchoring support for human structures and protect archeological treasures.

5.10 References and Further Reading

- Food and Agriculture Organization [FAO]. (2015). International year of soils 2015. FAO of the UN viale dell Terme dicaracalla 00153, Rome Italy.
- FAO (2008). An International technical workshop investing in sustainable crop intensification. The case for improving soil health. Integrated crop Management, vol.6, FAO, Rome.

MODULE 3: MANAGEMENT FOR ECOSYSTEM SERVICES

A major transition in management goals for Indian forests has been from timber to ecosystem services. This is acknowledged in policy documents, and timber extraction is now a minor forest product in India. How to manage for ecosystem services, however, is by no means a straightforward matter. Management requires new datasets, analysises, and decision management support unnessesary for timber production.

To orient practitioners on these issues, this module covers valuation of ecosystem services, watershed management, and biodiversity conservation in forested ecosystem. The climate regulation services of forests are covered in the following module.

LECTURE 6: FOREST ECOSYSTEM SERVICES AND THEIR VALUATION

This lecture covers the following:

- Concept of ecosystem services
- Forests as natural capital
- Classification of ecosystem services
- Valuation of ecosystem services
- Concept of green economy
- Ecosystem services as payments for environmental services (PES)
- Cost–benefit analysis of “developmental” projects

6 FOREST ECOSYSTEM SERVICES AND THEIR VALUATION

6.1 Introduction

Forests are one of the most important components of the terrestrial environmental system and provide a complete resource base. They are important to all human populations as forests play a vital role in the economic development of a country. Forests provides a vast array of environmental, social, and economic benefits and help in maintaining ecological balance by providing wide range of ecosystem services like carbon storage, regulation of climate, purification of water, and mitigation of natural hazards such as floods and droughts. There is an urgent need to recognize the important role of diverse ecosystem services from forests in the expanding economy. There is also the need for increased investment for forest conservation of this important resource base. For countries with large populations, particularly in developing countries, forests are more than a mere gift of nature—they are a source of their sustenance.

Ecosystem services are the benefits provided to humans through the transformations of resources (or environmental assets, including land, water, vegetation and atmosphere) into a flow of essential goods and services (e.g., clean air, water, and food) (Constanza et al., 1997). Environmental services produced by forests are not easily perceptible. Environmental services from forests are required in perpetuity, and there is no possibility of their being affected by any technological development, or change in the socio-economic conditions of the human population.

6.2 Forests as Natural Capital

The term “capital” is defined as something which earns its return through market mechanisms, and thus we invest in such capitals such as physical capital, human capital, social capital, and financial capital. Traditionally, most of the natural resources are taken as “free gifts of nature,” hence have not been treated as capital. The basis for estimating economic value of a resource or an environmental amenity is determined by its probable effect on human welfare.

There is lack of understanding of the true role of forests in the well-being of people. Forest lands have become degraded on account of overuse and mismanagement. The investment in the forestry sector has not kept pace with the removals and the few resources available to the forestry sector are often put to non-productive uses.

One of the reasons for forest degradation is low investment in the forestry sector. Whereas the investment in the man-made capital and financial capital is on rise, the forestry sector (on account of lack of appreciation of its true and total value) has always been less appreciated and thus has received less budgetary allocation and investment. If treated as a natural “capital” asset, forests” true contribution could be assessed through economic value of not only timber and non-timber goods, but also through their ecological services like carbon sequestration, watershed, eco-tourism,

biodiversity, and other factors. Then, their contribution to the economic system would be very high and this would attract investment in “natural-forest capital” (Lal, 2011).

The neoclassical economists introduced the term “natural capital” alongside “man-made capital” and, in assessing the value of resources, recognized the changes in natural capital from depletion, degradation, and regeneration that occurs as a result of human interference. Whereas man-made capital has established markets and the values generated by them enter into a country’s accounting system, most of the goods and services provided by forests do not have established markets. In the current scenario, the tangible values of forests are under-estimated and the intangibles are completely ignored by the prevalent accounting system. Therefore it is necessary to reflect the true contribution of forests in a country’s accounting system. This can be accomplished by incorporating the forests” total economic value so the sector receives due credit in the planning and decision-making process and an appropriate budgetary allocation is established for its sustainable management (Verma, 2008).

The concepts of ecosystem services and natural capital help us recognize the many benefits that nature provides. Maintaining stocks of natural capital allow the sustained provision of future flow of ecosystem services, and thereby help to ensure enduring human well being (The Economics of Ecosystems and Biodiversity [TEEB], 2010).

6.3 Classification of Ecosystem Services

6.3.1 Millennium Ecosystem Assessment

The Millennium Ecosystem Assessment (MA) (MA, 2005a), an international synthesis, analyzed the health of the Earth’s ecosystems and provided summaries and guidelines for decision-makers. It concluded that human activity has significant and escalating impact on the biodiversity of world’s ecosystems and has reduced both their resilience and biocapacity. The report referred to natural systems as humanity’s “life-support system,” providing essential “ecosystem services.” The assessment classifies these ecosystem services as provisioning (products obtained from ecosystems), regulating (benefits from regulation of ecosystem processes), cultural (non-monetary benefits that enrich the quality of life), and supporting (services needed to produce all other services) services (MA, 2005a). It placed human well-being as the central focus for assessment, while recognizing that biodiversity and ecosystems also have intrinsic value. Such linkages are very influential in India’s forestry sector as forest ecosystem services and human well-being through livelihood benefits, have a very high correlation.

TABLE 6.1: FOREST ECOSYSTEM SERVICES CLASSIFICATION PER MILLENNIUM ECOSYSTEM ASSESSMENT (2005)

Provisioning	Regulating	Cultural
Firewood, pulpwood, fodder, timber, non-edible oils, medicines, fibers and flosses, resins, lac, tendu and other leaves, bamboos and canes, raw materials for clothing, and other factors. Raw materials for manufacturing and other sectors, and construction, biochemicals, water habitat (indigenous people and wildlife), recreation.	Soil conservation, protection and regulation of water supplies, amelioration of climate, sediment control, shelter from hot and cold winds, absorption of dust and noise, maintenance of genetic pool, maintenance of visual quality of the environment, and maintenance of carbon dioxide balance in the atmosphere.	Aesthetic, artistic Spiritual, historic Scientific, educational Inspirational, and symbolic.
Supporting nutrient cycling, soil formation, primary production		

Source: MA, 2005a

The provisioning services provide direct benefits to society and can be often calculated in monetary terms. Regulating services are regulatory in nature and do not have a price tag in conventional markets. Cultural services do not provide direct monetary benefits but express the people's willingness to pay for the conservation. Although supporting services do not give any direct benefit, they are essential for ecosystem functioning.

6.3.2 Total Economic Value

Total economic value (TEV) as it appears in environmental economics is an aggregation of the values provided by a given ecosystem. The TEV is comprised of use values, option values, and non-use values. Use values include direct-use values and indirect use values, and optional values. Non-use values include existence values. Direct-use values refer to the products or the materials removed from the forests (for example timber and firewood) whereas indirect use values are non-removable (for example soil and water conservation, clean air, climate amelioration). Option value is the value that may not be currently in use, but people have option to use it in future.

Non-use values are benefits that are not realized by the individual expressing the value but by the future individuals. Non-use values or non-consumptive use values are rarely valued in monetary terms. The value which individuals give to the preservation of environment in their natural form independent of any present or future human use for that environment is referred to as existence value. Bequest value is the value to present generations of conserving the natural resource forests for the benefits of future generations. Existence value is the value for mere existence of the natural resource independent of its present or future human use.

6.3.3 Valuation of Ecosystem Services

Well-known words in environmental management are "if you can"t measure, you can"t manage." "The Economics of Ecosystem and Biodiversity" trend, known as TEEB, has been an attempt to demonstrate the economic value of biodiversity, ecosystem and their services, and their integration into everyday decision making. TEEB flags the importance of measuring ecosystems (which are often managed) and estimating ecosystem services as a percentage of the Gross Domestic Product

(GDP) of the poor. Thus there is a perceptible shift the way forests and its contribution to the economy is perceived.

The TEEB (2008) also emphasized that, in spite of the crucial ecological, cultural and economic importance of these services, the biodiversity of ecosystems is still declining worldwide. One major reason for the continued loss and degradation of ecosystems is that the value (importance) of ecosystems to human welfare is still underestimated in most economic development decisions because the benefits of their services are not, or only partly, captured in conventional market economics. Furthermore, the costs of externalities of economic development (e.g., pollution, deforestation) are usually not accounted for and inappropriate tax and subsidy systems stimulate over-exploitation of resources and other ecosystem services. There is, therefore, a need for developing a system to have reasonable estimates of contribution made by forests to the Gross National Product (GNP) and a comprehensive system of resource accounting to incorporate costs of environmental degradation in the use of natural resources for developmental purposes (Lal, 2005). Forest valuation provides an important tool for decision makers on weighing the cost and benefits of development projects.

6.3.4 Key Issues in Ecosystem Services Valuation

There is lack of detailed knowledge of the functions of ecosystem services and the relevant data. Most decisions involving trade-offs in ecosystem services are based on incomplete information, leading to non-sustainable developments. Often the economic and social costs of non-sustainable ecosystem use are only realized after values are lost that can often only be restored at high costs, if at all.

The divergence of private and social costs makes economic valuation of forest resources difficult. The valuation is an economic one and not a financial one. For most of the services the valuation uses shadow prices, and not the market prices because the latter may give a distorted picture of social costs.

The National Environment Policy of 2006 also recommended the use of economic principles in environmental decision-making. It states that “it is necessary that the costs associated with the degradation and depletion of natural resources be incorporated into the decisions of economic actors at various levels, to reverse the tendency to treat these resources as “free goods” and to pass the costs of degradation to other sections of society, or to future generations of the country.” It recommended:

1. To strengthen, including through capacity building, in the area of natural resource accounting, with a view to its adoption in the system of national income accounts. Further strengthen in all respects, the system of collection, collation and analysis of all significant and relevant environmental monitoring data,

2. Develop and promote the use of standardized environmental accounting practices and norms in preparation of statutory financial statements for large industrial enterprises, to encourage greater environmental responsibility in investment decision-making, management practices, and public scrutiny,

3. Facilitate the integration of environmental values into cost-benefit analysis (CBA), to encourage more efficient allocation of resources while making public investment decisions. It further emphasized on developing mechanisms for payments for various ecological services from ecosystems.

6.3.5 Valuation Techniques

Over time few credible valuation techniques for non–market forest products and services have evolved. Some of the techniques used for valuation of ecosystem services are illustrated below.

Change in Productivity Method

This method is mostly used to estimate the economic value of ecosystem goods and services that contribute to the production of marketed goods. Forests enhance agricultural productivity through soil and water conservation. Deforestation may result in loss of agricultural production. This loss may be attributed to loss of forest cover. Thus economic benefits in agricultural production by conserving forests can be a measure of watershed services provided by forests.

The advantages of this method are that it is straightforward and requires limited data. However, its use is limited to the resource that contributes to the production of marketed goods.

Replacement Cost Method

The replacement cost method directly accounts for the expenditure made to replace the environmental services that are lost due to damage or depletion of the resource. For example, the cost incurred in use of fertilizers to compensate for the loss in agricultural production by depletion of forest cover is a measure of the services provided by forests.

Substitution Method

This method is used to estimate the value based on the cost of providing a substitute. This is closely related to the replacement cost method except that it uses the cost of the substitute to estimate the value of ecosystem services. For example, the value of firewood, derived from forests, can be estimated by the related substitute, such as kerosene.

Hedonic Pricing

This method estimates the changes in the market prices on account of changes in the environmental attributes. The estimate is based on the cost or benefits associated with environmental qualities such as pollution, clean air and water, water logging, aesthetic views of the site, and other factors. The scope of this method is limited to housing or land-based projects.

Travel Cost Method

This estimate is based on the willingness to pay for using a particular resource as a function of expenditure made for its use. This method is mostly used to assess the

recreational services of the natural environment. It takes into account various costs involved in travelling to the site and other socio-economic variables.

The principal limitations of this method are that the total value of the estimated benefits are only reflected to the extent of willingness to pay by those who actually use the facility and does not truly reflect to the benefits to the society.

Contingent Valuation Method

This method can be used to estimate economic values of all kinds of ecosystem and environmental services. In this method people are asked to state their maximum willingness to pay for a particular environmental service or minimum willingness to accept the compensation for loss of the service in a hypothetical market. The method can be used to assess all types of both use values as well as non-use values. The contingent valuation method can also be used to estimate existence value, option value, and bequest values. The method has great significance in estimating values of biodiversity, wildlife, and other unique natural resources.

Benefit Transfer Method

The benefit transfer method is used to estimate economic values for ecosystem services by using data from earlier studies conducted in similar contexts elsewhere. The advantages of this method are it is cost effective and less time consuming. The accuracy of the method depends on the accuracy of the earlier study. Its scope is limited by finding similar studies to be applied elsewhere.

6.4 Payments for Environmental Services

PES involves schemes where payments or rewards are given by those who benefit from environmental services like clean and sufficient water, biodiversity, stable climate, or aesthetic beauty, to those who play a central role in providing or maintaining these services (The Center for People and Forests [RECOFTC], 2009).

6.4.1 Forests Resource and Poverty Alleviation

India’s forests, about one fifth of its land mass, are the single largest land-based resource that has the potential of reducing poverty of the population and, indeed, these forests have provided the poor with some basic requirements over the country’s long history. However, in the preceding few decades the capacity of the forests to cater to the poor has eroded. If managed properly, forests can play a very important role in addressing the Millennium Development Goals (MDG). The first MDG of eradication of extreme poverty and hunger and the seventh MGD of ensuring environmental sustainability are very strongly linked for India. The high dependence of India’s population on forest resources can play a vital role in ensuring eradication of poverty if India’s forests are managed properly with true understanding of their immense value. With the changing and evolving forestry sector, the increase in forest cover puts forward a strong case for the important ecosystem service (i..e.., carbon sequestration) as a mitigative strategy for climate change. Thus the evolving strategy of Reducing Emissions from Deforestation and Forest Degradation with increase in the carbon stock (REDD+) is a global PES mechanism for forest

conservation and enhancement with emphasizes on the community benefits and biodiversity conservation.

6.4.2 Constraints in PES Schemes

Some of the constraints in implementing the PES schemes are vague land tenure system, high financial costs, lack of capabilities and awareness among the local communities. The vague land tenure system makes it difficult to identify the actual beneficiaries of the scheme. The scheme involves high investments. Providing for adequate financial resource is yet another constraint. There is lack of awareness among the actual beneficiaries of the scheme. In addition, the beneficiaries do not have the capabilities to negotiate in terms of payment and rewards. As a result the local communities may not be adequately compensated or rewarded.

6.5 Net Present Value (NPV) of India's Forests

6.5.1 Rationale for Charging NPV of Forests in Diversion Cases

The Forest (Conservation) Act of 1980 provides that no state government or other authority shall make, except with the prior approval of the central government, any order directing: (i) dereservation of the "Reserved Forest," (ii) use of forest land for non-forestry purpose, (iii) leasing out of forest land to any private person or to any authority, corporation, agency or any other organization not owned, managed or controlled by government, or (iv) clear forest or naturally grown trees for reforestation. According to the Act, forests land diversion require the prior approval from the central government.

Diversion of forest for non-forestry use leads to loss of ecosystem services. Compensatory afforestation in lieu of forest lands diverted for non-forestry purposes, as provided in the Forest (Conservation) Act, takes a long time to replace the ecological services lost and for limited services only. The realization of NPV of forests is to compensate for this loss of services and to balance the interest of economic development and environment protection. The Supreme Court of India has directed that, "The amount is required to be used for achieving ecological plans, and for the regeneration of forest and maintenance of ecological balance and ecosystem. The payment of NPV is for the protection of the environment and not in relation to any property rights."(GoI, 1995).

6.5.2 NPV Estimation of Forests

For integrating the valuation approaches, the Supreme Court of India in its judgment dated September 26, 2005 (GoI, 1995), in T. N. Godavaraman Thirumulpad vs. Union of India directed to set up an expert group to suggest suitable NPV of forests. The committee setup by the Supreme Court gave its recommendation with respect to charge of NPV for forest diversion. The goods and services considered by the committee for assessment of NPV of forests were timber, carbon storage, fuel wood and fodder, non-timber forest products (NTFP), ecotourism, watershed services, and biodiversity. The report was further examined by the Central Empowered Committee (CEC) which recommended that forests be grouped into six eco-classes and three

forest canopy-density categories. The committee also considered the carbon sequestration value (instead of carbon storage), value of flagship species and bio-prospecting for the purpose of ecosystem services. The three canopy densities were very dense forest (crop density more than 70 percent), dense forest (crop density between 40 and 70 percent) and open forest (canopy density between 10 and 40 percent). The NPV ranges from Indian Rupees (INR) 699,000 to INR 1,043,000.

6.6 Need for Incorporating Forest Ecosystem Services Values in Cost-benefit Analysis of Forest Diversion Proposal

India is one of the seventeen mega-diverse countries (Conservation International, 1998). As per the latest estimate by the Forest Survey of India (India-FSI, 2015), India's forests constitute 21.34 percent of the total geographical area of the country. The area under tree cover outside forests is reported to be 2.82 percent. Thus the total of forest and tree cover in India is 24.16 percent (79.42 million hectares) of the geographical area of the country (328.73 million hectares).

Over the years India has witnessed large-scale deforestation and loss of forest cover. One of the major drivers of loss of forest cover in the country has been dereservation of forests and diversion of forestland for non-forestry uses. The Forest (Conservation) Act of 1980 had been an effective legal instrument in restraining the process. This regulatory mechanism is to balance the sustainable development need of the country with the conservation of forests. The guidelines regarding submission of proposals under the Act, issued by the Ministry of Environment, Forests and Climate Change, Government of India, envisage that a CBA of the project should accompany the proposal, wherever applicable. The guidelines further mandated that while considering proposals for dereservation or diversion of forest land for non-forest use, it is essential that ecological and environmental losses and socio-economic distress caused to displaced people are weighed against economic and social gain.

A CBA is a mechanism for calculating and comparing benefits and costs of a project to facilitate the decision-making process. It is most commonly used to determine the profitability of a project and choose the most economically attractive option among the various alternatives. The total expected costs are compared against the total expected benefits to ascertain whether the benefits outweigh the cost and to what extent. A CBA brings objectivity and transparency in the decision-making process.

India's forests have multiple demands on them both in terms of the goods and services they provide. Diversion of forestlands for non-forestry use has serious adverse impacts on the natural environment. To make a just decision on how to balance the conflicting interests on the use of natural resources is a complex exercise. This is especially true because most of the ecosystem services provided by the forests are not easy to quantify in monetary terms, though they are valuable to the society. Mere financial analysis of the projects necessitating diversion of forestland for non-forestry purposes is not enough. Environmental issues are a major concern in decision making. There is a need to evaluate the environmental benefits from the forests such as carbon sequestration, clean environment, maintaining the

hydrological cycle, soil and water conservation, forest ecotourism and other factors that should be included in the CBA.

There are external benefits of forest preservation. Projects must consider the externalities such as land degradation, air and water pollution, shrinking of wildlife habitat, loss of biodiversity, and other environmental effects caused by such diversion of forestlands. The CBA should also account for corrections on externalities.

6.7 Concept of Green Economy

The green economy is defined as one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities (United Nations Environment Program [UNEP]). In simpler terms, the green economy is one which is low-carbon, energy-efficient and with inclusive growth. A green economy is not a substitute to sustainable development but an important component toward achieving sustainability. The main focus of a green economy is on finding a balance between environment conservation and development. A green economy is an important tool for poverty alleviation, particularly in developing countries. The Green Economy Group defines a “green economy” as a sustainable economy and society with zero carbon emissions and a one-planet footprint where all energy is derived from renewable resources which are naturally replenished. A green economy provides energy infrastructure with zero carbon emissions. A green economy is key to make growth more inclusive and sustainable. The green economy exhibits the characteristic that “the preservation and protection of the world’s ecosystem, biological diversity and forests in partnership with indigenous peoples and all relevant stakeholders through the creation of sustainable governance models, markets and business models for delivering, maintaining and paying for ecosystem services.” (The Green Economy Group, 2012)

6.8 The Way Forward and Conclusion

For understanding the ecosystem services and the role of forests for human well-being, it is essential to develop a standardized framework for valuation of forest ecosystem services. Having estimated the values both in terms of cost of provisioning and the price of services, the next step would be to develop markets for ecosystem services from forests. This would help in getting returns on forest investment and to incentivize communities engaged in forest resource conservation. Further, these markets can also increase the economic value of forest ecosystems. Market-based approaches are increasingly applied to achieve conservation objectives all over the world. Compared to previous approaches followed in India for forest conservation, which were mostly command and control type, market-based mechanisms would play a dual role by means of performance based payments which would lead to livelihood opportunities and forest conservation.

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LECTURE 7: WATERSHED MANAGEMENT

This lecture covers the following:

- Why water is essential to life and ecosystem services
- How forests provide many ecosystem services, of which watershed services are the most important
- A few basic concepts in watershed management
- Watershed management and sustainable development

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7 WATERSHED MANAGEMENT

7.1 Introduction

Clean, fresh water is our most important natural resource. It is essential to sustaining people, forests, agriculture, industry, and ecosystems. It is also a resource in crisis worldwide. Existing freshwater supplies are highly stressed in many parts of the world, including India, owing to mismatches between supply and demand.

Water pollution, invasive species, and urban and rural development further threaten our capacity to supply adequate clean water and to support the ecosystems upon which society depends. In some areas, these conditions are causing significant social conflict and competition between water users.

Climate change will likely intensify these problems by altering the quantity, quality, timing, and distribution of water. For example, in high-elevation areas, less winter snow and earlier spring runoff will reduce water availability during the summer and fall. Altered stream flow and erosion regimes and higher air temperatures will affect water quality and aquatic ecosystems. Fire and flood frequency and severity will likely increase, and stream networks may contract.

Addressing these fundamental hydrologic changes and their interactions is a formidable and urgent challenge, but much can be done. Forest management provides important opportunities for adaptation because forests are the most plentiful source of the cleanest water; are the last refuges of valued species that have been eradicated from other areas; are often located in the mountains and thus provide the first opportunity to store, filter, and release water for downstream uses; and provide the earliest opportunity to measure precipitation and stream flows, thereby allowing water managers to forecast supplies and adjust downstream water storage systems.

7.1.1 Watershed Services: the Most Important of Forest Ecosystem Services

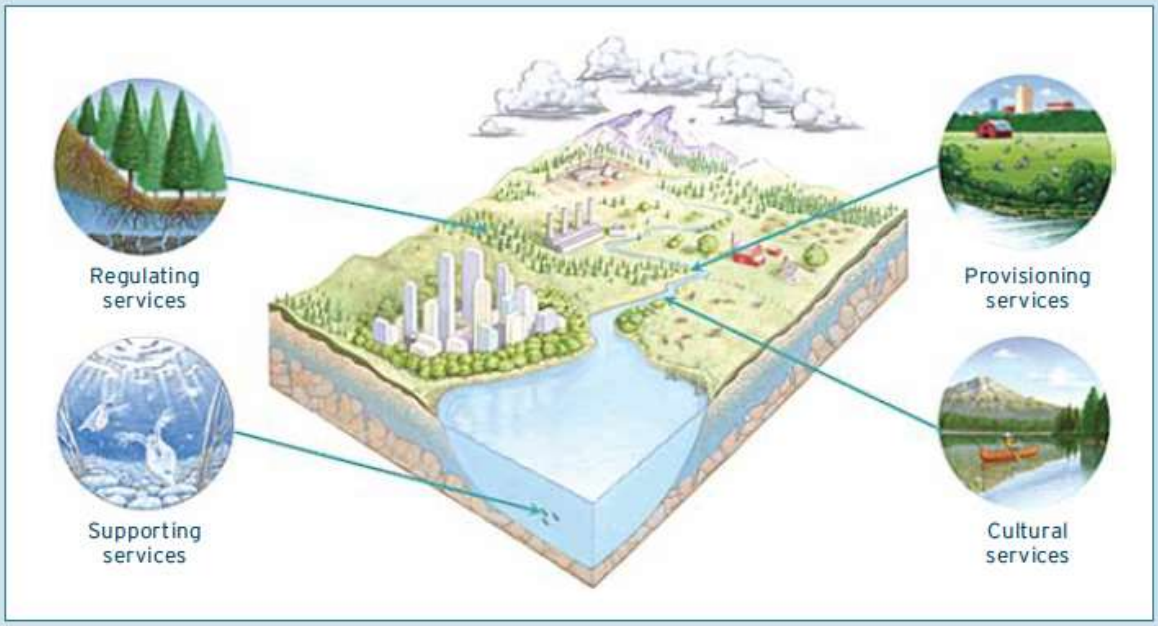
Forests supply many ecosystem services, many of which are vital for life and human well-being and cannot be replaced. The text box on the next page provides a description of ecosystem services.

Forested watersheds typically supply the highest quality water, with the greatest value for downstream users and the lowest treatment costs when used for domestic or industrial water supply.

FIGURE 7.1: WHAT ARE ECOSYSTEM SERVICES

What are ecosystem services?

Ecosystem services are benefits obtained from nature that are critical to human health and well-being. These services are typically grouped into four categories: regulating, supporting, provisioning, and cultural (Millennium Ecosystem Assessment 2005). Watershed services are a subset of ecosystem services that are associated with water and watersheds (fig. 3). Definitions of these different types of services and examples pertaining to watersheds are provided below.



- **Regulating services** are benefits obtained from the regulation of ecosystem processes. Examples include flow regulation (surface and groundwater flow), erosion control, water purification, and water temperature control.
- **Provisioning services** include products obtained from ecosystems. Principal watershed services from forests include freshwater supply for domestic, agricultural, commercial, industrial, and other uses.
- **Supporting services** include the basic ecological elements and processes necessary to sustain ecosystems. These include processes like soil development, and nutrient and water cycling.
- **Cultural services** are nonmaterial benefits people obtain from forests through recreation, spiritual enrichment, reflection, and aesthetic experiences. Forests provide significant water-based recreational opportunities in the form of boating, fishing, skiing, camping, hiking, sightseeing, and other activities. They also offer education and interpretation opportunities and afford protection for culturally and historically important water resources.

These services are provided naturally by well-functioning ecosystems. They are immensely valuable, because if they are compromised, replacing them is often not possible or is very costly. Ecological economists have begun efforts to value some ecosystem services, with the ultimate goal of enhancing efforts to more efficiently use, maintain, and protect them. Provision of water is a vital ecosystem service provided by forests, so one might ask: **What is the value of water?**

Water is essential for life—The Nation's total supply of water and ecosystem services provided by healthy watersheds are priceless. Because forests provide so much of the country's water, they are of tremendous importance. A lower bound on the total value of water from national forests alone is estimated to be several billions of dollars per year (Brown 2004). An accurate estimate of the total value is impossible to achieve, however, because only some products and services are assigned an economic market value. Moreover, these values apply at the margin, whereas forests tend to provide a large (nonmarginal) portion of the total water supply (Brown 2004).

From: Furniss et al., *2010*

TABLE 7.1: FOREST COVER AND PREDICTED WATER TREATMENT COSTS BASED ON 27 U.S. WATER SUPPLY SYSTEM

Share of Watershed Forested	Treatment Costs per 3,785 m3	Cost Increase Over 60% Forested
60%	$37	----
50%	$46	+24%
40%	$58	+57%
30%	$73	+97%
20%	$93	+151%
10%	$115	+211%

Source: Postel & Thomson, 2005.

Forest cover and predicted water treatment costs are based on 27 U.S. water supply systems. Forested catchments have the best water quality and the lowest water treatment costs.

Forested watersheds reduce storm runoff, stabilize stream banks, shade surface water, cycle nutrients, and filter pollutants. Consequently, the quality of this water is typically unsurpassed. Water from these areas is often cooler and generally contains less sediment, nutrients, and chemicals than water from other lands. Streams in forested watersheds also often provide high-quality habitat for sensitive freshwater aquatic species.

This large volume of high-quality water from forests is immensely valuable because it supports many uses, ranging from meeting basic human needs to providing habitat for rare and endangered species. It fills our rivers, streams, lakes, and aquifers; sustains fish, plants, and wildlife; supports food, energy, and industrial production; enables navigation; and pours from the faucets of our homes and businesses.

7.2 A Few Basic Concepts in Watershed Management

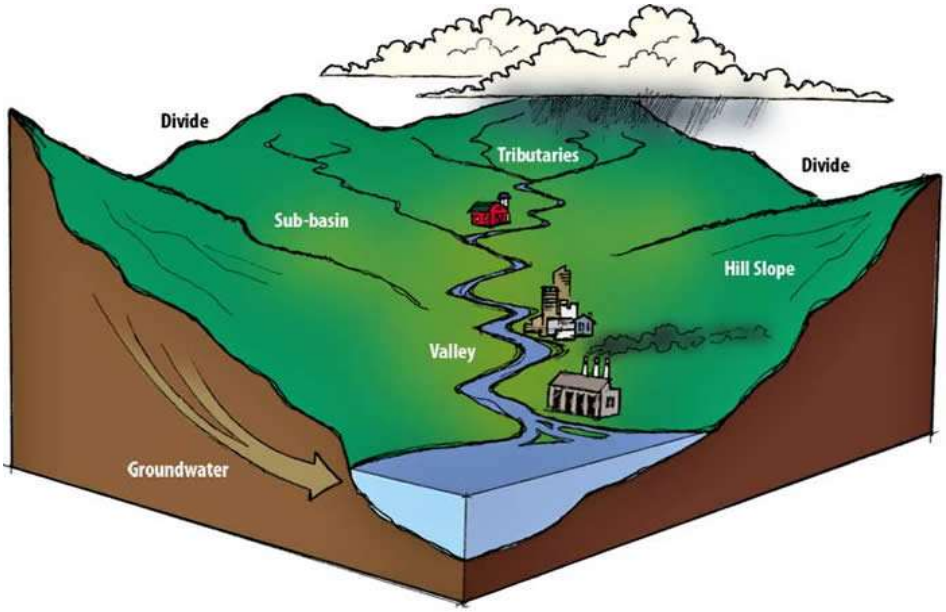
7.2.1 What is a Watershed?

A watershed, also called a “catchment” or “basin,” is the land that drains into a body of water such as a stream, lake, or wetland. Because water flows downhill, watershed boundaries are always located on the top of hills or mountains. Rain falling on one side of the hill will flow into one water body, while rain falling on the other side of the hill will flow into another water body. Watersheds come in all shapes and sizes and have many different features. They can have hills or mountains or be nearly flat. Some are millions of km^2 while others are just a few hectares.

Any changes to the land in a watershed will affect the river or lake it drains into. For instance, replacing forests and prairies with housing developments decreases the amount of water that can seep into the ground. More water flows over streets and sidewalks into street drains that empty into the river (either directly or via a water treatment facility). Thus, a river tends to flood more often when it rains because so much water is reaching it so quickly.

A watershed or catchment is the area of land that drains into a particular point on a stream or river (see Figure 7.2).

FIGURE 7.2: WATERSHED DIAGRAM



From Heatcore, 1998

7.2.2 What is Watershed Management?

According to B.P. Hooper (2005), Watershed management is defined as follows: A system of water resource management that recognizes watersheds as natural systems producing multiple economic, social, and environmental benefits that can be sustained in perpetuity and optimized with education, sound data, cooperative public processes, adaptive management, and science-based leadership.

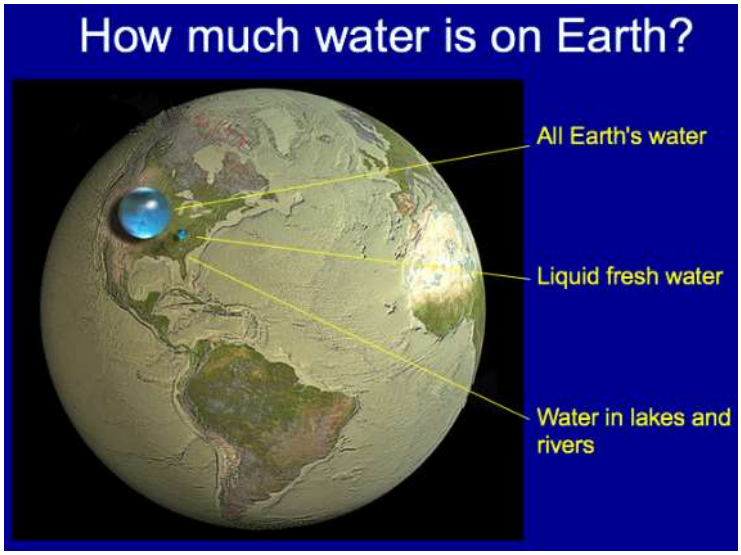
TABLE 7.2: WATER AND WATERSHED MANAGEMENT DICHOTOMIES

Water Management	Watershed Management
Green Water	Blue Water
Green Water supports plant growth, while Blue Water runs into streams and supports freshwater ecosystems and downstream users. Soils provide this fractionation function and form the reservoir for Green Water.	
Water Quality	Water Quantity
What is in it? vs. How much is there? These are different properties and, while connected, have differing management considerations, best practices, and monitoring.	
In-Place Values	Diverted Values
Ecosystem services for water in streams, lakes, and springs differ from those where water is diverted and used off site. These values can be in conflict and may require difficult management decisions.	
Total or average precipitation or runoff	Timing of precipitation or runoff
Totals and averages are useful, but the timing is usually the key to freshwater habitats and the value of the water downstream; therefore, both totals and averages should be known.	
Point-Source Water Pollution	Nonpoint-Source Water Pollution
Point sources of pollution are easily discerned and regulated with discharge limits and relatively simple monitoring, while nonpoint sources can be numerous, dispersed, and are controlled with Best Practices	
Watershed Protection and Stewardship	Watershed Restoration
Protecting watershed values is always more efficient and effective, but if values are degraded or lost, restoring them is often necessary.	

Furniss, 2016

7.2.3 How Much Water is Available?

FIGURE 7.3: EARTH IS A WATER PLANET



US Geological Survey

7.2.4 What is the History of Watershed Management?

Long before the age of farms, axes, and armies, humans were altering the face of the earth and their chief agent for doing so was fire. Fire, natural or intentional, has changed the vegetation pattern on every continent. Hunters used fire as a calculated tool. Consumption of wood for cooking game paled to the loss of woodland for the hunt. As animals were domesticated, fire was used as a tool to green up grasses for grazing. When such fires are set too often, or go out of control, the consequences are less benign. Many ecologists currently see the reckless use of fire by herders as a major cause of desert expansion and soil erosion in semi-arid regions.

The pace of forest destruction quickened on every continent with the emergence of agriculture and organized societies. Not only were areas cleared for agricultural expansion, but the impacts of the deforestation had affected lower portions of the watershed. There has been a long association of people with water. If you look at the locations of cultural resources in any area throughout the world, people and communities congregate around water; their villages are near water, as well as their farms and recreation areas, and they need water for their survival. Ever since agriculture began, humans have been manipulating water and slopes to benefit cultivation and control floods and droughts. By 3000 BC, there were sophisticated irrigation systems in the fertile Crescent, (Nile, Euphrates, and Tiger Rivers) of Mesopotamia. These systems spread throughout the Asian continent and by 1500 BC, irrigations systems were found in the Americas.

7.3 Watershed Management and Sustainable Development

In the 1970s, people all over the world started to notice the environmental threats affecting the planet. The first Earth Day celebration took place in April 1970 and launched the environmental movement in the United States, which quickly spread

across the globe. People rose up against environmental impacts that were threatening their health and their future. Following a warning from the scientific community, the United Nations convened the Conference on Human Environment in 1972, urging member states to pay more attention to the management and conservation of natural resources in their development efforts.

In the following years, environmental concerns became an essential ingredient of political rhetoric, mass communications, and the thinking of the general public. Green movements mushroomed in the North and South pockets of United States, and new “ecologically sound” rules and behaviors were promoted.

Environmental laws were passed to protect the environment. Environmental law is a complex and interlocking body of statutes, common law, treaties, conventions, regulations and policies which, very broadly, operate to regulate the interaction of humanity and the rest of the biophysical or natural environment, toward the purpose of reducing or minimizing the impacts of human activity, both on the natural environment for its own sake, and on humanity itself. Environmental law draws from and is influenced by principles of environmentalism, including ecology, conservation, stewardship, responsibility, and sustainability. From an economic perspective, the law is concerned with the prevention of present and future externalities.

7.4 Codifying Best Practices for Watershed Protection

High-quality water from forested lands provides water for municipal drinking, water-based recreation, and fish and wildlife populations. Forests and grasslands generally produce high-quality water, especially when the ecosystems are intact and functioning properly. Water quality is influenced by the pattern, magnitude, intensity, and location of land use and management activities. Sediment, nutrients, temperature, and changes in aquatic habitats are the most significant water quality issues on forested lands.

7.5 Prevention is Cheaper than a Cure

To ensure water quality is protected, a best management strategy is used to control nonpoint source pollution to meet applicable water quality standards and other requirements. Codified best practices for watershed management, referred to as best management practices (BMPs) in the United States, are used in an adaptive management approach, as described below.

- Apply appropriate BMPs in all management activities;
- Monitor implementation and effectiveness of those BMPs; and
- Use the monitoring results to inform and improve management activities and water quality.

The U.S. Forest Service has very recently developed a national set of “core” best management practices, including a system for monitoring the implementation and effectiveness of the practices. This was considered a historic achievement for the U.S. Forest Service, and program information is now available if desired.

7.6 Watershed Services Are Threatened by Existing Impacts

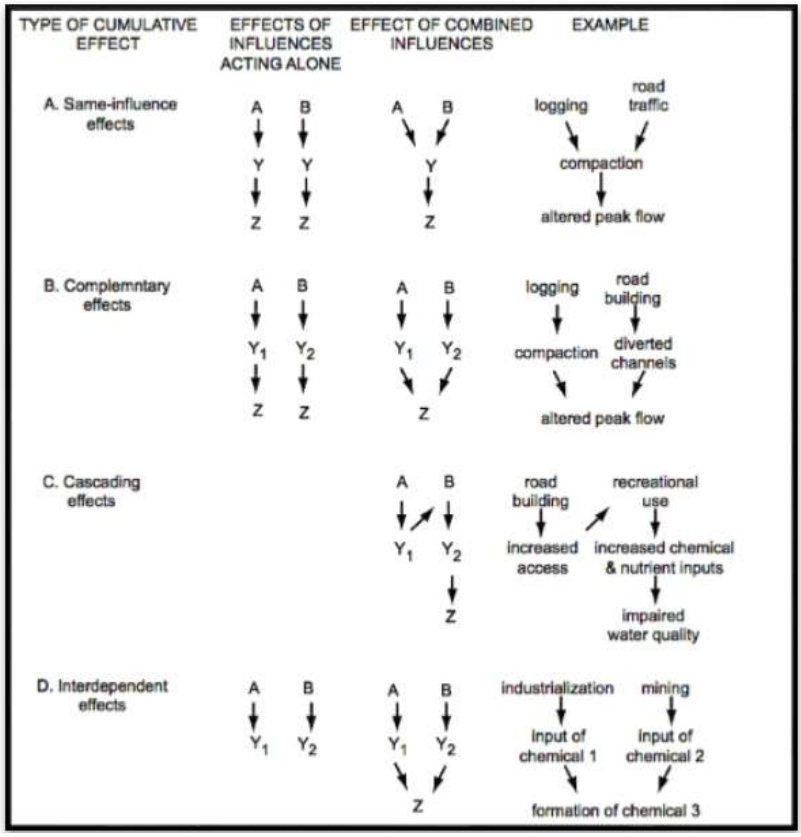
Although forests naturally supply a steady flow of watershed services, long-term provision of these services is not guaranteed. The amount and quality of these services depend on the condition of the forest—when watershed conditions are stressed or degraded, critical services can be threatened or compromised. Today, essential watershed services are threatened by a variety of human impacts on watersheds and aquatic ecosystems.

In many areas, these services have suffered from significant alterations of natural flow patterns, water pollution, and habitat degradation and fragmentation. Serious impacts exist in many places, but they differ dramatically in magnitude and extent.

7.7 Impacts to watershed services are often cumulative and effects are linked

The effects of human activities do not occur in isolation, but are linked and cumulative. The full range of past and potential future effects must be considered when evaluating the effects of an action. The adjacent table shows that cu mulative effects take several forms. A and B are activities, Y is an environmental parameter, and Z is an impact (Reid, 1993). Watershed effects are linked and cumulative.

FIGURE 7.4: FORMS OF CUMULATIVE EFFECTS



Reid, 1993

7.8 Climate Change and Watershed Services

Weather and climate are driven by solar radiation and the resulting temperature differentials, and the distribution of typical weather patterns will shift as global warming increases average temperatures. To the extent that new conditions differ from pre-change conditions, local ecosystems, landscape systems, and human communities will experience climatic stresses. The process of adaptation to the new conditions is likely to result in a period of increased disturbance to terrestrial ecosystems (e.g., increased wildfire severity, disease outbreaks, and species invasions), stream networks, and patterns of human use. Each change means repercussions for the supply and use of water from forests and the ability of these lands to support watershed services.

General patterns of climate change emerge from all predictive models, with some areas more likely to receive added precipitation and some less likely. Warming temperatures will result in less precipitation, such as falling snow, smaller snowpacks, earlier snowmelt, increased incidence of rain-on-snow flooding, reduced dry-season stream flows, greater moisture stress on vegetation, and increased stress on aquatic ecosystems. Areas subject to increased climatic extremes are likely to experience more frequent and larger floods and more frequent and longer droughts. Warming conditions are likely to trigger more extensive and severe insect outbreaks and more frequent, larger, and more severe wildfires, contributing to reduced water quality through increased erosion. Clean water supplies will become increasingly scarce, and water-related ecosystem services will be at greater risk.

Climate change must be considered in context of the individual and cumulative effects of other stresses affecting watersheds. Climate change will compound the severity of other problems such as species extirpation, population pressures, and water scarcity. Aquatic habitats in marginal conditions may be rendered unusable for some species by warming temperatures and reduced flows.

7.9 Protecting Watersheds and Watershed Services and Adapting to Climate Change

Established principles of watershed management will remain a primary response to the increased demands and risks imposed by a warming planet. Because of increased climatic stresses, the consequences of inadequate watershed management will become more serious and more immediate. Watershed managers will need to carefully consider the many potential interactions between altered physical, biological, and social environments to ensure that management decisions are appropriate for likely future conditions.

Assessing watershed and aquatic ecosystem vulnerability and setting priorities for application of effective measures is especially important at this time. Land managers will need to be able to (1) set priorities for adaptive actions by identifying watersheds and amenities most vulnerable to climate change, (2) construct scenarios for a range of plausible future climatic changes and assess the likely effects of each, and (3)

select mitigation actions appropriate for the impacts likely to occur in particular watersheds for each scenario.

Vegetation management measures, such as large-scale thinning and riparian vegetation removal are often proposed to increase water yield from wild lands. Such proposals may be suggested in the future as an adaption to climate-induced changes in available water supply. However, it is unlikely that vegetation management can produce significant long-term increases in downstream water flows at the scales of interest (Ziemer, 1987; Kuhn et al., 2007), and short-term increases in flow can be negated by reductions in water quality due to increased erosion, and by reductions of flow below original levels during some stages of regrowth. A more effective adaptation strategy would focus on maintaining and restoring watershed health and resiliency, because such systems are more likely to provide a sustained flow of ecological services in face of ongoing and future disturbances, including those associated with climate change. The types of actions that might be implemented will differ dramatically in different landscapes—they will depend on dominant watershed processes, key watershed services, and principal threats to those services. A few examples are included below.

- Protecting and restoring riparian forests to reduce stream temperatures and increase the quality of aquatic habitats.
- Ensuring that soils are intact, do not erode, and maintain high productivity by not losing thickness, organic matter (OM), porosity, fertility. Soils create watershed functions and services. Keeping them intact and productive is the best way to adapt to changing climates, increasing populations, and increasing demand for watershed and other ecosystem services. It is the highest priority.
- Improving or decommissioning roads to reduce erosion, increase flood plain connectivity, decrease peak flows, reduce maintenance expenses, and improve wildlife habitats.
- Restoring meadows, wetlands, and floodplains to improve ecological continuity, increase water storage, reduce flood flows; increase local late-season summer low flows, and decrease stream temperatures. Restoring and maintaining persistently wet places in the terrestrial environment as “biological oases” for watershed resilience and to build a network of refugia.
- Maintaining and restoring environmental flows needed to support myriad stream processes in watersheds and aquatic ecosystems.
- Removing migration barriers and reestablishing habitat connectivity to help species adapt to changing conditions.
- Strategically reducing wildfire risks in watersheds vulnerable to excessive erosion, stream temperature increases, and other impacts.

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LECTURE 8: BIODIVERSITY CONSERVATION IN MANAGED FORESTS

This lecture covers the following:

- Biodiversity conservation in managed forests
- Diversity of life forms across landscapes
- Biodiversity outside protected areas (PAs) and its significance as a corridor/ connectivity area
- Area-based conservation approaches
- Challenges and way ahead
- Group exercise

8 BIODIVERSITY CONSERVATION IN MANAGED FORESTS

8.1 Background

The State of India's Forests Report (Forest Survey of India [FSI], 2015) notes "Recorded Forests" occupy a 76.45 million hectare area in the country (23.26 percent of the geographic area). India's "Forest Cover" is less than the "Recorded Forests" at 70.16 million hectares (21.34 percent of country's geographic area). However, add to this "Forest Cover" the 9.26 million hectare (2.82 percent) area outside recorded forests as "Tree Cover" and that would make 24.16 percent of country's land area as ecological space for forest biodiversity. The area covered by very dense, moderately dense, open, and scrub forests is reported to be 2.61 percent, 9.59 percent, 9.14 percent and 1.26 percent respectively.

India has also established a protected area (PA) network covering about 5 percent of the geographic area. Most of the PAs have been carved out of the Recorded Forests. Additionally, forest departments all over the country have been raising plantations of commercially important trees, mostly in the Recorded Forests. These plantations occupy 5.31 percent of the geographic area. While, the PAs have been specifically constituted to maintain the floral, faunal, and ecological values of the respective area, the other forest areas are managed for either wood production purposes or multiple-use functions. The PAs are managed under the guidance of management plans, whereas the rest of the government forest areas are managed as prescribed in the working plans.

8.2 Working Plans and Management Plans

More than 95 percent of India's forests are government forests and have a scientific management history of more than 200 years. One of the oldest institutions, the country's forest departments, have been managing forests as prescribed in the respective working plans. The working plans were conceived as a policy and operational instrument guiding plan for India's forest management, initially for timber production and regulating hunting by the British administration. Post-independence, the working plans continued to provide scientific and management guidance for improving forest productivity to meet the objective of sustained yield of desirable timber. Although the working plans contained detailed information on forest resources, local markets, and issues of management of forests, they were more focused on timber yielding valuable trees and increasing the area under good timber forests. Commensurate with the recorded rights of the local communities, the working plans, however, also provided for management protocols for fuel wood and non-timber forest products (NTFPs) for the use of local villagers. Nonetheless, the working plans largely constituted a scientific bureaucratic instrument of the governments, ordering landscapes and people in consonance with the state policy of developing forests as a revenue generating enterprise. Until the mid-1970s, the working plans hardly concerned themselves with management of biodiversity, and

wildlife was considered either as a hunting opportunity or a conflicting entity causing problems for local populations.

In 1969, the International Union for the Conservation of Nature (IUCN) held its congress in New Delhi, which brought forward concerns about wildlife conservation, especially in view of the serious depletion of the tiger populations in India. The commotions led to the launch of Project Tiger, which earmarked areas to focus on tiger conservation based on ecosystem management principles. After the promulgation of the Wildlife (Protection) Act in 1972 (WPA), a number of wildlife sanctuaries and national parks were notified and created all over the country. Before 1972, India had only five designated national parks. This boosted conservation efforts of local flora and fauna, as opposed to timber production as the primary function of the forests, at least in the PAs. The number of wildlife sanctuaries rose from 64 in 1970, to 526 by 2015. In the corresponding period, the number of national parks rose from 5 to 102. Wildlife management plans, initially based on IUCN guidelines and formatted as working plans minus timber production prescriptions, included ecological information on local flora and fauna, and initiated systematic planning for wildlife management. Subsequently, the Wildlife Institute of India, providing scientific trainings to forest managers on wildlife management, refined the wildlife management guidelines and created a trained manpower base for improved conservation management in the country. With systematic wildlife management planning, biodiversity conservation in the forests of India picked up steam.

8.3 Shifting Conversations on Forest and Wildlife Management

The year 1988 was a watershed year for changing the course of forest and wildlife management in the country. The National Forest Policy of 1988 (NFP) shifted the focus of forest management from a timber production enterprise to India's ecological security with a primary focus on ecology and local communities. The details of the NFP mandate flow from its nine basic objectives. Regardless of interpretion, conservation of biological diversity has become central to the forester's mandate and all other actions taken under the NFP become subordinate to this requirement. The concerned objectives that address biological diversity are stated verbatim as under:

- Maintenance of environmental stability through preservation and, where necessary, restoration of the ecological balance that has been adversely disturbed by serious depletion of the forests of the country.
- Conserving the natural heritage of the country by preserving the remaining natural forests with the vast variety of flora and fauna, which represent the remarkable biological diversity and genetic resources of the country.

(Source: NFP, 1988)

The principal aim of the NFP is to ensure environmental stability and maintenance of ecological balance, which is vital for sustenance of all life forms: human, animal, and plant. Direct economic benefit must be subordinated to this principal aim. Commensurate with the increasing democratization of polity, greater representation of civil society, especially of the proximate communities to forest areas, was

incorporated in the management paradigm. This was institutionalized through the Government of India Resolution on Joint Forest Management of 1990. Participatory approaches were also established in the management of wildlife through implementation of the India Eco Development Project in select Project Tiger areas from 1996 to 2003. As the forest departments learned participatory management, community-centric forest and wildlife management became the new idiom of conservation management.

8.4 Biological Diversity, Wildlife, and Forest Productivity

Biological diversity is defined as "the variety and variability of life, the interacting ecological processes and functions" (Wilson, E. O. (ed), 1988). The "variety and variability of life" is sustained by complex ecological relationships, processes and functions; the interdependence between species of plants; between plants and animals; between plants, animals and their abiotic environment; and exemplify the contours of ecological complexities. These are fundamental mechanisms of evolution that are geographically mediated by climate. The forest cover that is part of the recorded forest area of the country is managed mainly under two principal objectives (i) for conservation of biological diversity more commonly referred to as wildlife represented by the four categories of PAs as legally defined under the WPA, and (ii) for production of goods and services or simply for production functions to include timber and NTFPs, which for convenience is referred to as "production forestry."

The term "wildlife" is often used in conjunction with the term "biological diversity," thereby alluding to some distinction between the two terms. The term "wildlife" literally means life in the wild and it includes both wild plants and wild animals. The WPA defines "wildlife" under Section 2 (37) (Dutta, R. et al., 2004). Wild plants include a range from unicellular forms such as the phytoplankton to trees. It does not matter where the plants and animals live--on land or in water. All non-domesticated plants and animals, including their habitats, constitute wildlife. This implies that the term "wildlife" represents the diversity or variety of life forms in their entirety. Thus "wildlife" and "biological diversity" become synonymous.

Forests are ecological entities made up of diverse assemblages of natural ecosystems that are evolutionary expressions of millions of years of complex natural processes. The ecological definition of "productivity" is the "capability of the soil for producing a series of native plants" (USDA, 1957). This is interpreted as the populations and communities of wild plants (species) that can naturally grow in a given area under the given locality factors. It is known that animals and plants are inseparably dependent on each other. The definition of "productivity" therefore has to be understood as "the capability of the soil for producing a series of native plants and animals at a given geographic location" (USDA, 1957). Ecologists tend to separate plants and animals as primary and secondary producers but in the operative sense, the distinction is not important. What is important is the link between them. The "geographic location" combines all factors that influence formation of specific populations and communities of plants and animals. Thus productivity is sustained by complex biotic and abiotic relationships recognized as ecological processes and

functions. Therefore, the term “productivity” becomes synonymous with “biological diversity” and “wildlife.”

In production forestry a series of strategies are applied for maintaining and restoring “productivity” such as application of silvicultural treatments, raising plantations, resorting to soil conservation measures, cordoning off areas for strict protection, removing miscellaneous competitive species of little economic value, removing dead and dying moribund trees, cutting climbers, attempting assisted natural regeneration and other factors. However, there is only one option to maintain long-term production interests: strategies for restoration and maintenance of biological diversity. To accomplish that in production forestry, management methods are being continuously devised and adaptive management processes are used.

8.5 Habitats as Key to Conserve Biological Diversity

A habitat is the place where an animal or plant normally lives. Habitat has a structure, a composition and space that together are (in generic terms) referred to as “habitat condition.” The habitat must satisfy basic necessities of a species and its populations so that the species may exist, reproduce, rear its young into adulthood. This must be done so that the rate of recruitment into the population is more than the rate of mortality. This will enable populating geographic space assigned to it by evolutionary processes and representing the historic range of its distribution. Due to developmental necessities of human societies, the natural forests have shrunk in size and fragmented to an extent of alarming seriousness, affecting the historical ranges of a multitude of species.

The 2015 FSI Report states that there are only 15 large forest patches in the country, each 5,000 to 10,000 km^2 in size, which constitute 13.21 percent of the geographic area (FSI, 2015). However, there are also 0.937 million forest fragments, each less than 1 km^2 in size, which constitute 7.20 percent of geographic area, more than 2 percent of the area occupied by the PAs. Notwithstanding the size of forest patches, each patch constitutes habitats for some species and their populations, and may play an important role in conservation management. Such patches may act as stepping stones for connecting metapopulations across large landscapes. Therefore, biodiversity conservation has to include all kinds of forests and forest patches, and management has to adopt newer methods of maintaining habitats and life support processes in these fragments.

As discussed above, the working plans initially considered only timber production from the forest estate. However, in the changed scenario, production forests too have to maintain biodiversity to the extent possible while upholding their timber production. The production forests need to be considered as being made up of a series of habitats of different attributes supporting different species. To maintain forest productivity, there are no options but to manage habitats in the interest of native species of plants and animals. This includes the miscellaneous category of plants and those with little or no economic value. Habitat management is not contradictory to the objectives of production, only that this has not been considered before. However, the silvicultural tools have all the capabilities to accomplish a

series of vegetation/habitat conditions. Within the Recorded Forests, there is a necessity to see beyond the areas suitable for production. This includes areas that are open (including grasslands), areas with boulders and rocks including rocky sea shores and cliffs, sandy beaches and sand dunes, perennial and seasonal marshes, salt marshes, and areas under cover of permanent snow/ice. The last habitat, under permanent snow/ice, is very important as a water supply source. These areas are usually included under the moniker of “barren lands.”

8.6 Managing Plantations and Managed Forests for Biodiversity Conservation

Of the total forest area in the country, PAs occupy about 25 percent and focus on biodiversity conservation. However, the remaining 75 percent of forests are primarily for production forestry. Such forests include natural forests managed under various silviculture system and classified as managed forests (50 percent of total forests), and plantations of commercially important trees, mostly monoculture (25 percent of total forests). Forest departments and corporations manage such areas for enhancing productivity of timber and commercial wood. Tree plantations have been raised to support paper, plywood and fuel wood industries and therefore, necessarily use silvicultural tools to promote desirable species such as teak, sall, eucalyptus and/or acacias, at the cost of miscellaneous species. As the PAs have been carved out of the Recorded Forests, tree plantations still exist in many PAs, which have been left untouched due to conservation concerns and legal provisions. The plantations in PAs have changed the vegetation composition of such areas and have impacted biodiversity. These plantations displace the native species, either through their competitive superiority or because they were also nurtured through plantation management. Now the plantations in PAs are left alone. Plantations support relatively impoverished fauna until the local fauna is able to adapt to the new plant associations. There are also old-growth forests that undergo a commercial felling regime in production forests. Therefore, in the present context of improving biodiversity across all forest lands, not only in PAs, the foresters are confronted with the following two situations (i) the large extent of timber plantations in the PAs that have modified the habitats, and (ii) old-growth forests, where commercial operations exist, thereby removal of the old growth and commercial felling regime impacting biodiversity. Foresters use silviculture tools to manage forests for timber production. However, the same tools can be used to manage forests to enhance habitat values and biodiversity while also generating commercially viable timber. Following the principle of “diversity begets diversity,” a forest landscape with multi-aged stands will, all other things being equal, have more kinds of wildlife than a single-age landscape. Simplicity of plantations makes them easier to manage. Thus, for managing biodiversity in plantations in PAs and managed forests, they have to be viewed as wildlife habitats and silviculturally treated to improve the habitat values for native biodiversity.

Forest biodiversity depends on the successional stages present in a forest area, as various successional stages support a range of dependent wildlife communities. The age of a forest stand is considered a reasonable index of its successional state in

terms of biodiversity management in managed forests. Species requirements are also ‘stand age dependent.” Gregarious species require lower-age, relatively short-statured open forests. The word Gregarious was originally used to describe animals that live in flocks—it’s from the Latin word *grex*, meaning “herd.” For example *Psittacula krameri, Scotophilus heathi, Bubulcus ibis*, etc.Thus maintenance of various age classes in a plantation creates different successional stages leading to better diversity of floral and faunal communities.

8.7 The New Perspective

In 1984, the controversy of the spotted owl and old-growth forests was on the front page of the *New York Times*. The story involved a very rare and highly endangered bird, the spotted owl, which inhabited the virgin old-growth conifer forests (about 200 years old) from Washington State in the northwest U.S., down to California. A pair of spotted owl needs a very large area (1700 hectare) of old-growth conifer forest to breed. The timber in these stands was worth about US $10,000 per hectare. Due to its unique habitat requirements, the spotted owl is considered a flagship species for a much larger ecological entity–the old-growth forest. The presence of spotted owl is considered as an arbiter to the good health of old-growth conifer forests. However, the U.S. Forest Service (USFS) was giving huge concessions to the timber industry in these forests, generating substantial revenue and employment. The conservation groups strongly voiced their concerns about the habitat needs of this rare species and its demography being affected by catastrophic environmental changes from large clear felling and timber operations. The USFS was caught between the timber industry and the environmental groups. In 1986, based on the recommendations of an expert group, the USFS issued new directions on management of spotted owl habitats, resulting in development of the “New Perspective.”

The “New Perspective” permitted felling of trees under certain prescriptions that were based on the premise that “forestry operations do not destroy, but alter the habitat” (Yerrow, G. 2009). Therefore, as required by the habitat of a particular species or a guild, silviculture operations could be suitably modified. The prescriptions ranged from identification of unique habitats such as snags, dens, talus, caves, cliffs, and riverine areas, to mimicking natural disturbance while planning tree felling. The USFS found that the average natural disturbance rate in the old-growth conifer forests is about 1 percent per year, ranging from 0.5 to 2 percent. This equated to any given spot in the forest would be disturbed about once in every 50 to 200 years. Therefore the USFS stated that some disturbance can be allowed commensurate with the rate of natural disturbance. Furthermore, the prescriptions required that the landscape management principles in such areas to maintain spatial heterogeneity. At a landscape level, the repertoire of felling should include selection felling, patch cutting and clear felling.

The “New Perspective” viewed the totality of diversity and not only the mega fauna. At any given time, there are many more small stands than large stands in a forest. Similarly, there are fewer large-sized animals than small ones. For example, there are only seven species of bears in the world, but hundreds of species of mice. There

could be about a million bears all over the world, but maybe more than a billion mice. Thus multiplying stand size with number of stands leads to not only more numerous small stands, but they collectively occupy a larger area than large stands. This analogy can also be applied to rivers: a larger river versus small numerous rivulets.

Therefore, the rule of thumb for felling wildlife habitat is to harvest forests at a range of different scales, and allocate approximately equal areas to different points along the continuum from small scale to large. Forest managers should not create uniform large stands. Concepts like edge effect, interspersion and juxtaposition, rule of geometry and others that explain diversity richness on the ground should be applied in managing plantations and managed forests as wildlife habitats and for biodiversity.

8.8 Plantation Management in PAs: The Case of Parambikulam (Kerala)

Parambikulam was created as a wildlife sanctuary in 1984 and carved out from the highly managed forests and teak plantations of the Nenmara Forest Division in Kerala. Of the 285 km^2 area of the wildlife sanctuary, 90 km^2 were covered with teak plantations of various age classes. The plantations occupied flat valleys around the three reservoirs constructed for hydro-electric power in the 1970s. Five tribal settlements also existed within these forests, which were brought in to the area in the 1920s to raise the plantations. The tribal people sustained their lives through regular employment in plantation management activities, such as thinning, final felling, and cultural operations. After Parambikulam was created, the forest department was confronted with continuing plantation management.

Considering the habitat condition of the plantations (poor habitats as opposed to the natural mixed forests) and livelihood of the tribal people, the plantations were treated under habitat management, using the provisions of Section 29 and 33 of the WPA. Clear felling was stopped and mature plantations were thinned, limiting the removal of teak to less than 25 percent of the stock to gradually convert the teak plantations into miscellaneous deciduous forests. The prescriptions included removal of teak trees from the vicinity of upcoming miscellaneous native species growing naturally in the plantations. The open marshy lands (locally known as “vayal”), interspersed in the plantations, were cleared of weeds and maintained as grassy foraging ground for ungulates. The scheme was duly approved in the first management plan of the sanctuary and received wide interest for discussion as well as controversy. It provided revenue to the forest department and ensured employment to the tribal communities. However, after approximately 10 years, the operations were discontinued due to a lack of monitoring of the regeneration and valuation of habitat quality. With subsequent amendments to the WPA, the harvested teak was used for bonafide needs of the local community. Under the changed circumstances, the economic value of the harvest was not sufficient for the forest department to continue with the program.

8.9 Management Principles

As noted above, with the changed mandate of forest departments as custodians of India's ecological security, biodiversity management becomes the major focus for managers. The forest areas in the country need to be managed as habitats for a range of wildlife. Silvicultural tools are available to help managers with this task. The forest managers often struggle with the complexity of stand-, landscape-, and region-specific solutions as well as integrating conservation and wood production interests. However, consideration of the general ecological principles should assist the development of more credible forest conservation plans both on government lands and even in private forests. The broad principles that must be adopted for improving biodiversity in managed forests include:

- Establishment of as large ecological reserves as possible (PAs). For this purpose, the biogeographic classification by the Wildlife Institute of India is a good reference point.
- Creation of conservation areas within production forests by identification of unique habitats and species such as wetlands, open grassy patches, scrub and bush lands, dens, snags, talus, cliffs, and other habitats; and preparation of a biodiversity inventory.
- Establishment of riparian buffers. The riparian areas are very sensitive habitats and timber operations must note them as important conservation areas.
- Appropriate location of road networks. Roads are a major disturbance to the habitats and therefore, timber transporation corridors should be planned in a manner that is cognizant of the rarity and ecological value of the area. Roads should be aligned to avoid, as much as possible, disturbance to unique habitats, and habitats of the rare and endangered species.
- Spatial and temporal arrangement of harvest units. Knowing the requirements of targeted species and creating harvesting schedules that avoid disturbing target species during their breeding time or other vulnerable periods are crucial.
- Appropriate fire management practices.
- Retention of key elements of stand structural complexity at the time of harvest, such as large trees with hollows (plus recruits), understory thickets and large fallen logs.
- Longer rotation times for timber harvesting (coupled with structural retention at harvest).
- Altered silvicultural systems, including novel approaches to retention and the application of modified thinning regimes. For many areas with poor timber growth and the pressure of local villagers" use of the forests, a coppice system may be useful.
- A participatory approach of management is the key element of biodiversity management over a large landscape. Forest departments all over the country

have significantly progressed in this direction. There is a continued need to strengthen local institutions and enable local communities through transfer of forest management technologies.

8.10 Ecosystem-Based Management

Production forestry would do well to adopt Ecosystem-Based Management (EBM) to forest management. EBM differs from a single species or a single-sector approach to management by engaging complex interactions between the living and non-living environment and people in multiple scales of space and time. The principles of EBM are to sustainably manage both target and non-target species involving a three pronged approach of protection, conservation, and restoration of habitat quality to maintain ecosystem functions and services. The features of EBM goals are:

- Emphasizing connectivity within and between systems (i.e., attempting connectivity between habitat patches through a network of corridors aiming at large landscapes). This connectivity would include PAs and production forests on land and between terrestrial habitats, inland wetlands, estuaries and the sea.
- Emphasizing protection and restoration of ecosystem structure, functions, and processes.
- Focusing within a specific ecosystem/management area to affect human behaviors and actions within that area.
- Incorporating the social dimensions of resource use and ecosystem values into management.
- Integrating biological, socio-economic, and governance perspectives.
- Recognizing the high level of uncertainty and variability in the dynamics of ecosystems.
- Reflecting a common vision among stakeholders.
- Attempting informed adaptation from learning based on science and local knowledge.

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LECTURE 9: LANDSCAPE-LEVEL CONSERVATION PLANNING - AN OVERVIEW

This lecture covers the following:

- Systematic conservation planning process
- Purpose of biodiversity elements in conservation planning
- Criteria for selecting biodiversity elements
- Information and capacity required to complete a landscape-level conservation plan

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9.1 Introduction

Conservation planning must address the dual problems that 1) biodiversity is complex and dynamic and 2) in any landscape, the available data and knowledge regarding the composition, structure and function of biodiversity are always limited. The field of systematic conservation planning developed to cope with this challenge and draws from a broad, diverse body of scientific research to provide practical guidance and methods to identify conservation priorities. Multiple approaches, methods, and tools exist that have been adapted for use in different landscapes and biomes and varying levels of available data and knowledge. This lecture will outline the conservation planning process in terms of data development and analysis and describe key principles, best practices, and the underlying science, but is not a comprehensive review. Most of the guidance described in this lecture is drawn from a methodology described in Groves (2003) that was developed over last 20-30 years and applied across the world.

9.2 Overview of Landscape-Level Conservation Planning

9.2.1 Science and Stakeholders

Landscape-level conservation planning must organize and integrate data, expertise, and knowledge from multiple sources and requires technical capacity to manage data, analysis, and expert input. However, to be effective, planning must be a participatory process that involves major stakeholders from academia, government, NGOs and the private sector. Well-coordinated, active stakeholder engagement is an essential and necessary part of the process to guide both the planning process and implementation of the results.

9.2.2 Landscape-Level Plan

A landscape-level plan is a practical vision and guide for maintaining native plants, animals and ecosystems of a given landscape based on available data, science and knowledge. To be effective, conservation efforts should consider distributions of habitats, threats and impacts at a regional- or landscape-level, and be guided by a systematic identification of conservation priorities (Margules & Pressey, 2000; Groves, 2003). Systematic conservation planning is a methodical and comprehensive process for identifying a set of places or areas that together represent the majority of native species" habitats, natural communities and ecological systems found within a planning area as priorities for action. The products of conservation planning are 1) a network of conservation areas, or a "conservation portfolio," selected to represent the full distribution and diversity of native species and ecosystems, based on 2) a landscape-level assessment and information system that describes the larger landscape.

A recommended general framework to guide conservation area network design (from Groves, 2003 and Shaffer & Stein, 2000) consists of four simple criteria:

- **Representative** of the full array of native species and environments
- **Resilient** to natural and human disturbances.

- **Redundant** with multiple examples to account for local extinctions.
- **Restorative:** consider restoration opportunities.

9.2.3 Design of the Portfolio of Conservation Areas

These criteria can be translated into more specific design criteria, such as the following criteria commonly used in conservation plans. However, there are multiple possible criteria that should be discussed and chosen by the planning team.

- Representation: define representative biodiversity elements and quantitative goals for the number or amount of each biodiversity element required to maintain ecological and evolutionary potential over time.
- Ecological Condition: within the limits of available data and knowledge, ensure that the selected areas contain biodiversity elements that have the highest relative viability or ecological integrity.
- Connectivity, measured or represented as:
    1. Where possible, select adjacent planning units in contiguous groups, following the general principle that a portfolio consisting of fewer, larger contiguous sites is preferable to one consisting of many, smaller sites.
    2. Ensure that the conservation areas are part of a landscape matrix that allow movement and habitat connectivity. Connectivity conservation is the topic of another lecture.
- Efficiency, measured or represented as:
    1. The portfolio contains the least area and number of sites necessary to meet biodiversity goals, with some redundancy to withstand current and future threats.
    2. Minimize conflict with future development. That requires including development plans and trends in the planning process and is the focus of TNC's development by design strategy.

Designing a conservation area network, or portfolio, to meet the criteria described above involves a process of data development and spatial analysis that includes the following components shown in the diagram below. This approach is based on ecoregional assessment practices and standards described by Groves et al., (2002); Groves, (2003) and Higgins & Esselman (2006).

1) Select biodiversity elements: define and map distributions of a set of biodiversity elements—species, ecosystems or other features—that collectively represent the biological diversity of the study area.
2) Set representation goals: set quantitative goals for the estimated abundance and distribution of biodiversity elements necessary to maintain ecological and evolutionary potential over time.

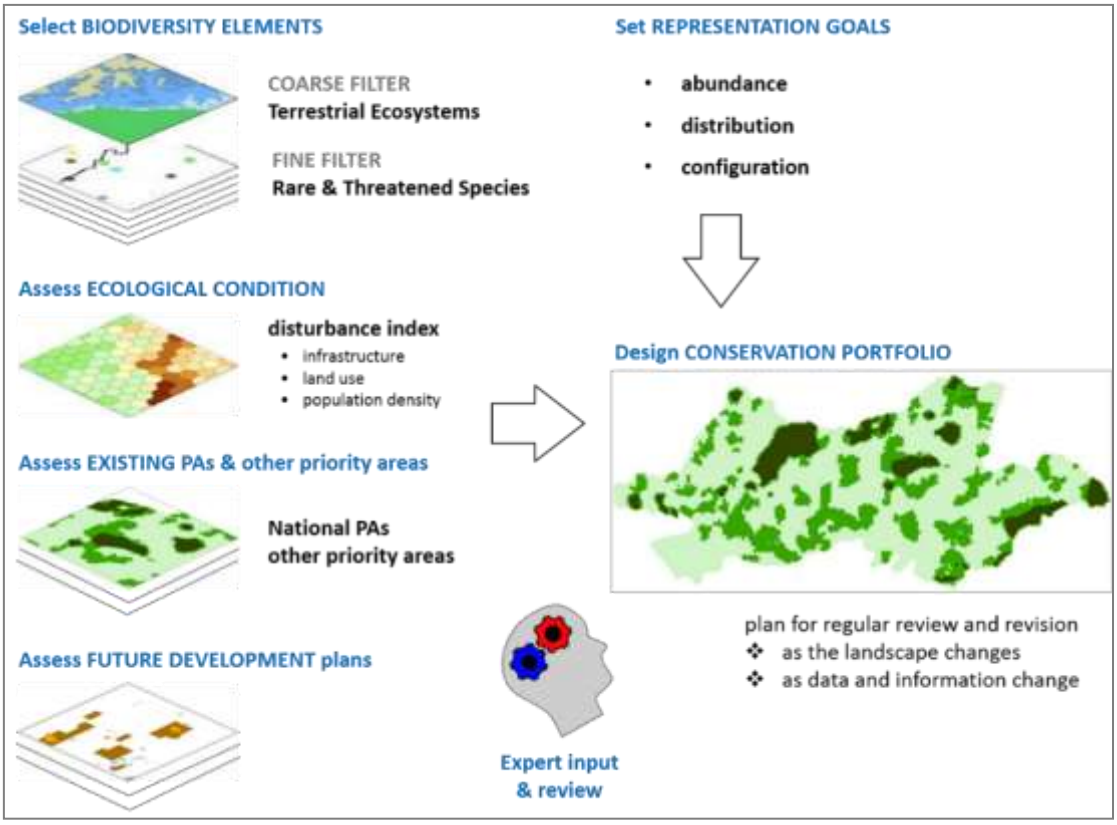
3) Assess ecological condition: evaluate the relative viability and ecological integrity of occurrences of biodiversity elements (species populations and/or occupied habitat, and examples of communities and ecosystems). This can be measured spatially with an index of disturbance and cumulative impacts.

4) Assess existing conservation areas: determine what elements are already under adequate management in nature reserves, managed forests or other public lands, and what areas have been identified as conservation priorities in other assessments.

5) Assess threats: develop maps and predictions of future development plans, and incorporate that information into network design to minimize conflicts.

6) Design a network or portfolio of conservation areas: use this information to identify a network or portfolio of conservation areas that contain occurrences of biodiversity elements that collectively meet representation goals and are the most likely to persist, i.e., are viable, with the highest relative ecological integrity and minimal risk from future threats. Often, systematic conservation plans use an optimization approach automated with spatial analysis tools such as Marxan (Pressey et al., 1997; Ball et al., 2009).

FIGURE 9.1: COMPONENTS OF LANDSCAPE-LEVEL CONSERVATION PLANNING



From Heiner et al.*, 2013*

9.2.4 Conservation of the Network of Priority Areas

Designating nature reserves is one way to protect the conservation area network, but is limited and impractical in a highly-developed landscape. Conserving the portfolio can and must be achieved through means other than new protected area (PA) designations. A more practical and widely-applicable strategy to conserve the portfolio outside PAs is through sustainable management. The conservation areas and supporting information system can guide land use decisions and management plans of working lands to maintain species habitat and ecosystems.

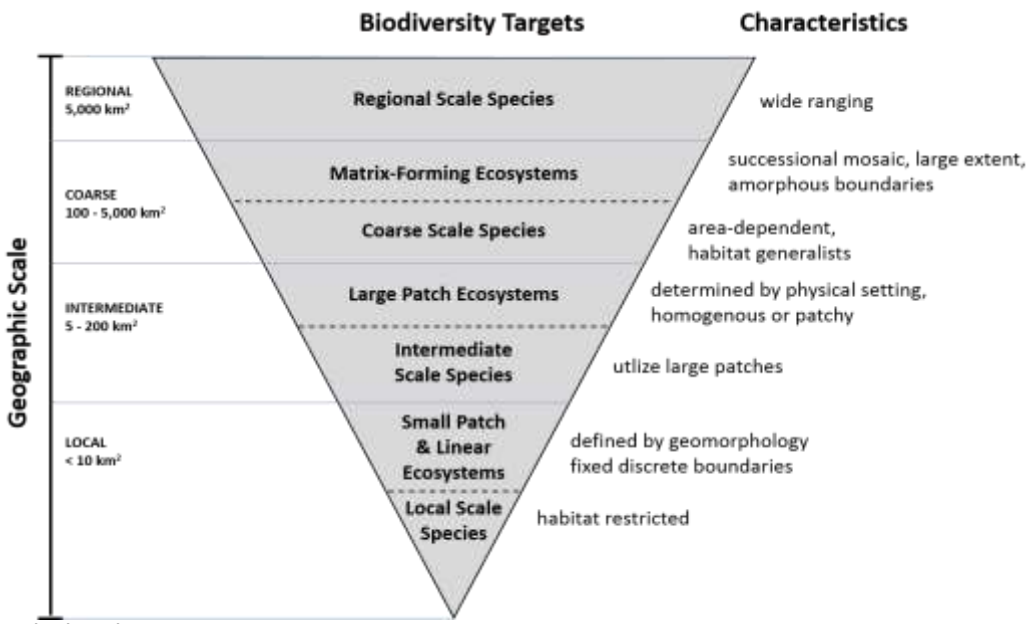
9.3 Biodiversity Elements: Problem Statement

A fundamental first step in systematic conservation planning for biodiversity is to define biodiversity, or decide how to represent the biodiversity of a given area. That presents several conceptual and practical challenges:

- First, biodiversity is complex, and occurs across a range of spatial scales, from rare plants to wide-ranging species such as tigers or migratory birds as illustrated in the figure below by (Poiani et al., 2000). Effective conservation of biodiversity requires maintaining composition, or the elements, and also the structure and function of habitat and ecosystems across a range of scales (Noss, 1990, Redford and Richter, 1999).
- Second, data and knowledge of the dynamics and needs of all species and ecosystems are always incomplete, everywhere.
- Third, there are practical limits to how much information can be managed and analyzed through a planning process.

The field of systematic conservation planning developed to cope with these challenges.

FIGURE 9.2: SPATIAL SCALES AND BIODIVERSITY ELEMENTS



Adapted from Poiani et al. *2000*

Historically, conservation efforts focused on rare, charismatic species such as large carnivores and popular game species. In the 1970s in the US, Natural Heritage programs were established to collect, organize and share information on the status and distribution of rare plants and animals. The goal was to make this information available to guide management and development.

In the 1990s, the growing fields of ecology and ecosystem science produced more evidence that nature, ecosystems and environmental processes are dynamic and interconnected, and that sustainable management of natural resources both for biodiversity, and ecosystem services such as water and agriculture, requires a broad-scale, landscape-level or watershed-level approach. However, though decisions are made by political units, political borders rarely align with "biogeography," the geographic distribution of species and ecosystems. That is a key challenge to biodiversity and sustainable resource management. Science-based, landscape-level or watershed-level frameworks developed to effectively consider biogeography" and related ecosystem services, and address the following practical decisions (Groves, 2003).

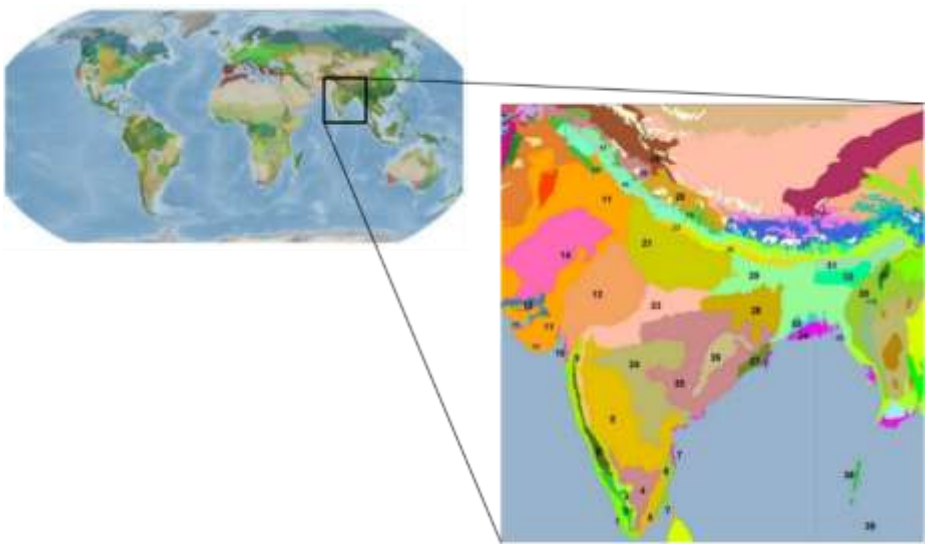
- Guide **local** decisions about protection and management
- Implement **global** efforts and policy commitments
- Guide **efficient spending** on conservation

9.4 Biogeography and Ecoregions

Therefore, a fundamental standard for landscape-level or watershed-level planning is to plan conservation and management across an ecologically or biogeographically meaningful area (Groves, 2003; Higgins & Esselman, 2006). To support this, WWF has developed a global map of terrestrial ecoregions, based on national and regional

maps of biogeographic regions and expert input from around the world. The figure below shows the WWF global ecoregions across India.

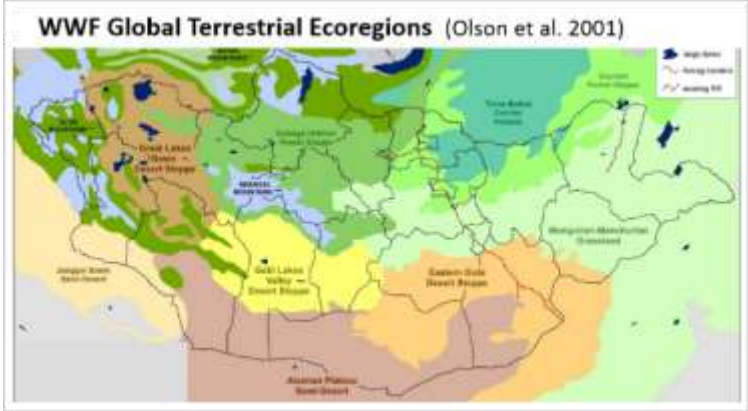
FIGURE 9.3: WWF GLOBAL TERRESTRIAL ECOREGIONS



Olson et al.*, 2001*

Often, multiple maps or biogeographic classifications will exist for a given country or region. The figure below shows two ecoregional classifications for Mongolia: WWF Global Ecoregions and a National map of Landscape-Ecological regions. These two maps are similar in some areas and quite different in others. In Mongolia, experts recommended using the National biogeographic regions, not the global ecoregions, to define study areas for landscape-level planning.

FIGURE 9.4: MONGOLIA: COMPARISON OF GLOBAL AND NATIONAL BIOGEOGRAPHIC REGIONS



Key principles to remember in choosing an ecoregional classification for a planning exercise (Groves, 2003):

- No one biogeographic or ecoregional classification will fit every species or ecosystem.
- Boundaries between ecoregions are gradual transitions, not hard borders. And the transitions are important for biodiversity as well.
- Every ecoregion contains patches of neighboring ecoregions.

There are often real limits to building datasets and planning teams across political borders. For example, Mongolia lies between Russia and China and conservation plans have not crossed that border, but there are cross-border conservation efforts focused on wide-ranging species like Argali and Gazelle that use habitat across the borders.

9.5 Coarse Filter/Fine Filter Strategy

After defining the study area, the next task is to choose a practical set of biodiversity elements that represent the native biodiversity of the region. Again, this is a challenge because biodiversity occurs at range of spatial scales, data and knowledge are always incomplete, and there are practical limits to how much information can be managed and analyzed through a planning process. A widely used solution is a “coarse-filter / fine-filter” strategy.”

The “coarse-filter” is often terrestrial ecosystems, or a mapped classification of terrestrial ecosystems. Ecosystems by definition consist of biotic (e.g., vegetation

types) and abiotic (physical environmental features and processes) components and occur at distinct spatial scales and in spatial patterns driven by the underlying physical processes. The coarse filter hypothesis (Hunter, 1991, 1988) is that representing the array of communities and ecosystems will capture the majority of common species. However, that may miss rare or range-limited species or habitat specialists.

Therefore, the “fine-filter” elements are individual species or communities that are not well-represented by the coarse filter. These include species that are rare or with limited distribution, and often include threatened/endangered species and narrow-range endemics. Fine-filter elements can also include wide-ranging migratory species or any species with unique habitat or life-history requirements.

Datasets available to map coarse-filter elements typically include regional or national maps of vegetation, landforms, soils, and climate zones. The result is a coarse-scale but regionally consistent map of major ecosystems or habitat types. Datasets available to map fine-filter elements typically include field surveys, species distribution models (dependent on data and modeling methods), range maps and expert knowledge. The results are accurate locally where data exists but often with gaps and uncertainty in the regional coverage.

Therefore, the coarse-filter and fine-filter elements serve complementary roles, and the coarse-filter / fine-filter strategy has both ecological and practical advantages:

- Represents multiple scales of organization and major ecological processes.
- Makes best use of available data to address gaps in data and knowledge, combining a) maps of vegetation, ecosystems, and other biophysical classifications that are coarse but regionally consistent with b) species-level information that is locally accurate but with regionally incomplete and uncertain coverage.
- Produces a practical number of elements to represent the biodiversity of the study area.

9.6 Data Development to Map Biodiversity Elements

9.6.1 Data Development: Coarse-Filter Elements

Terrestrial coarse-filter elements are often vegetation communities or ecosystems represented by a mapped classification of terrestrial ecosystems. Ecosystems by definition consist of biotic (e.g., vegetation types) and abiotic (physical environmental features and processes) components and occur at distinct spatial scales and in spatial patterns driven by the underlying physical processes.

NatureServe has developed a classification approach for defining and mapping “ecological systems” that has been applied across North America, Central and South America and Africa (Comer et al., 2003). This approach defines a “meso-scale” ecological classification of units that can be mapped accurately at a regional level with available datasets and recognized in the field. This classification system is

organized as a hierarchy of biogeographic zones or ecoregions and ecosystems based on vegetation and biophysical units, organized as four categories:

- Matrix: form extensive, contiguous cover responding to regional climate patterns, such as major forest and grassland types.
- Large patch: form larger patches ranging from 50-2,00 ha in area, often created by disturbance events.
- Small patch: occur as small, discrete vegetation types limited by local environmental features. Patches range from 1-50 ha in area.
- Linear: occur as linear features, such as river floodplains and riverine wetlands.

If a mapped ecosystem classification does not exist for the study area, a spatial model can be developed with existing GIS datasets, remote sensing (satellite image classification) and DEM-derived topographic models. This typically involves developing 1) a set of ecosystem type definitions based on literature + expert knowledge, and 2) a spatial model to map the ecosystem types. Appendix 1 at the end of this document describes an example of a mapped ecosystem classification developed for the Mongolian Gobi Desert.

The recently published vegetation map of India, by Dr. Parth Satathi Roy et al. (2015), may be a valuable dataset for defining and mapping coarse-filter biodiversity elements in India. This mapped classification is based on climatic vegetation zones, biogeographic zones, topography and satellite image classifications, so it maps major vegetation types and captures variation in biophysical (climate, landforms) settings and biogeography across India.

EXAMPLE of selecting and mapping coarse-filter elements: For conservation planning in the Great Western Woodlands, a dry forest system in Southwest Australia, the planning team chose three types of coarse filter elements from three different data sources (see Fitzsimons et al., 2014):

1. Vegetation sub-formations defined and mapped by the Australian national vegetation information system (Beard & Webb, 1974; ESCAVI, 2003). The vegetation classification is hierarchical, with five levels: class, structural formation, floristic formation, sub-formation, association, sub-association. The planning team chose the sub-formation level to represent major floristic groups of plant associations across structural types (Acacia- and Eucalyptus-dominated forest, shrublands and grasslands).
2. Surficial geology (Stewart et al. 2008), reclassified to 10 significant lithology types. According to expert advice and literature, several soil lithology types provide unique habitat for endemic flora and herptile fauna in the study area.

Landforms mapped with a DEM-derived topographic model. Landforms represent fine-scale variation in soils, hydrology and physical habitat..

9.6.2 Data Development: Fine-Filter Elements

To choose fine-filter elements, or species elements, the first step is to define selection criteria. Possible criteria or types of species elements are listed below. Because many possible criteria exist, expert input and participatory discussion is critical to choosing fine-filter elements. For this selection process, it's important consult many experts in different taxa both re: species and the criteria for listing. It's also important to organize and manage the discussion to produce a practical list with clear criteria, because the many opinions and perspectives will produce many lists and possible criteria.

Types of species elements (from Groves, 2003): Note that for some types of species elements—particularly flagship, umbrella, and indicator species—evidence and opinions vary regarding their effectiveness for conservation planning (Groves, 2003).

- Threatened/ endangered status from national or global red lists or other sources. For example, in Mongolia, national red lists have been developed for mammals, herptiles, birds, and plants, but the several other national listings exist with different species and criteria. The IUCN global red-list is regularly updated and available online, however global and national red-lists often differ in terms of species and status information. There are other global species listings (e.g., CITES, CMS) of different species and different criteria.
- Species with unique habitat or life-history requirements, such as migratory species with seasonal habitat in the study area.
- Endemic species exist only within one given study area, nation or region.
- Keystone species play irreplaceable roles in maintaining the communities and ecosystems in which they occur.
- Flagship species are charismatic and attract public support for conservation.
- Umbrella species" habitat and conservation needs support other co-occurring species.
- Indicator species" status provide indicators of the condition of other species of interest that are difficult to observe or measure.

Datasets available to map the distribution of fine-filter species elements typically include:

- Field surveys
- Species distribution models (dependent on data and modeling methods)
- Expert knowledge
- Range maps

EXAMPLE of selecting fine-filter species elements and mapping their distribution: For a landscape-level conservation plan in the Mongolian Gobi Desert (Heiner et al., 2013), biodiversity elements included:

1) Coarse filter elements: a terrestrial ecosystem classification that maps 99 ecosystem types as unique combinations of biogeographic zone, biophysical ecosystem type, and landforms (see Appendix 1).

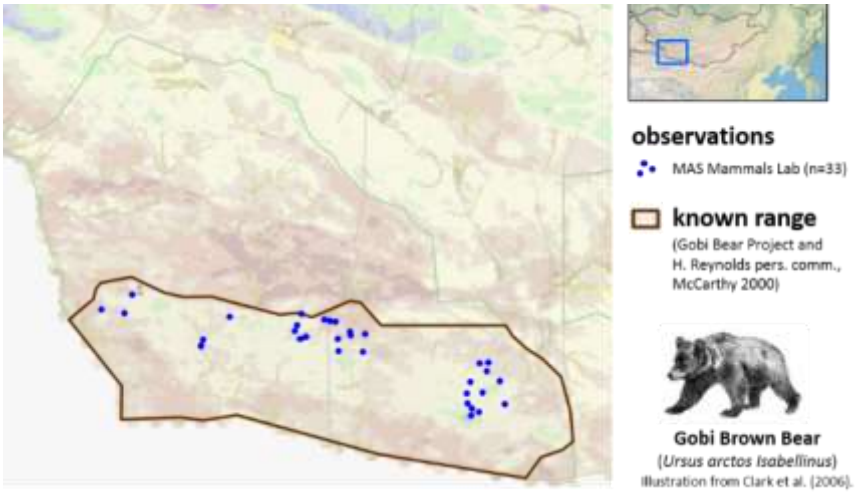
2) Fine-filter elements: modeled habitat distributions of 33 species of birds, mammals and reptiles listed by the National Red Lists as endangered, threatened, vulnerable or near threatened.

The following examples of fine-filter species elements describe four species with different distribution and habitat requirements and different datasets and methods for mapping current distribution.

Gobi Bear known range (Heiner et al. 2013)

The Gobi bear (Ursus Gobiensis) is a desert subspecies of brown bear. It's very rare (about 30 individuals remaining globally) with a very limited range. Distribution is mapped based on known range and observation records.

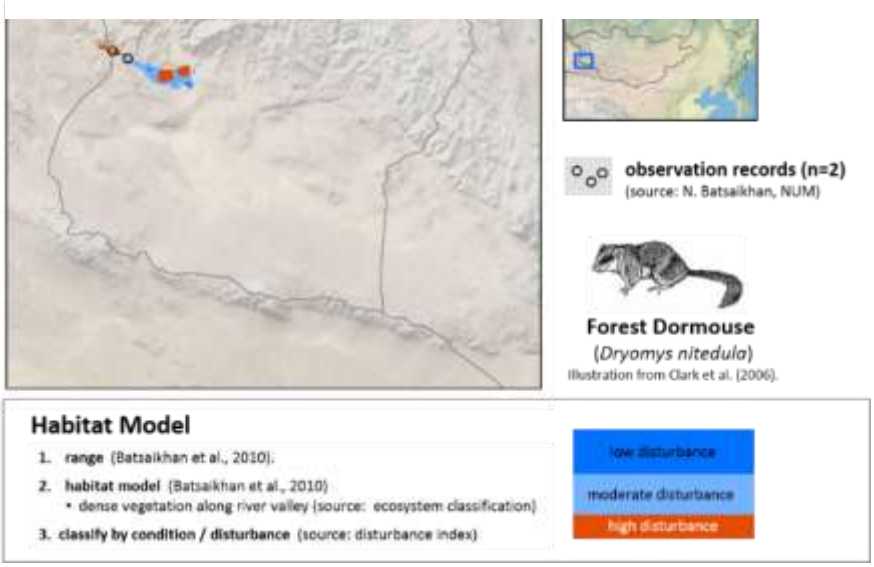
FIGURE 9.5: GOBI BEAR RANGE



Forest Dormouse range and habitat model

The Forest dormouse (Dryomys nitedula) occupies a small range in Mongolia, occurring in one riverine wetland, that is the eastern edge of a much larger global range across Europe

FIGURE 9.6: FOREST DORMOUSE RANGE

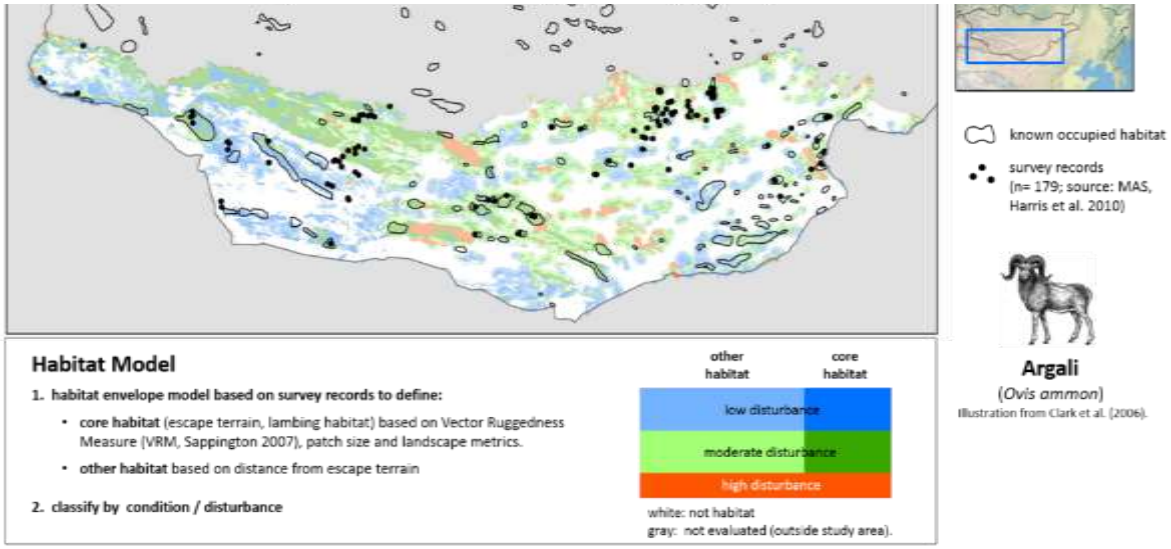


and Asia. The species status is “Near Threatened” in Mongolia according to the national red list (Clark et al. 2016), and “Least Concern” globally according to the IUCN Global Red List (Batsaikhan et al., 2016). Distribution is mapped is based on two observation records and and a habitat model.

Argali observations and habitat model

Argali (*Ovis ammon*) occurs in many places across Mongolia, but numbers are declining rapidly because of hunting and habitat loss. The datasets used to map distribution are 1) known occupied habitat, 2) field survey observations, and 3) a habitat model based on landforms.

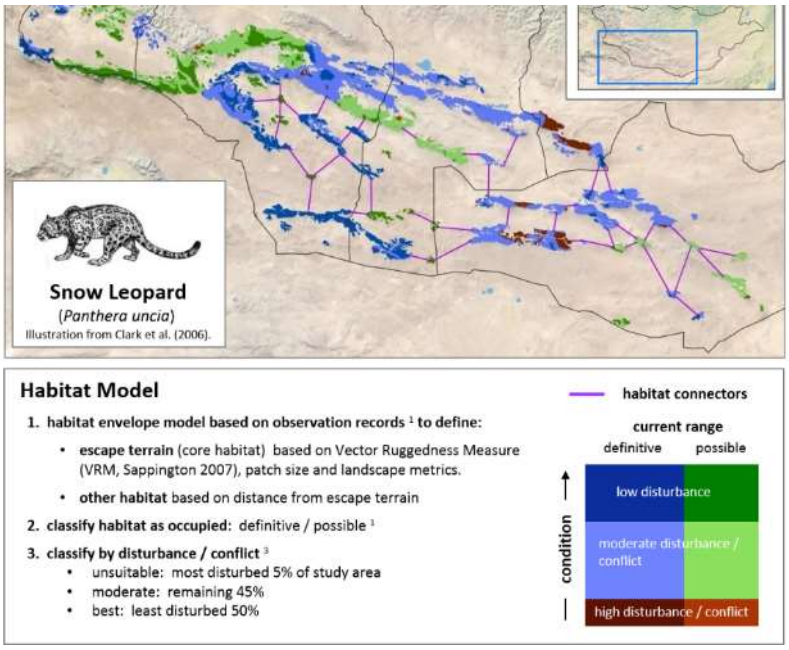
FIGURE 9.7: ARGALI RANGE



Snow Leopard (*Panthera uncia*) habitat model (Heiner et al., 2013)

Snow Leopard (*Panthera uncia*) covers a large range in Mongolia and Asia, but is considered rare because numbers are low. Range has been mapped by experts, and classified as “definite” and “probable” to represent uncertainty about the actual locations and numbers.

FIGURE 9.8: SNOW LEOPARD RANGE



Habitat connectivity: For wide-ranging species like Argali and Snow Leopard, survival depends on ability to move to find food and water, to find mates and breed, and to find new habitat. So maintaining connectivity, or the ability to move and the availability of movement habitat, is critical to conservation, and is the topic of another lecture.

9.7 Conservation Goals

The next step is to set quantitative goals for representation biodiversity elements, or answer the question “How much is enough?” Planners can set goals in terms of:

- **Abundance:** how much area or how many occurrences?
- **Distribution:** for redundancy, set goals by sub-regions to include multiple examples in different parts of the study area?
- **Configuration:** for example, include vegetation or ecosystem types in patches larger than a minimum area.

Quantitative goals and objectives drive the results of conservation planning and prioritization, but setting goals is challenging, again because biodiversity is complex and dynamic and data and knowledge are incomplete. There are several review papers that provide guidance re: the process of choosing goals. The recommendations can be summarized:

- Set clear, measurable goals
- Follow a transparent and well-documented process
- Use relevant information and research regarding, for example, ecological integrity thresholds and population viability analyses.
- Involve experts and other stakeholders.
- Relate goals to policy commitments, national and international.

Recommended principles and standards from Tear et al. (2005):

Principles	Standards
• State clear goals	• Use best available science
• Define measurable objectives	• Provide multiple alternatives
• Separate science from feasibility	• Define short- and long-term objectives
• Follow the scientific method	• Incorporate representation, redundancy, and resilience
• Anticipate change	• Tailor objectives to the biological system of concern
	• Estimate Error

Recommendations from Carwardine et al. (2005):

- Reference national & international significance policy statements
- Set thresholds based on ecological integrity of processes
- Where possible, consider population viability studies
- Include all stakeholders and property owners

EXAMPLE: Setting conservation goals. This is an example of setting goals for amount and distribution of coarse-filter features from a landscape-level plan in the US Rocky Mountains. This organizes small patch ecosystems by four distribution categories and sets goals by category, listed from highest to lowest:

- Endemic to ecoregion—highest goal
- Limited distribution in study ecoregion and adjacent ecoregions
- Widespread in study ecoregion and adjacent ecoregions
- Peripheral to study ecoregion (widespread in adjacent ecoregions)—lowest goal

Goals are also set by sub-regions within the study ecoregion to capture genetic differences between sub-regions and to account for catastrophic events such as epizootic die-offs and major disturbances. For other ecosystem types (matrix, large patch and linear), goals are set as 30 percent of historic distribution as described below.

FIGURE 9.9: SPECIES/AREA CURVE

Table 5. Conservation goals for terrestrial and aquatic ecological systems in the Southern Rocky Mountain ecoregion.

	Conservation goal		
	Matrix forming, large patch, and linear	Small patch	
Distribution relative to the ecoregion	Goal per section/ ecological drainage unit	Total number of occurrences	Goal per section/ ecological drainage unit
Endemic	Minimum of 30% of historic distribution (proportionally representing major gradients as expressed with ecological land unit and aquatic macrohabitat modeling)	25	2
Limited		15	2
Widespread		10	2
Peripheral		3	2

Note: See text for explanation.
Source: Modified from Neely et al. (2001).

Adapted from Dobson (1996) and Neely et al. *(2001)*

This shows a general relationship between declining habitat area and the remaining number of native species, based on studies of island biogeography. As area declines, number of native species declines to a critical threshold between 10-30 percent of historic area. This general relationship has been used as a rough guide to set goals for area of terrestrial ecosystems as 30 percent percent of historic area. For example, for a given forest formation (e.g., 'sub-tropical broadleaved evergreen forest"), the conservation goal might be set at 30 percent of the historic range area, and effective management to meet that area goal would require both protecting all remaining native forest and restoration of historic forest.

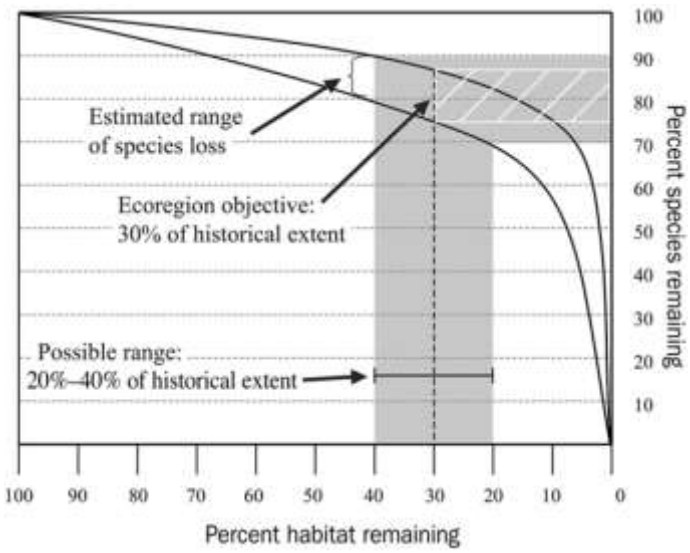


FIGURE 9.10: GENERALIZED SPECIES-AREA CURVE

9.8 Viability of Biodiversity Elements

The next step is to assess the viability or ecological integrity of biodiversity elements, to identify the occurrences, populations or patches that are the most viable, and most resilient to natural and human disturbances. This has been described in terms of:

- Size—generally larger is better
- Condition—health or ecological integrity
- Landscape context—vulnerability to nearby threats or disturbances

A way to measure this is with a spatial model of disturbance or cumulative impacts developed in a GIS. The result is a coarse-scale, generalized measure of current condition and cumulative impacts. This may be used to:

- Rank and compare parcels and habitat areas in terms of ecological condition, to design a conservation portfolio that optimizes for ecological condition
- Identify disturbed habitat for species distribution models
- Map and visualize patterns of disturbance across landscape

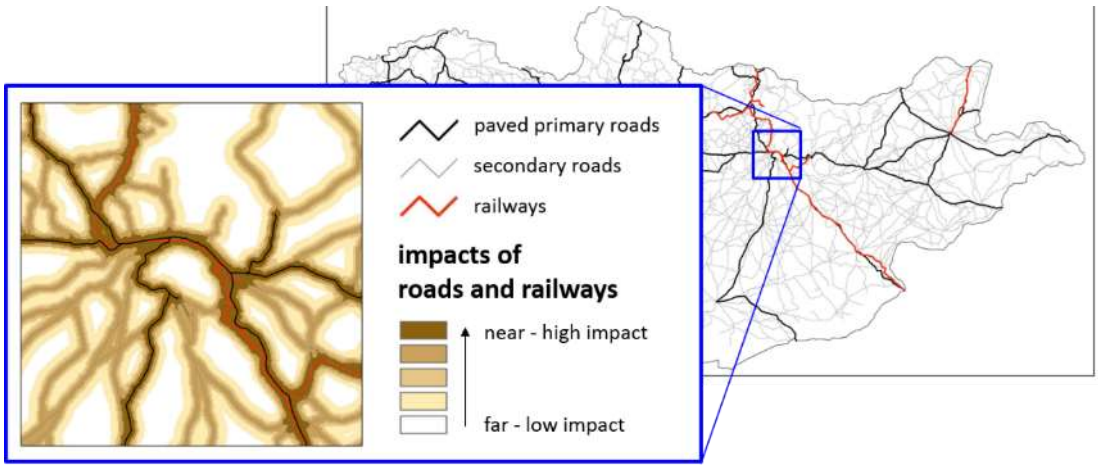
9.8.1 EXAMPLE: Mongolia National Disturbance Index

For a landscape-level conservation plan in Mongolia (Heiner et al., 2013), to measure cumulative human impacts as an indirect indicator of ecological integrity or departure from historic or natural conditions, an index of disturbance was calculated with available GIS data for sources and types of disturbance, described below.

Disturbance factors:

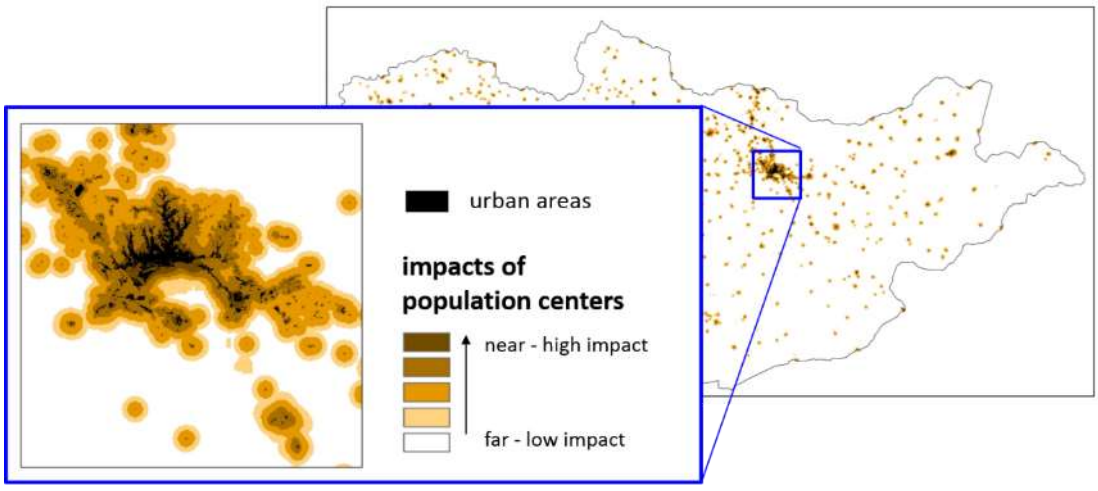
1. Transportation infrastructure (roads and railways) and areas of impact: Roads have multiple negative impacts on wildlife habitat and habitat use (Trombulak and Frissell, 2000; Benitez-Lopez et al., 2010). Measured as proximity to roads and railways and weighted by type: higher (paved primary roads, railways) and lower (secondary roads).

FIGURE 9.11: IMPACT OF ROADS AND RAILWAYS ON WILDLIFE



2. Population centers and associated areas of impact: in Mongolia, areas around population centers are typically overgrazed and hunting and predation and harassment by dogs are common. Measured as proximity to population centers.

FIGURE 9.12: IMPACTS OF POPULATION CENTERS ON WILDLIFE



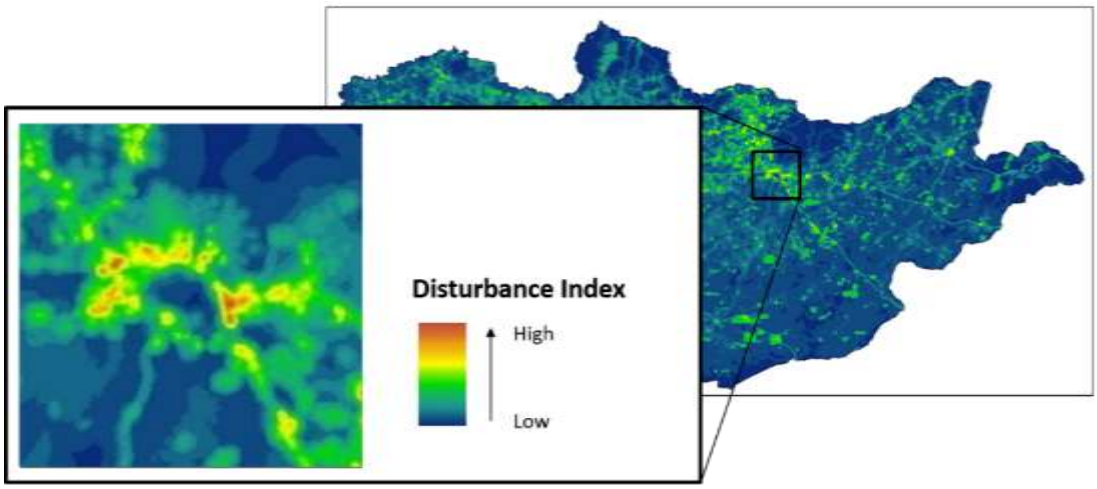
3. Mines and supporting infrastructure: Aside from the site-level impacts, impacts to vegetation and groundwater can extend far from the mine footprint (pit and infrastructure). Water extraction for mining operations causes drawdown of near-surface groundwater

in the local cone of depression, and potentially over large distances depending on groundwater hydrology (Walton, 2010). This can affect wells, springs and vegetation productivity. Mine operations and high traffic on mining roads also create large amounts of dust that can travel far and affect vegetation growth (Walton, 2010). Represented by active mining and petroleum leases.

4. Agriculture: large-scale agriculture causes habitat loss through avoidance and has impacts on soil and water. Disturbance measures are weighted by type: high impacts (crops and vegetables), moderate (wheat) and low (hay).
5. Livestock grazing intensity: Livestock grazing can affect plant species composition and may impact availability and quality of habitat for wildlife, through exclusion and competition or by reducing palatable species. Mongolian gazelle avoid areas near herder households, and high densities of herder households may create barriers to movement and limit access to forage. Hunting and predation or harassment by feral dogs also likely increase with proximity to and density of herder households. Measured as density of households within a moving window, by season: winter/spring (5km radius circular window) and summer/autumn (10km radius circular window).

The disturbance index was calculated as the sum of the five factors (range of values

FIGURE 9.13: DISTURBANCE INDEX IN MONGOLIA



rescaled 0 to 1).

The disturbance index was used in portfolio site selection to rank ecosystem occurrences by ecological condition and maximize selection of undisturbed ecosystems, and to minimize selection of areas with competing economic values, such as areas heavily grazed by livestock. As such, this index functions as a generalized, coarse-scale measure of cumulative impacts of human activities, ecological condition, and the relative cost of conservation effort and investment.

9.9 Portfolio of Conservation Sites

With this information, it is possible to begin to design a network or “portfolio” of priority conservation areas to meet the design criteria. There are many possible design criteria that depend on the objectives of the planning team, and many methods and tools exist for this process of reserve network design or ‘spatial optimization.” Often, systematic conservation plans use an optimization approach automated with spatial analysis tools such as Marxan (Pressey et al., 1997; Ball et al., 2009).

An important step in portfolio design is to assess future development plans and incorporate them into portfolio design. This is very important, because if conservation plans don”t incorporate future development plans, the results will be difficult or impossible to implement, and will likely be ignored completely. The mitigation hierarchy—first avoid, then minimize, then offset impacts—is the basis for EIA policy and regulation and is a mechanism to drive implementation of conservation plans, by guiding avoid/protection and offsets. Blending landscape-level conservation planning with the mitigation hierarchy is the overarching goal of TNC’s Development by Design strategy (Kiesecker et al., 2008).

Note that PAs and nature reserves alone may not be enough to maintain wide-ranging species. To be effective, PAs and nature reserves must be managed as core habitat in a landscape matrix that allows movement and seasonal habitat use. Connectivity conservation is the topic of another lecture.

Finally, conservation planning is an adaptive, iterative process. As the landscape changes and data and information change, review and revision of the conservation area portfolio and the supporting information system will be necessary to maintain accuracy and relevance to stakeholders and decision makers.

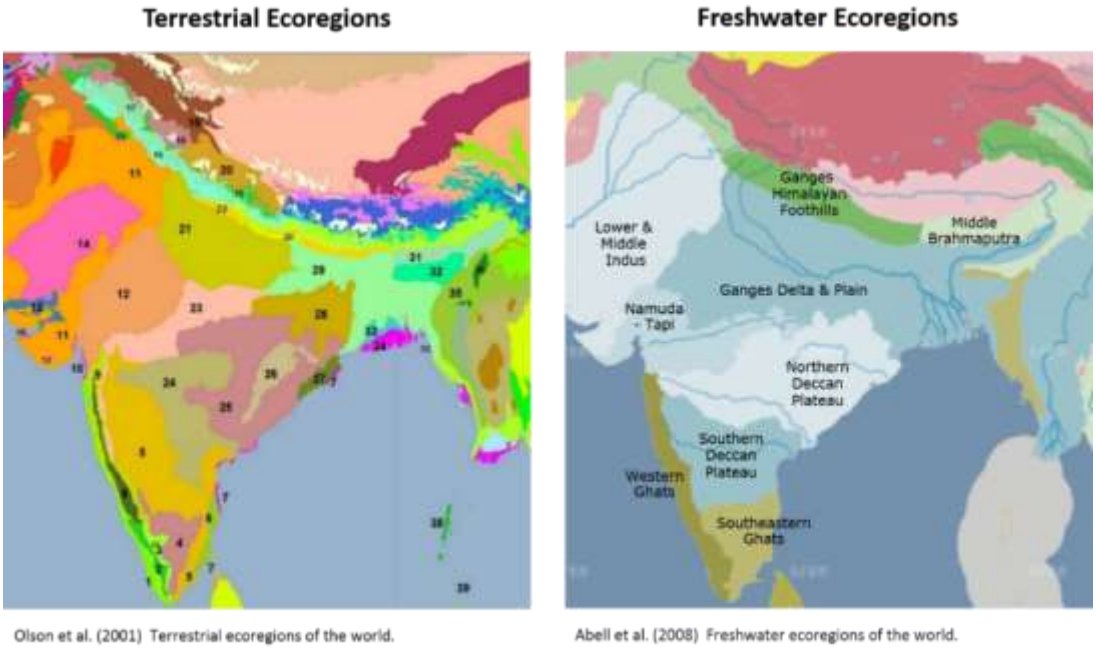
9.10 Freshwater and Marine Conservation Planning

This examples described in this lecture included only terrestrial species and ecosystems. For the freshwater and marine realms, the same principles and criteria apply. However, the datasets and methods are different to represent differences between terrestrial, freshwater and marine systems and biodiversity.

Freshwater (watershed-level) conservation planning

For freshwater, conservation planning is organized around watersheds or river basins. WWF has defined and mapped Freshwater Ecoregions of the World (Abell et al., 2007), organized by river basins.

FIGURE 9.14: GLOBAL TERRESTRIAL AND FRESHWATER ECOREGIONS



Source: Terrestrial: Olson et al, 2001; Freshwater: Abell et all, 2008

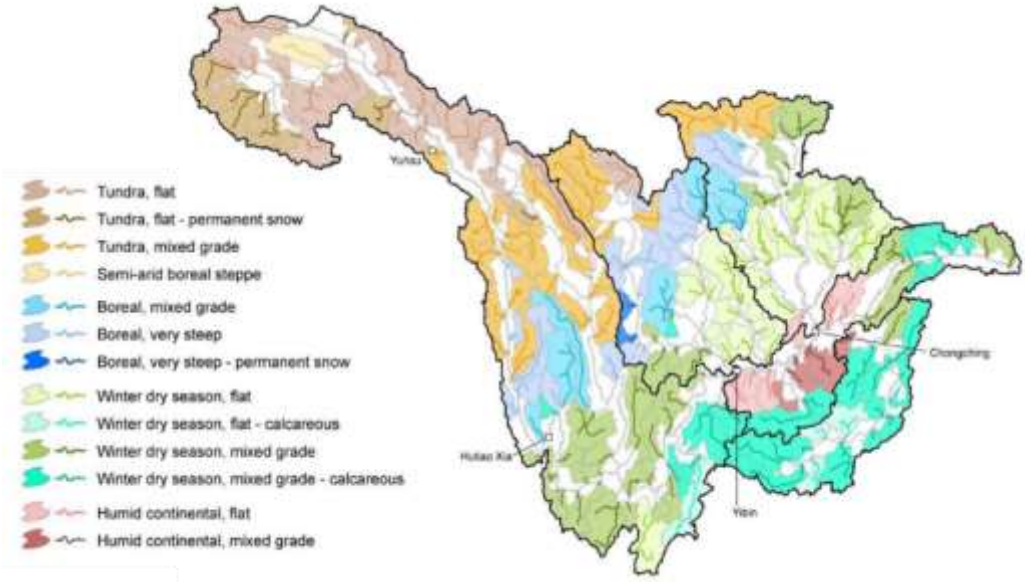
9.10.1 Example: Upper Yangtze River Basins Freshwater (watershed-level) Conservation Planning (Heiner et al., 2011)

Freshwater ecosystem classification, Upper Yangtze River Basin

This shows an example of an aquatic or freshwater ecosystem classification, organized by watersheds and based on physical environmental factors:

- Stream/river size (basin area)
- Climate
- Geology
- Stream grade

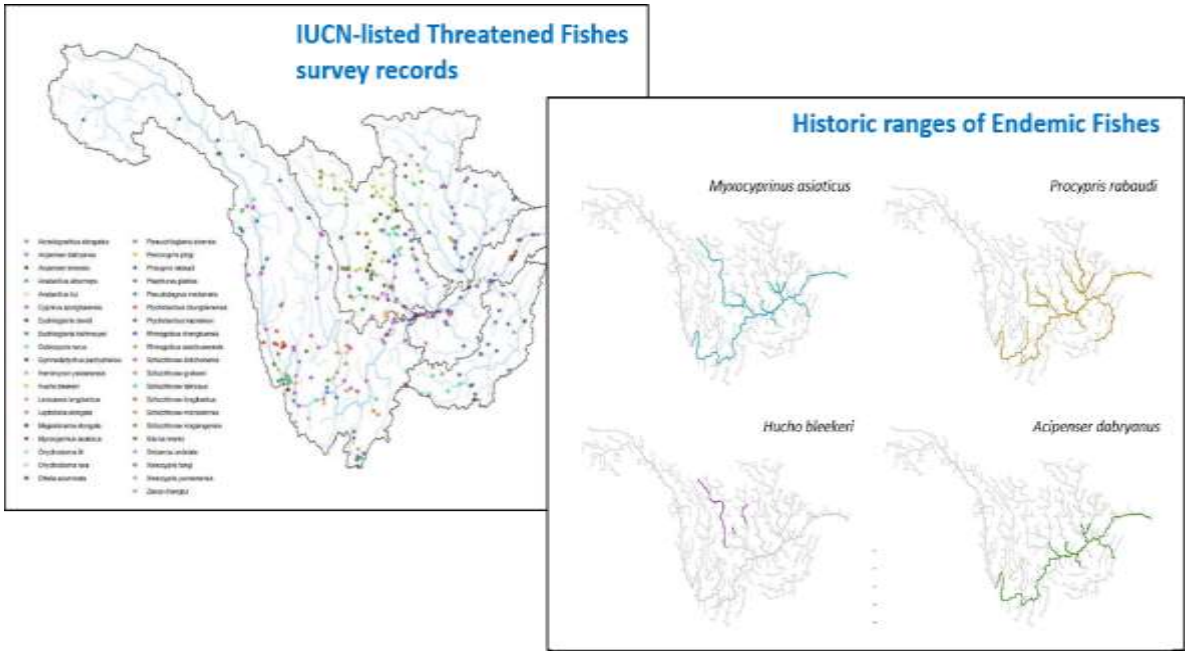
FIGURE 9.15: FRESHWATER ECOSYSTEM CLASSIFICATION



Freshwater fine-filter elements, Upper Yangtze River Basin

- Survey records for IUCN-listed threatened fish species
- Historic ranges of endemic fish species

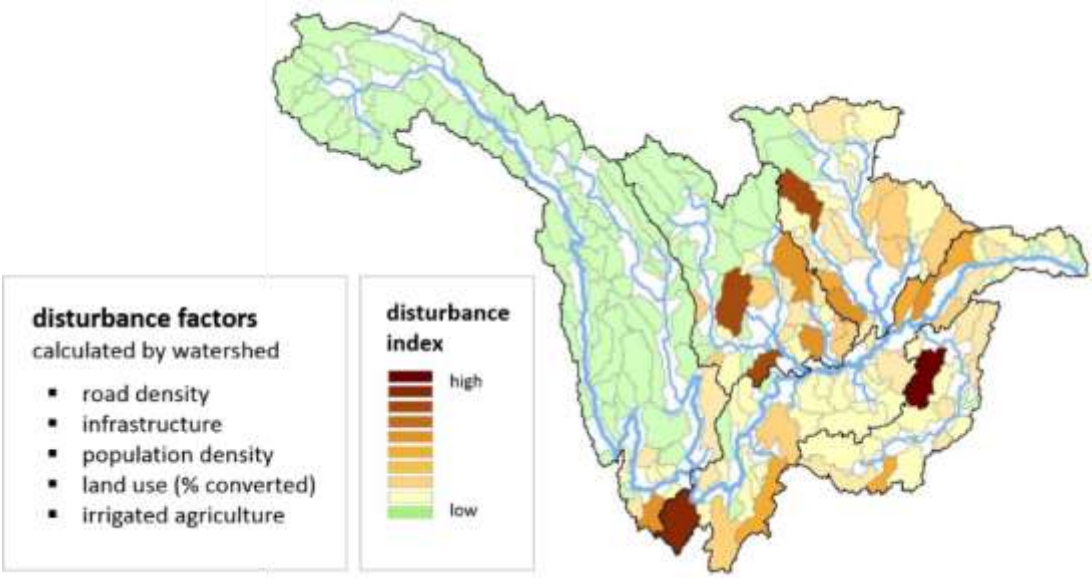
FIGURE 9.16: SURVEYS AND RECORDS OF FISH SPECIES



Freshwater disturbance index

This shows a disturbance index calculated by watershed to represent cumulative human impacts to rivers and streams.

FIGURE 9.17: DISTURBANCE FACTORS FOR WATERSHEDS

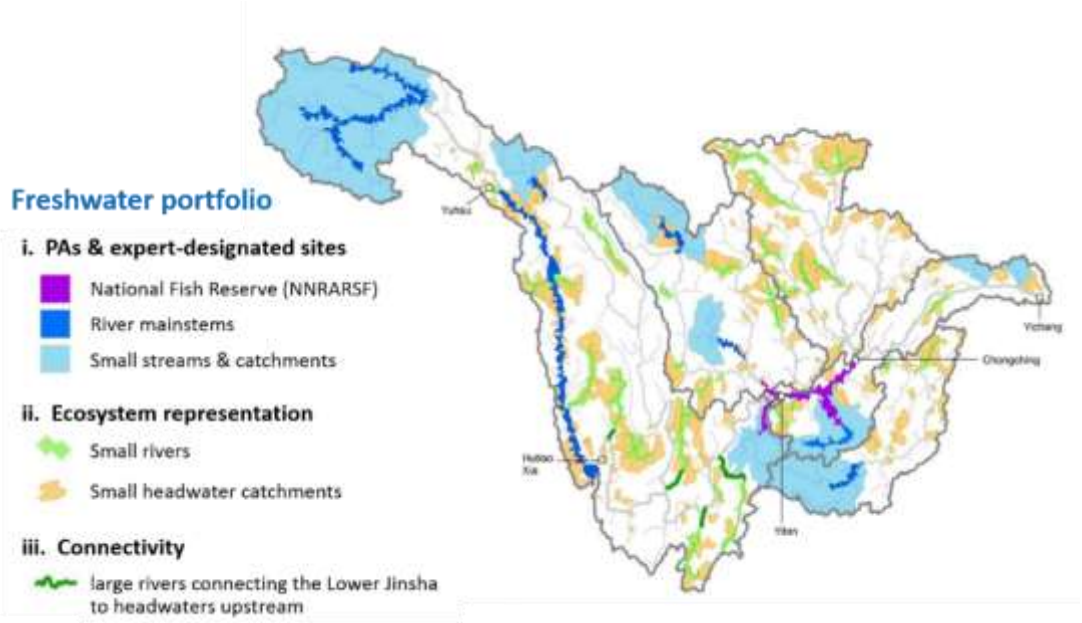


Freshwater conservation portfolio

This shows a portfolio of conservation areas designed to

- To meet representation goals for freshwater ecosystems (river length and number of watersheds)
- In a network of rivers streams and headwater catchments connected longitudinally
- Minimize disturbance measured as watershed-level cumulative impacts to rivers and streams.

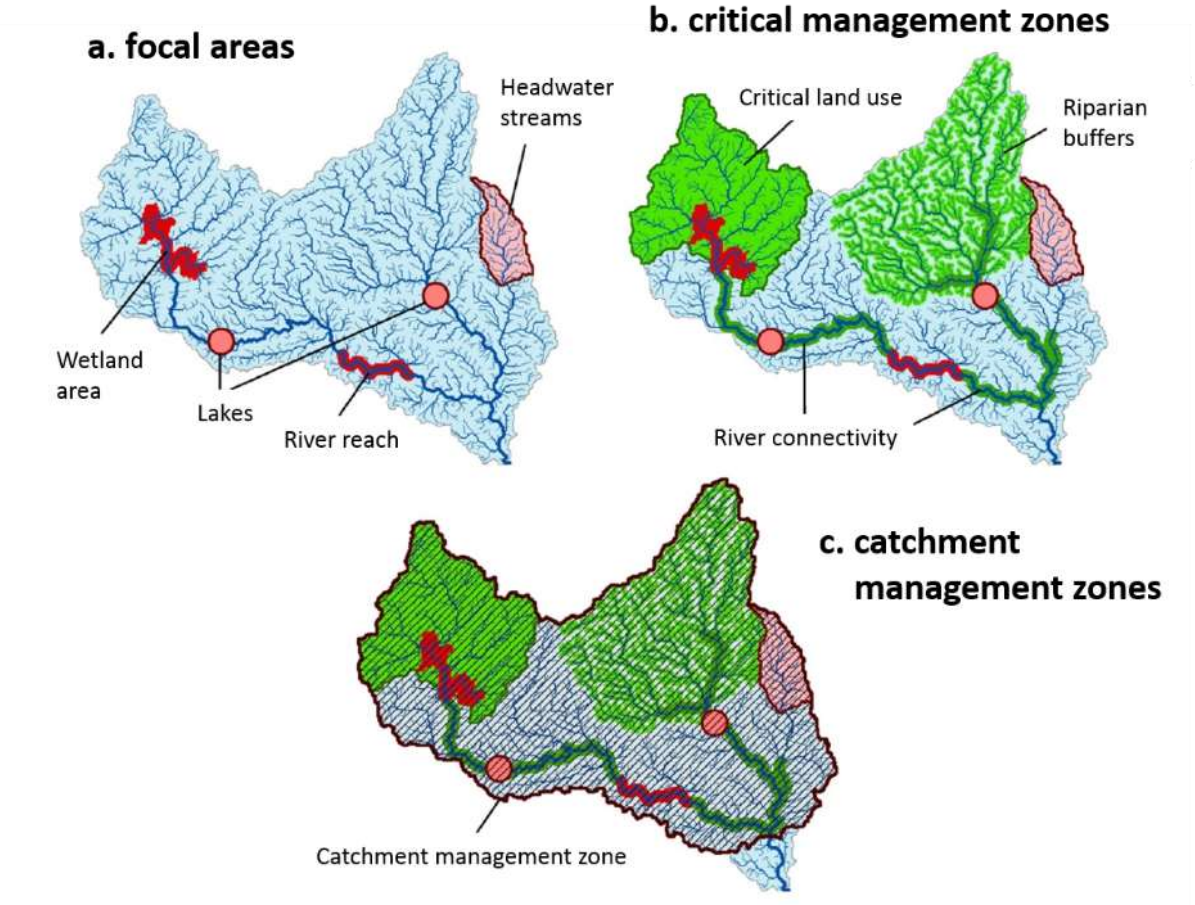
FIGURE 9.18: FRESHWATER CONSERVATION PORTFOLIO



Freshwater Protection Areas

This shows a framework proposed by Abell et al. (2007) for Freshwater Protection Areas that defines different categories of protection and management restrictions for different components and function of the river basin and river network.

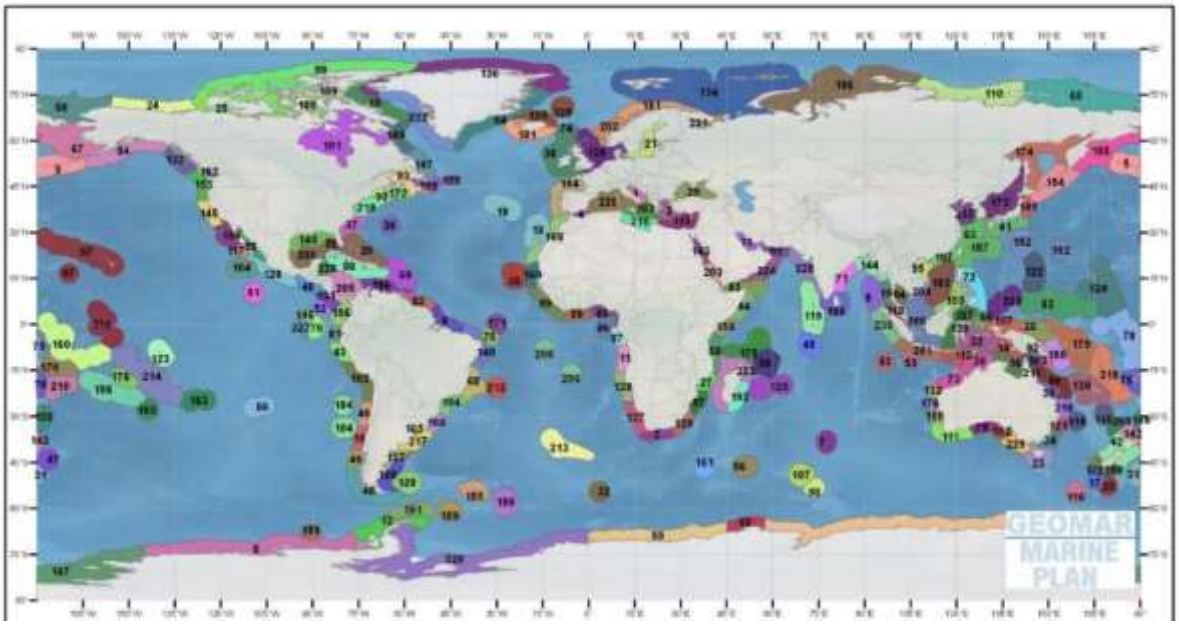
FIGURE 9.19: FRESHWATER PROTECTION AREAS



Marine conservation planning

As with the terrestrial and freshwater realms, marine ecoregions have also been mapped globally (Spalding et al., 2007), and planning methods have been developed specifically for marine species and ecosystems.

FIGURE 9.20: MARINE ECOREGIONS



Spalding, 2007

9.11 Online Conservation Planning Resources

Groves, C. (2003). *Drafting a conservation blueprint: a practitioner's guide to planning for biodiversity*. Island Press: http://islandpress.org/book/drafting-a-conservation-blueprint

Groves, C., Game, ET (2016). Conservation Planning: Informed Decisions for a Healthier Planet. MacMillan Learning: http://www.macmillanlearning.com/Catalog/product/conservationplanninginformeddecisionsforahealthierplanet-firstedition-groves

Conservation Gateway: https://www.conservationgateway.org/Pages/default.aspx

Ecoregional Assessment Toolbox (Higgins & Esselman, 2010): https://www.conservationgateway.org/Files/Pages/ecoregional-assessment-to.aspx

Conservation Planning: https://www.conservationgateway.org/ConservationPlanning/Pages/conservation-planning.aspx

EAST: Ecoregional Assessment Status Tool: https://www.conservationgateway.org/ConservationPlanning/SettingPriorities/EcoregionalReports/Pages/EastData.aspx

Setting Freshwater Priorities: https://www.conservationgateway.org/ConservationPlanning/SettingPriorities/SettingFreshwaterPriorities/Pages/setting-freshwater-priori.aspx

Conservation Gateway - Marine: https://www.conservationgateway.org/ConservationPractices/Marine/Pages/marine.aspx

Special Issue: Freshwater Conservation Planning. (2011). Freshwater Biology, 56(1): http://onlinelibrary.wiley.com/doi/10.1111/fwb.2010.56.issue-1/issuetoc

Marine Spatial Planning Initiative (UNESCO): http://www.unesco-ioc-marinesp.be/marine_spatial_planning_msp

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MODULE 4: CLIMATE CHANGE AND MANAGEMENT

Anthropogenic climate warming and its potential impacts on sustainable development and ecosystem structure and function has had profound impacts and implications for the forest sector. While in the Indian context forest cover loss is not a major source of emissions, degredation of the forest resource base in the face of continued population growth is. India's Natioanlly Determined Contribution to the UNFCCC also factors in the forest sector as a large sink for carbon dioxide in the form of carbon stored in forest ecosystems.

Forests are not only important sources and sinks of carbon for the atmosphere, but are also important for any efforts to successfully adapt to climate warming. To successfully manage forests as the comprehensive change that global warming will cause affects forests, the practice of management will have to take an integrated approach. This is the subject of the second lecture in this module.

LECTURE 10: CLIMATE CHANGE AND ECOSYSTEM MANAGEMENT

This lecture covers the following:

- Climate change impacts, mitigation, and adaptation
- Emerging issues in climate change
- Emissions from forests, and impacts on and mitigation of climate change by forests

10.1 Introduction

Climate change is real, and is supported by scientifc evidence. Its impacts are evident and any remaining skepticism about climate change is untenable. The average global temperature has risen by 0.8 degrees Celsius since the industrial revolution. Emissions from greenhouse gases (GHG) continue to increase despite the intentions of the international community as decribed in the United Nations Framework Convention on Climate Change (UNFCCC). The Intergovernmental Penal on Climate Change's (IPCC) latest report, the Fifth Assessment Report (2014), has provided more evidence that climate change is real and that the international community must take action to avoid disasters resulting from the rise of global temperatures. There is a general consensus among nations that the average global temperature increase should not rise above 2° Celsius by 2050.

10.2 Ecosystem Management and Climate Change (impacts, mitigation and adaptation)

EAFM focuses on managing forests in an integrated manner to ensure sustainable flow of goods and services. A multi-species and multi-layered forest stand structure not only carries higher quantities of forest carbon but also sequesters more carbon dioxide from the atmosphere. Unevenly aged forests make optimum use of environmental resources for higher growth of biomass, and thereby carbon. Long rotation timber species that are harvested and used for construction or furniture, ship building, and other products, serve as carbon sinks or reservoirs, and restrict the release of CO_2 to the atmosphere. For example, continuous cover forestry (CCF), which involves selection method of harvesting, conserves carbon compared to clear cutting of forests. Soil carbon and soil erosions are limited in CCF. In some cases continuous cover forestry may mechanically reduce sediment transport due to less distributed soil and vegetation. It may help to conserve soil quality and potentially contribute to an improved carbon balance (through lower rates of organic carbon leaching and mineralization) in the forest landscape.

There are two approaches to ecosystem management: (i) conservation oriented, and (ii) restoration oriented. Conservation strategies seek to protect areas against human-induced stresses and disturbances such as heavy extraction, pollution, etc. and provide plant and animal species to live at their own biom / environment. Restoration-focused strategies, on the other hand, seek to assist recovery of degraded areas to as close to their original state without human impact (Sandler, 2013).

Rapid and uncertain ecological change has serious implications for ecosystems. These changes are so rapid that coping with them may prove difficult. Coping methods require rethinking ecosystem management goals. As far as protected areas (PAs) are concerned, traditional conservation objectives will hold up, as efforts are to preserve fauna and flora, and to restrict or eliminate external disturbances so they do not interfere with the well-being of the species within the PA and its surrounding communities. However, management of forests outside PAs requires a paradigm shift to an ecosystem-based management (EBM).

Forests, when managed well, are a source of a wide range of goods and ecosystem services. However, an additional stressor, climate change, is threatening perpetual supplies of goods and services. Climate change is likely to affect the distribution of forest ecosystems, species populations and communities, productivity, soil nutrients, and biodiversity. The effects of climate change will exacerbate forest fires, insect and pathogen attacks, floods, drought, temperature extremes, and other aspects of the natural ecosystem.

The public forestry sector, by improving forest management policies and practices, can contribute to decelerating climate change and helping forest ecosystems and society adapt to its effects while maintaining forest values and the sustainable flow of goods and services. An ecosystem approach to forest management, with sustainability at its core, ensures adaptation and contributes to the economic, social, and environmental needs of society. Specific strategies and actions regarding climate change will differ by location, forest productivity, local management objectives, and the extent and nature of expected climate change impacts. Forestry institutions need to continue their efforts to understand climate change threats and opportunities as they emerge (FAO, 2013).

10.3 Paris Agreement

The international community has adopted the UNFCC Paris Agreement on Climate Change and has resolved hold the increase of the average global temperature to less than 2° Celsius above pre-industrial levels. Article 2 of the Agreement reads as follows:

ARTICLE 2

1. This Agreement, in enhancing the implementation of the Convention, including its objective, in enhancing the implementation of the Convention, including its objective, aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including by:
   (a) Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change;
   (b) Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production;
   (c) Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.
2. This Agreement will be implemented to reflect equity and the principle of common but differentiated responsibilities and respective capabilities, in the light of different national circumstances.

10.4 Intended Nationally Determined Contributions

Most countries submitted their intended nationally determined contributions (INDC) to the UNFCCC prior to the Paris Conference setting targets for mitigation and adaptation. India has communicated its INDC, which has the following main points:

INDIA'S INDC

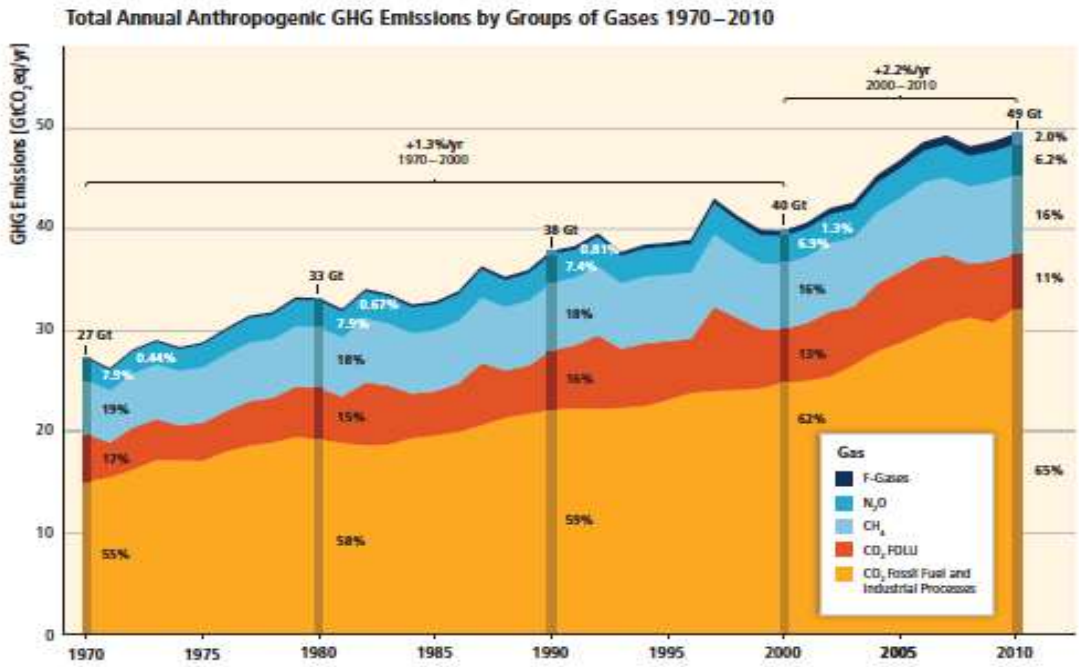
1. To put forward and further propagate a healthy and **sustainable way of living** based on traditions and **values of conservation and moderation**.
2. To adopt a **climate friendly and a cleaner path** than the one followed hitherto by others at corresponding level of economic development.
3. To **reduce the emissions intensity of its GDP** by **33 to 35 percent by 2030** from **2005 level**.
4. To achieve about **40 percent cumulative electric power installed capacity** from **non-fossil fuel based energy resources** by **2030** with the help of transfer of technology and low cost international finance including from Green Climate Fund (GCF).
5. To **create an additional carbon sink of 2.5 to 3 billion tons** of **CO_2 equivalent** through additional forest and tree cover by **2030**.
6. To **better adapt** to climate change by enhancing investments in development programs in sectors vulnerable to climate change, particularly agriculture, water resources, Himalayan region, coastal regions, health and disaster management.
7. To mobilize **domestic and new & additional funds** from developed countries to implement the above mitigation and adaptation actions in view of the resource required and the resource gap.
8. To **build capacities**, create domestic framework and international architecture for quick diffusion of cutting edge climate technology in India and for joint collaborative R&D for such future technologies.

According to IPCC's Fifth Assessment Report (2014), mitigation is a human intervention to reduce the sources or enhance the sinks of GHG. Together with adaptation to climate change, mitigation will stabilize the concentration of GHG in the atmosphere and prevent dangerous anthropogenic interference with the climate system. Mitigation includes the following to reduce GHG emissions in the atmosphere:

- Reduction of carbon concentration in the atmosphere;
- Geo-engineering: capture, transport, and store (CTS); and
- Biological sequestration.

10.4.1 Trends in Stocks and the Flow of GHG and Their Drivers

FIGURE 10.1: TOTAL ANNUAL ANTHROPOGENIC GHG EMISSIONS (GTCO2EQ/YEAR) BY GROUPS OF GASES 1970—2010: CO2 FROM FOSSIL FUEL COMBUSTION AND INDUSTRIAL PROCESSES; CO_2 FROM FORESTRY AND OTHER LAND USE (FOLU); METHANE (CH4); NITROUS OXIDE (N2O); FLUORINATED GASES.



Source: IPCC 5th Assessment Report, Summary for Policy Makers-Working Group III

Total anthropogenic GHG emissions continued to increase from 1970 to 2010 with larger absolute decadal increases toward the end of this period. Despite a growing number of CO_2 equivalent ($GtCO_2eq$) (2.2 percent) per year from 2000 to 2010 compared to 0.4 $GtCO_2eq$ (1.3 percent) per year from 1970 to 2000 (Figure 10.1). Total anthropogenic GHG emissions were the highest in human history from 2000 to 2010 and reached 49 ($\pm$4.5) $GtCO_2eq$/year in 2010. The global economic crisis in 2007 and 2008 only temporarily reduced emissions (IPCC, 2014).

CO_2 emissions from fossil fuel combustion and industrial processes contributed about 78 percent of the total GHG emission increase from 1970 to 2010, with a similar percentage contribution for the period 2000 to 2010. Fossil fuel-related CO_2 emissions reached 32 ($\pm$2.7) $GtCO_2$/year, in 2010, and grew further by about 3 percent between 2010 and 2011 and by about 1–2 percent between 2011 and 2012. Of the 49 ($\pm$4.5) $GtCO_2eq$/year in total anthropogenic GHG emissions in 2010, CO_2 remains the major anthropogenic GHG, accounting for 76 percent (38 $\pm$ 3.8 $GtCO_2eq$/year) of total anthropogenic GHG emissions in 2010. Sixteen percent (7.8$\pm$1.6 $GtCO_2eq$/year) come from methane (CH_4), 6.2 percent (3.1$\pm$1.9 $GtCO_2eq$/year) from nitrous oxide (N_2O), and 2.0 percent (1.0$\pm$ 0.2 $GtCO_2eq$/year) from fluorinated gases (Figure 1). Annually, since 1970, about 25 percent of anthropogenic GHG emissions have been in the form of non-CO_2 gases (IPCC, 2014).

10.5 Role of Forests

Forests cover about one-third of the earth's land surface (approximately 4 billion hectares) and contain the largest carbon stock. When deforestation and forest degradation take place, carbon stored in forests is released in the atmosphere. Thus forests can also be sources of carbon emissions as well as carbon sinks. About half of the forests are in need of restoration and thus provide a potential opportunity for reducing emissions and removing carbon from the atmosphere.

10.5.1 Emissions from Forests

According to the United Nation's Food and Agriculture Organization (FAO), approximately 13 million hectares of forests are cleared every year, primarily for agricultural purposes (for the period from 1990 to 2005). Deforestation continues at an alarming rate. Countries with the highest rate of deforestation are in the tropics: the Amazon basin, Indonesia, and the Congo basin. The cut trees are burned, and that combined with the gradual release of emissions from decaying organic material results in the immediate release of the carbon originally stored in the trees as CO_2 emissions (with small amounts of carbon monoxide [CO], and CH_4).

The IPCC's Working Group III Report, released in 2014, estimated that 24 percent (12 $GtCO_2eq$) net GHG emissions were released in the agriculture, forestry, and other land use (AFOLU) sector in 2010 (IPCC, 2014 Summary for Policy Makers Working Group 1). This indicates the AFOLU sector accounts for a quarter of net anthropogenic emissions, mainly from deforestation, agricultural emissions from soil and nutrient management, and livestock. In the future, net baseline CO_2 emissions are projected to decline, with net emissions potentially less than half the 2010 level by 2050 and the possibility of the AFLOU sector becoming a net emission of CO_2 before the end of century.

10.5.2 Forests and Climate Change

There are two primary approaches to climate change: mitigation and adaptation, the former addressing its causes, and the latter its impacts. Adjustments in forest policies or in the new policy under development and management plans and management practices will be required in India to address the challenges posed by climate change. Changes in management practices will help in coping up with the vulnerability of humans and forests to climate change.

10.5.3 Mitigation Actions through Forests

Reduction and/or prevention of deforestation is a key climate change impact mitigation option for reducing carbon emissions. Forests sequester CO_2 from the atmosphere and store it, serving as an important sink. The mitigation of climate change impacts by forests is more cost-effective than engineering methods that involve carbon capture, carriage, and sequestration underground.

There are two broad categories of climate change mitigation actions in the forestry sector:

- Reducing GHG emissions by sources[1] (reducing emissions), and
- Increasing GHG removal by sinks[2] (increasing the removal of GHGs from the atmosphere).

Within these two categories, mitigation options are of four types:

- Reducing deforestation, protecting and conserving forests, thereby maintaining the land area of forests;
- Increasing forest cover (e.g., through afforestation and reforestation);
- Conserving or enhancing forest stocks and density at the stand and landscape scales:
  - By preventing forest degradation and managing timber production in forests to ensure that carbon stocks remain constant or increase over time, and
  - Through the restoration of degraded forests; and
- Accumulating off-site carbon stocks in wood products (e.g., displacing fossil fuels with wood fuels and replacing construction materials such as concrete, steel, aluminum, and plastics with wood).

Note that the PAs or protection working circles (used specifically for the protection of soil and water resources), where timber extraction is not permissible or limited under working plan prescriptions, cannot be considered a mitigation action unless such forests would otherwise have been cleared or degraded.

Forest area can be increased through planting, sowing, and assisting natural regeneration, and through natural succession. Afforestation leads to increases in the carbon pools held in above- and below ground biomass, and in dead organic matter. Optimal increases of stock in forests can be achieved through enrichment planting or planting under the suitable tree, bamboo, and shrub species in degraded / open areas.

Activities to maintain forest carbon stocks include applying reduced impact logging, and sustaining yield management in timber production forests; maintaining partial forest cover, and minimizing the loss of the dead organic matter and soil carbon

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[1] A source of GHG emissions is any process or activity that releases GHGs into the atmosphere. Deforestation and forest degradation are major sources of GHG emissions because they cause the release of the carbon stored in forests in the form of CO2 and other GHGs, such as methane to the atmosphere (FAO, 2013).

[2] A carbon sink is a reservoir that takes up (sequesters) carbon from the atmosphere in the form of CO_2. When forests grow, they act as carbon sinks. Globally, forests are responsible for a large proportion of removals of CO_2 from the atmosphere (FAO, 2013).

pools by reducing high-emission activities such as soil erosion and slash and burn farming.

Replanting after harvesting or natural disturbances accelerates growth and reduces carbon losses relative to natural regeneration. However, retaining additional carbon on the site will delay revenues from harvesting, and forest managers should consider carefully the benefits and costs of this approach.

Another mitigation action is the use of harvested wood products. When wood is transformed into long-life products, such as buildings and furniture, the products can act as a reservoir of carbon for centuries.

Forest departments should consider the various available mitigation options and actions in light of their management objectives; the presence of degraded land; pressures on the land (e.g., encroachment, grazing, or fire); and laws, regulations, or other governance factors that affect the range of available land use and forest management actions.

Climate change is expected to increase the risk of economic loss. Among other things, forestry institutions can encourage the uptake of fuel-efficient stoves for cooking.The introduction of efficient technologies can have economic, social, and environmental benefits.

10.6 REDD+

International consensus on REDD+ has increased in the last decade, beginning in 2007 at the Conference of Parties 13 (COP 13) in Bali. It was given an initial framework acceptable shape in 2010 at the COP 16 in Cancun; and in 2013, the Parties agreed to the Warsaw framework for REDD+ at COP 19.

10.6.1 PARIS Agreement: December 2015

The agreement adopted in Paris in COP 21 in December 2015 (Paris Agreement)

Article 5

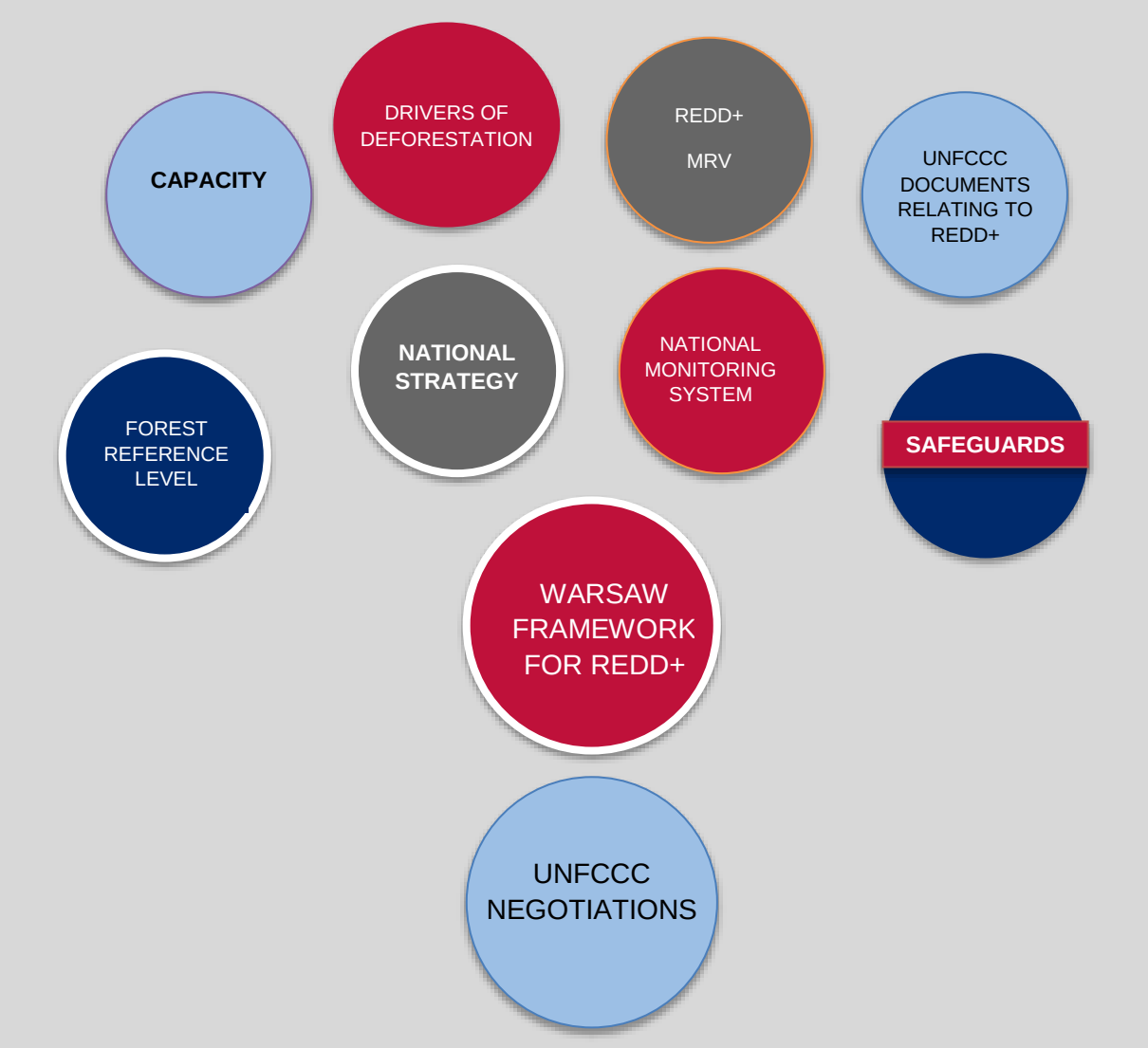
1. Parties should take action to conserve and enhance, as appropriate, sinks and reservoirs of greenhouse gases as referred to in Article 4, paragraph 1(d), of the Convention, including forests.
2. Parties are encouraged to take action to implement and support, including through results-based payments, the existing framework as set out in related guidance and decisions already agreed under the Convention for: policy approaches and positive incentives for activities relating to reducing emissions from deforestation and forest degradation, and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries; and alternative policy approaches, such as joint mitigation and adaptation approaches for the integral and sustainable management of forests, while reaffirming the importance of incentivizing, as appropriate, non-carbon benefits associated with such approaches.

includes Article 5 on mitigation through forests. It is states as follows:

10.6.2 What is REDD+?

REDD+ activities include reducing emissions from deforestation; reducing emissions from forest degradation; conserving carbon stocks; sustainably managing forests, and enhancing forest carbon stocks.

FIGURE 10.2: REDD+ FACTSHEET (ADAPTED FROM HTTP://REDD.UNFCCC.INT/)



10.6.3 REDD+ Policy Architecture

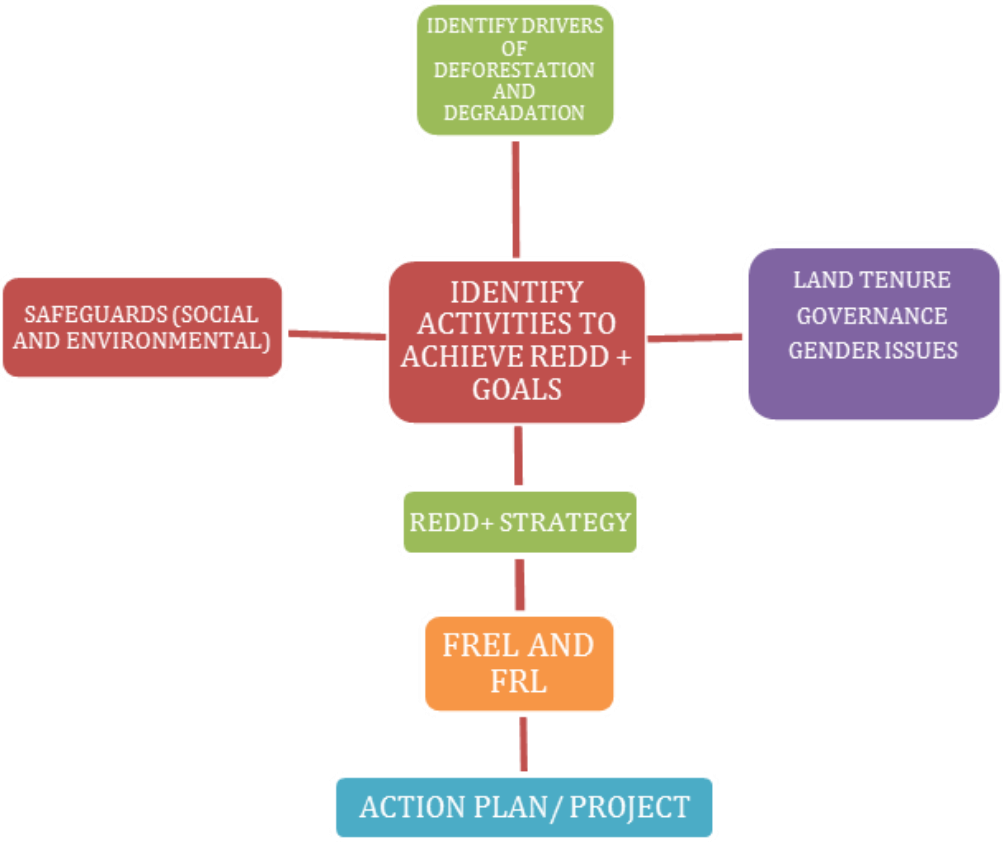
Developing countries have agreed to reduce deforestation and forest degradation that emit GHGs as well as to manage forests sustainably to conserve and enhance forest carbon stocks. This is termed as REDD+. A country implementing REDD+ is required to identify drivers of deforestation and forest degradation, as well as activities it can undertake to address the drivers and manage its forests sustainably. A national strategy or action plan must be developed for implementing REDD+ activities. Development and implementation of a national strategy or action plan needs to address the issues of forest governance, land tenure, and gender. Social and environmental needs must also be considered to avoid adverse impacts.

If financial incentives are sought, outcomes from the REDD+ activities should be fully measured, reported, and verified. Results-based actions eligible for results-based finance are to be monitored against emission reference levels and forest reference levels in metric tons of CO_2 equivalent. The UNFCCC secretariat or expert group then assesses the reported measurements. An implementing country is required to set up a robust and transparent national monitoring system or a subnational

monitoring system in the interim. The monitoring report will also include information how the safeguards are being respected and implemented.

Financing for results-based actions can be obtained from a variety of sources—both the public and private sectors, multi- and bi-lateral donor agencies, and alternate sources (market, and non-market). The financing should be innovative adequate, and predictable.

FIGURE 10.3: REDD+ STRUCTURE AS IT HAS EVOLVED THROUGH INTERNATIONAL NEGOTIATIONS SINCE 2007



Financing should cover all phases of REDD+ activities, to include the development of a national strategy or action plan, capacity building, and establishment of a monitoring system.

10.6.4 REDD+ Activities

Activities to achieve policy objectives will include preventing or reducing forest clearing for land use changes; and avoiding, preventing, or reducing forest degradation that results in reduced forest density and stocks. The management of forests should be sustainable, and promote resource use in such a way that there is no further depletion of forests but improvement in forest health. Activities should conserve forest carbon, and together with afforestation and reforestation activities, their impacts will increase forest carbon stocks. These activities must be undertaken

by developing tropical countries where forests are being cleared at an alarming rate (i.e., the Amazon basin, Indonesia, and Congo basin).

10.6.5 Drivers of Deforestation and Forest Degradation

Drivers of deforestation and degradation are diverse. They vary in intensity from place to place and from one region to another. Drivers originate from human habitation and relate to the level of dependence of local populations on forests, the stage of economic development of a country, and whether livelihoods are primitive or modern. If alternative affordable energy, pastures, and wood and wood products are not available or have not been provided by the country's economy or socioeconomic circumstances, people are compelled to extract products from nearby natural ecosystems to satisfy their day-to-day subsistence needs.

a. Deforestation

Deforestation is caused both legally through legal means, and illegally by local populations for agriculture or house construction (this is termed as encroachment).

Key drivers of deforestation include

- Conversion of forest land for agricultural use (legal and illegal);
- Clearance for urbanization;
- Clearance for infrastructure development: roads, railway lines, dams, transmission lines, irrigation canals, water reservoirs, etc.;
- Mining of ores and minerals (coal, lignite, copper, bauxite, iron, zinc, limestone);
- Stone quarries;
- Settlement of displaced persons;
- Government buildings; and
- Industries.

b. Degradation

Forest degradation is a result of numerous and often complex causes. The consequences are reflected in damage to an ecosystem beyond recovery, depleted productive capability, scarcity of forest products, and further advancement of the degradation process. Degradation leads to deforestation. Restoration of ecosystems is not only difficult but also costly and of long duration. There are uncertainties and risks associated with the anticipated success. The attempt can restore productivity of forest land but the integrity of an ecosystem once lost cannot be restored.

10.6.6 Sustainable Management of Forests

REDD+ policy includes the sustainable management of forests (SMF), but there has been no attempt to define what this means or to clarify its implementation and measurement process. As a result, SMF does not involve any direct incentives. It

can be assumed that SMF is key to REDD+ in the sense that if forests are managed sustainably, then there will be no large-scale deforestation and forest degradation, and forest carbon stocks will be conserved and enhanced. Only changes in carbon stocks can be measured and verified for receipt of incentives or results-based payments.

10.6.7 Strategy/Action Plans

REDD+ implementation begins with preparedness, as developing countries were not prepared to undertake REDD+-related activities and measure the results. India is an interesting case of forest policy and governance. It belongs to a selected group of developing countries thet exhebited negative flux of carbon from changes in land used in the period 1950-2000 (Schrope, 2009). A recent study shows that India has strong forest monitoring capabilities across the developing world (Romijn et al., 2012). The study used, among others, indicators for existing monitoring capacities, challenges with respect to forest monitoring under particular national circumstances and technical challenges for the use of remote sensing. The study finds that forty-nine countries have a very large capacity gap, forty-six a large, medium or small capacity gap, and only four countries (Argentina, China, India and Mexico) a very small capacity gap. At the same time the study reports that India has “medium” remote sensing challenges. Thus, a phased approach has been adopted. A country that intends to implement REDD+ begins by identifying drivers of deforestation and forest degradation within its boundaries, and then developing its national REDD+ strategy or action plan. While developing and implementing the strategy or action plan, issues of forest governance, land tenure, and gender must be addressed. Each country must ensure that safeguards are respected when implementiing REDD+. The next phase of implementation is building the capacity of all stakeholders, through the development and transfer of technology and demonstration activities. As discussed above, to receive results-based financing, a country is required to develop and put in place a robust and transparent monitoring system and measure forest reference emission levels (REL) and forest reference levels (RL).

Governance

Governance issues will need to be addressed when implementing REDD+ activities. This will require an assessment of the adequacy of current policies, laws, and organizational structures to successfully achieve the REDD+ objectives, and if new policies and legislation will be required, with necessary restructuring of organizations responsible for forest management.

Land tenure

Many countries have problems with unclear land tenure policies. This discourages investment in forest management, carbon stock enhancement, and conservation due to uncertainty as to who will draw incentives, if any. Indigenous populations have rights over land that they have been using for centuries; common use land may be privatized; or land might be parceled by the state to transfer ownership to individuals or households. Land tenure issues are common in tropical countries. In some

countries, rights had been settled but due to historical injustice, the tenure issue was reopened and new rights were granted. For REDD+ purposes, land ownership must be clear, as the owner will be the party to commit to a long-term agreement to abide by REDD+ policies.

Gender

Women are the primary collectors of wood and non-timber forest products (NTFPs) from forests. In many locations, they tend to grazing livestock. If not thought through carefully, a REDD+ activity may adversely affect their rights, or they may be ignored. Gender needs must be considered when developing and implementing REDD+ activities.

Safeguards

Successive COP decisions have emphasized the environmental and social safeguards are prerequisites when undertaking REDD+-related activities. A country that implements REDD+ is required to develop approaches to minimize

Appendix I

The following safeguards should be promoted and supported

(a) That actions complement or are consistent with the objectives of national forest programs and relevant international conventions and agreements;

(b) Transparent and effective national forest governance structures, taking into account national legislation and sovereignty;

(c) Respect for the knowledge and rights of indigenous peoples and members of local communities, by taking into account relevant international obligations, national circumstances and laws, and noting that the United Nations General Assembly has adopted the United Nations Declaration on the Rights of Indigenous Peoples;

(d) The full and effective participation of relevant stakeholders, in particular indigenous peoples and local communities, in the actions referred to in paragraphs 70 and 72 of this decision;

(e) That actions are consistent with the conservation of natural forests and biological diversity, ensuring that the actions referred to in paragraph 70 of this decision are not used for the conversion of natural forests, but are instead used to incentivize the protection and conservation of natural forests and their ecosystem services, and to enhance other social and environmental benefits;

(f) Actions to address the risks of reversals;

environmental and social risks and enhance positive impacts or benefits.

As shown in the box below, the main obligation of complying with the safeguards is to respect and protect the knowledge and rights of the indigenous and local communities, and take into account relevant national and international law and declarations. Relevant stakeholders should have full and effective participation while REDD+ strategy or action plans are developed and implemented. Actions should be consistent with the conservation of natural forests and biological diversity, with emphasis on and incentives for conserving natural forests and their ecosystem services, and to enhance other social and environmental benefits. Actions should

also be taken to address risks and reversals and to reduce displacement of emissions.

Parties from developing country that undertake REDD+ activities should provide a summary to UNFCCC on how all safeguards are being addressed and respected throughout implementation. These summaries should be provided periodically and included in national communications, consistent with relevant decisions of the COPs on guidelines on national communications from Parties not included in Annex I to the Convention, or communication channels agreed by the COPs. Debate on what details to include in these summaries was still being debated in 2014 at COP 20 (Lima).

10.6.8 Capacity Building

To implement REDD+ activities, a country needs to build the capacity of its relevant institutions to carry out the program work in accordance with agreed-upon COP policies and principles. Any government agency, civil society organization, or community-based organization responsible for the program or project must ensure they have the capacity to implement the activities. It should have adequate human resources with required the skill mix of technology, ecology, forestry, communications, economics, and rural sociology. Managers and staff should be trained in measurement, reporting, and verification (MRV) so they can measure forest-level emissions and carbon stocks. They should be able to develop and implement strategies and action plans with appropriate delegation of authority. Capacity building takes time and is a continuous process.

10.6.9 Measurement, Reporting, and Verification

Forest reference emission levels (RELs) and/or forest reference levels (RLs) are benchmarks for assessing a country's performance in implementing REDD+ activities. According to Indrawan et al. (2012). "REL is the amount of gross emissions from a geographical area estimated within a reference time period, while RL is the amount of net/gross emission and removals from a geographical area estimated within a reference time period." A REL is the level of emission used to demonstrate emission reduction from avoided deforestation and forest degradation, while RL is the level of carbon stocks used to demonstrate emission reduction from conservation, SMF, and enhancement of carbon stock. Both RELs and RLs are expressed in metric tons of CO2 equivalent (tCO2e).

A developing country implementing REDD+ must develop the following elements:

- A national forest reference (sub-national) level as an interim measure, emission level, or forest reference level; and
- A robust and transparent national forest monitoring system for the monitoring and reporting of activities, or if appropriate, at the subnational level.

10.7 The Warsaw COP 19 (2013): Framework for REDD+

At COP 19 in Warsaw, the policy approach for REDD+ was given a concrete shape, which had been evolving since 2007.

According to the UNFCCC in a breakthrough outcome, the framework (or rulebook) for reducing emissions from deforestation and forest degradation was agreed upon, together with measures to bolster forest preservation and a results-based payment system to promote forest protection. Highlights ofbthe Warsaw Framework for REDD+ include:

- Governments agreed on a set of decisions to reduce emissions from deforestation and forest degradation. These decisions were the culmination of seven years of work, and their agreement came as a clear breakthrough for action on climate change.
- Global deforestation accounts for about 20 percent of the world's CO_2 emissions. The set of decisions will bolster forest preservation and sustainable use of forests with direct benefits for people who live in and around forests.
- The package provides a foundation for the transparency and integrity of actions and clarifies the coordination of support.
- It establishes the means for results-based payments if developing countries can demonstrate forest protection. For this purpose, the package is backed by initial pledges of US $280 million.

The following are the seven decisions agreed upon in COP 19: Warsaw (2013), which constitute the Warsaw Framework for REDD+ (the rulebook).

- Set up a work program on **results-based finance** to progress full implementation of REDD+ activities.
- **Coordinate support** for the implementation of activities in relation to mitigation actions in the forest sector by developing countries, including institutional arrangements.
- Develop modalities for n**ational forest monitoring systems**.
- Ensure the timing and the frequency of presentations of the summary of information on how all **safeguards** referred to in decision 1/CP.16, appendix I, are being addressed and respected.
- Develop guidelines and procedures for the **technical assessment of submissions** from Parties on proposed forest reference emission levels and/or forest reference levels.
- Develop modalities for **measurement, reporting, and verification**.
- Address the drivers of deforestation and forest degradation.

10.7.1 Results-Based Finance

COP 19 reaffirmed that results-based adequate and predictable finance, which may come from a variety of sources (public and private, bilateral and multilateral, including alternative sources [market and non-market], should be provided to developing countries for REDD+ implementation.

The results-based progression has to occur for all phases of actions and activities of REDD+ as agreed at COP 16 in Cancun. These results-based actions must be fully measured, reported, and verified. (This will include development and implementation of national strategies or action plans, and capacity building in a phased manner). All REDD+ elements must be in place in a developing country that undertakes results-based actions.

To receive a results-based payment, a country must address safeguards and provide information on how they will accomplish this. The funding entities (including the Green Climate Fund) are to provide adequate and predictable financing for REDD+ activities in a fair and equitable manner, taking into account different policy approaches while expanding the recipient countries. They will also apply agreed methodologies, decided at various sessions of the COP.

An information hub will be established on the UNFCCC's web platform to increase transparency of information on REDD+ activities, results-based actions, corresponding payments, safeguards, periodic results (tCO_2e), FERL and FRL, and national strategies or action plans. A REDD+ forest reference level/reference emission level (FREL/FRL) is a benchmark for assessing a country's performance in implementing REDD+ activities. It is expressed in CO2 equivalents per year, and has a pre-determined timeframe over which it is applied. A REL/RL is either established at the national level or is elaborated at the subnational scale, representing less than the country's entire national territory of forest area, in an interim period. It may reflect one or more of the five REDD+ activities, as long as the activities that are significant, are reflected. The distinction between the terms FRL (Forest Reference Level) and FREL (Forest Reference Emission Level) is not defined under the UNFCCC and not applied consistently in the literature. REL commonly refers to emissions from gross deforestation and forest degradation (REDD) in a given time period while RL refers to net emissions and removals, in the case that the other REDD+ activities (comprising the "+") have also been included in the scope. Results-based finance is subjected to the following condition:

- Financing is for all phases of actions and activities.
- Actions must be fully measured, reported and verified.
- All elements of REDD+ must be in place.
- Safeguard implementation-summary must be periodically reported.
- Entities, financing from a wide variety of sources, collectively channelize assistance, and take into account policy approaches.

- Methodological guidance must be applied.
- All information must be uploaded to the information hub.

10.7.2 Coordination Support

At Durban, COP 18 recognized the need to improve coordination of support for implementation of REDD+ activities and to provide adequate and predictable support, including financial resources, and technical and technological support to developing countries for implementation of those activities. It asked the Subsidiary Body for Scientific and Technological Advice (SBSTA) and the Subsidiary Body for Implementation (SBI), at their 38th sessions, to jointly initiate a process to address the above matters, and to consider existing institutional arrangements or potential governance alternatives including a body, a board or a committee, and to make recommendations on these matters to the COPs at its 19th session.

- COP 19 (Warsaw) recognized the need for adequate and predictable support and effective and transparent coordination of support for the implementation of REDD+ activities and elements. It invited interested Parties to designate a national entity or focal point to serve as a liaison with the UNFCCC secretariat and the relevant bodies under the convention on the coordination of support for the full implementation of REDD+ activities and elements including different policy approaches, such as joint mitigation and adaptation, and to inform the secretariat accordingly.
- The COP noted that the national entities or focal points of developing countries may, in accordance with national circumstances and the principles of sovereignty, nominate their entities to obtain and receive results-based payments, consistent with any specific operational modalities of the financing entities, providing them with support for the full implementation of REDD+ activities.
- Coordination of support for REDD+ implementation is based on the following needs and functions:
  - Strengthen, consolidate, and enhance sharing of relevant information, knowledge, experiences and good practices at the international level, taking into account national experiences, and as appropriate, traditional knowledge and practices;
  - Identify and consider possible needs and gaps in coordination of support, taking into consideration relevant information communicated under the convention and other multilateral and bilateral arrangements.

10.7.3 National monitoring system

Developing country Parties agreed at COP 16 (Cancun) to develop:

- A national (or sub-national) forest reference as an interim measure, emission level, or forest reference level; and

- A robust and transparent national forest monitoring system for the monitoring and reporting of activities or if appropriate at subnational level.

As descrbed above, COP 19 confirmed that the above activities will need adequate and predictable support (finance, technical, technological) to developing country Parties. It was also decided that the Parties developing monitoring and reporting systems for REDD+ activities should take into account the guidance provided in in COP 15 (Copenhagen) as well as latest IPCC guidance and guidelines.

10.7.4 Safeguards

At COP 19 (Warsaw) it was decided that a country implementing REDD+ activities is required to furnish information to UNFCCC on how safeguards are respected. This information must be submitted as part of a national communication. The first information summary will be submitted after start-up of implementation, and then along with the national communication thereafter.

Guidance on safeguard principles that are to be complied with were adopted at Cancun (COP 16) in 2010 and are contained in appendix I to its decision (1/CP.16).

10.7.5 Assessment of RELs and RLs Submitted by a Country Seeking Finance

COP 19 (Warsaw):

- Decided that each submission on REL/RL shall be subject to a technical assessment;
- Recalled that developing countries may, on a voluntary basis and when deemed appropriate, submit a proposed REL and/or RL, and that such proposed RELs and/or RLs might be technically assessed in the context of results-based payments;
- Adopted the guidelines and procedures for the technical assessment of submissions from Parties on RELs and/or RLs contained in the annex. Each submission shall be assessed by two land use/land use change and forestry experts selected from the UNFCCC roster of experts, one from a developed country and one from a developing country. The annex describes the objectives, scope, procedures, and timeframe for such an assessment.

After the first year's assessments, subject to availability of finance, the UNFCCC secretariat would prepare a synthesis report on the technical assessment process, which will be considered by SBSTA. Developing countries and intergovernmental organizations have been asked to nominate experts for UNFCCC's roster of experts. Developing countries have been asked to support capacity building in developing countries in REL/RL development and assessment.

10.7.6 Modalities for Measurement, Reporting, and Verification

National REL and/or RL

COP 19 (Warsaw) confirmed that the above activities should be undertaken with adequate and predictable support (finance, technical, technological) to developing country Parties. Parties developing monitoring and reporting systems for REDD+ activities should consider the guidance provided in COP 15 (Copenhagen) as well as latest IPCC guidance and guidelines. The COP 15 relevant decision has the following guidance:

- Use the most recent IPCC guidance and guidelines, as adopted or encouraged by the COPs, as appropriate, as a basis for estimating anthropogenic forest-related GHGs by sources and removals by sinks, forest carbon stocks, and forest area changes.
- Establish, according to national circumstances and capabilities, robust and transparent national forest monitoring systems, and if appropriate, sub-national systems as part of national monitoring systems that:
  - Use a combination of remote sensing and ground-based forest carbon inventory approaches for estimating, as appropriate, anthropogenic forest-related GHGs by sources and removals by sinks, forest carbon stocks and forest area changes;
  - Provide estimates that are transparent, consistent, accurate (as far as possible), and that reduce uncertainties, taking into account national capabilities and capacities; and
  - Are transparent and their results are available and suitable for review as agreed by the COPs.

10.7.7 Drivers of Deforestation and Forest Degradation

The Warsaw framework for REDD+ recognizes that deforestation and forest degradation are complex problems with multiple drivers and different national situations, and addressing these may affect livelihoods, thus having an economic cost and implications for countries" internal resources. The framework, however, reiterated the importance of addressing the said drivers in the context of development and implementation of national strategies and action plans. It also appreciated that that actions to address the drivers are unique to countries" national circumstances (conditions), capacities, and capabilities. The COP urged all countries, organizations, the private sector, and other stakeholders to take action to reduce the drivers and continue their work to address said drivers and share their experiences via the UNFCCC web platform. Developing countries should take note of the ongoing and existing work on addressing the drivers undertaken by other various developing countries.

10.8 References and Further Reading

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LECTURE 11: ADAPTING TO CLIMATE CHANGE IN FOREST MANAGEMENT

This lecture covers the following:

- Observed changes in climate in India
- Projected changes in climate in India
- Impacts to forest ecosystems
- Adaptive responses in forest management
- Adaptations and responses to climate change

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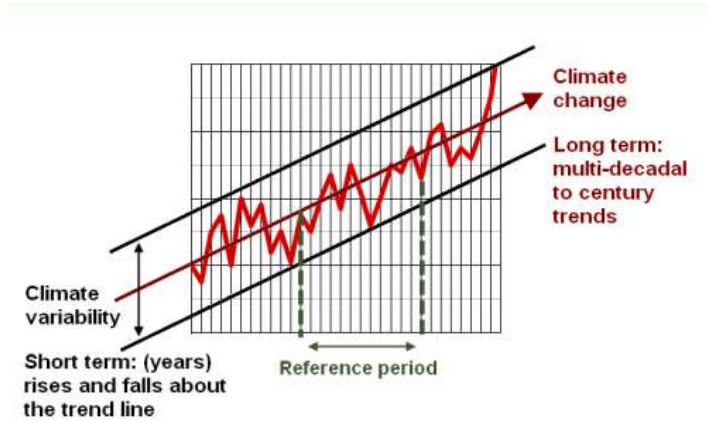
11.1 Observed Changes in Climate in India

11.1.1 Distinguishing Climate Variability and Climate Change

It is important to understand the difference between climate variability and climate change. Variations in climate often result in the same kinds of impacts and response measures as climate change, but climate change is more persistent and changes the envelope in which variability occurs as well as the variability itself.

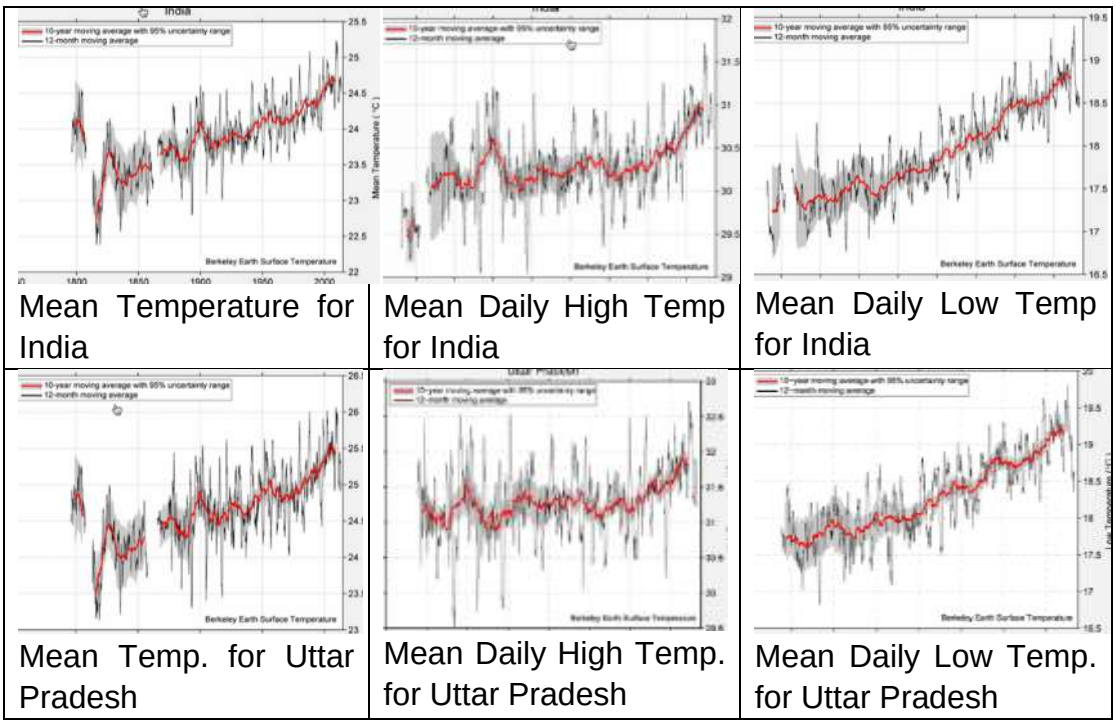
FIGURE 11.1: TITLE CLIMATE CHANGE & VARIABILITY CONCEPT



Source:www.cccns.ec.gc.ca/?page=seen-intro

Temperature trends are well-documented for India, and conform well to modeled and projected changes as shown in Figure 11.2 below.

FIGURE 11.2: OBSERVED TEMPERATURE TRENDS FOR INDIA AND UTTAR PRADESH



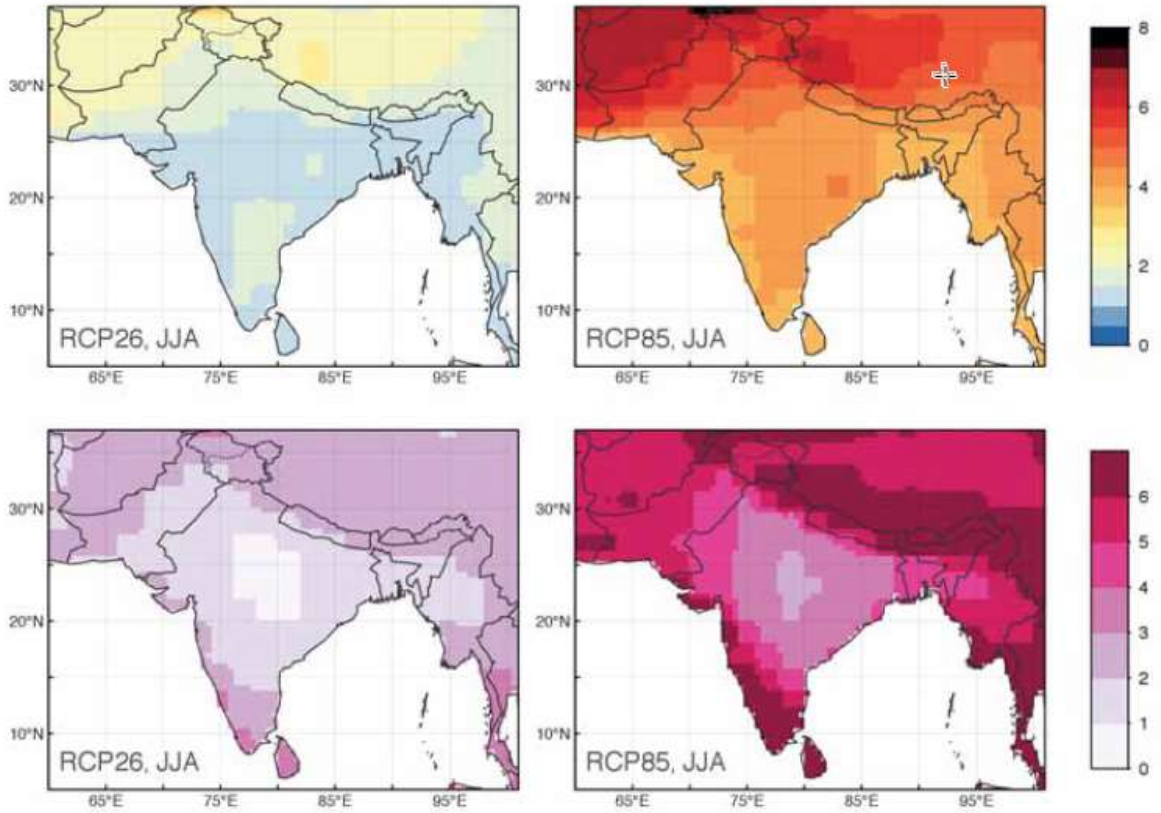
Note: *Spend some time to ensure you understand what these data show, and discuss what this means.* (Source: Berkeley Earth Surface Temperature Project. Based on all credible temperature station records.)

The observational data indicate that global atmospheric warming is also strongly expressed in India. Mean temperatures, as well as daily high and low temperatures are increasing rapidly in recent decades. Extremes of heat are increasing, and minimum temperatures are increasing as well, with important implications for rapid changes in ecosystem composition and, longer term, the persistence of species.

11.2 Projected Changes in Climate in India

Existing predictions of the effects of climate change differ widely, and predictions made at a regional scale do not apply to all. Climate change science is advancing rapidly, but uncertainty is expected to persist well into the future.

FIGURE 11.3: MULTI-MODEL MEAN TEMPERATURE ANOMALY FOR RCP2.6 (LEFT) AND RCP8.5 (RIGHT) FOR THE MONTHS OF JUNE, JULY, AND AUGUST (JJA) FOR SOUTH ASIA



Note: Temperature anomalies in degrees Celsius (top row) are averaged over the time period from 2071-2099 relative to 1951-1980, and normalized by the local standard deviation (bottom row) Source: Schellnhuber et al.*, 2013*

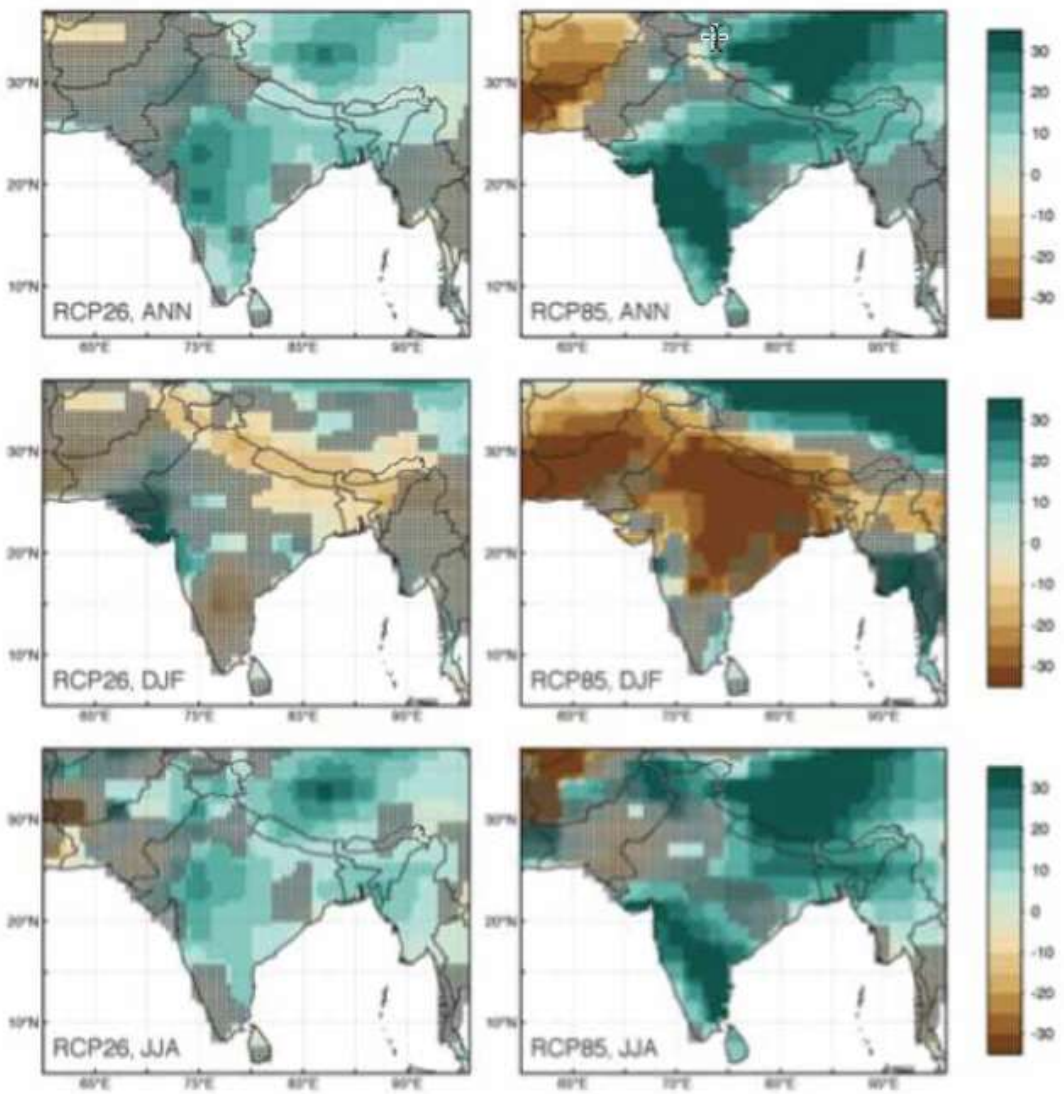
Representative Concentration Pathways (RCPs) are four greenhouse gas concentration (not emissions) trajectories adopted by the IPCC for its fifth Assessment Report (AR5) in 2014. It supersedes Special Report on Emissions Scenarios (SRES) projections published in 2000.

The pathways are used for climate modeling and research. They describe four possible climate futures, all of which are considered possible depending on how much greenhouse gases are emitted in the years to come. The four RCPs, RCP2.6,

RCP4.5, RCP6, and RCP8.5, are named after a possible range of radiative forcing values in the year 2100 relative to pre-industrial values (+2.6, +4.5, +6.0, and +8.5W/m^2 respectively).

Precipitation projections are far less reliable than temperature projections. All models and atmospheric physics all point to increased variation in precipitation, but the degree of change cannot be quantified at present.

FIGURE 11.4: MULTI-MODEL MEAN OF THE PERCENTAGE CHANGE IN ANNUAL (ANN--TOP), DRY-SEASON (DECEMBER, JANUARY, FEBRUARY [DJF]--MIDDLE), AND WET-SEASON (JUNE, JULY, AUGUST [JJA]--BOTTOM) PRECIPITATION FOR RCP2.6 (LEFT) AND RCP8.5 (RIGHT) FOR SOUTH ASIA BY 2071-2099 RELATIVE TO 1951-1980



Hatched areas indicate uncertainty regions, with 2 out of 5 models disagreeing on the direction of change compared to the remaining 3 models.

Source: Schellnhuber et al. *2013*

To accommodate variation and uncertainty, scenario-based planning is a key tool for assessing plausible outcomes and related options. Scenario-based planning considers a range of potential ecological trajectories, and assesses the benefits and

risks associated with an action or set of actions. It can be used in the design of contingency plans for unknown events or impacts. Such analyses may be used to provide decision-makers with relevant information about specific impacts at a variety of spatial scales.

11.3 Impacts to Forest Ecosystems

Forests are sensitive to climate change in many ways. The following are some of the most important forest attributes that are sensitive to changes in climate.

- Water flows–quantity, quality, and timing;
- Soil moisture;
- Soil erosion;
- Tolerance to drought, inundation, and salinity;
- Insect tolerance;
- Vulnerability to wildfire;
- Tolerance to invasive species;
- Critical habitats;
- Disturbance regime; and
- Species composition.

We can divide impacts to forest ecosystems into two categories: species-to-landscape-level impacts, and community-to-landscape-level impacts. Both of these are dicsussed further below.

11.4 Species-to-Landscape-Level Impacts

11.4.1 Physiology and Phenology

Climate change impacts on species physiology and phenology are already being observed in many places. Question for students: How are these changing in the forests in your area?

11.4.2 Range and Distribution of Species

Some impacts will be manifest at multiple scales. Greater tolerance of deciduous forest species to drought stress is projected to favor drought-tolerant deciduous species as well as savannas instead of tropical broadleaf evergreen forests. India has many forest species. Each will have a tolerance/sensitivity to changes in range and distribution. These changes are difficult to predict, even when projecting what the future climates will be, which is not an exact science. Vegetation modeling can be helpful to make educated guesses, but is not expected to accurately predict changes. Most changes in species composition will be the result of water availability. Temperature alone does not tend to extirpate species, but has a strong effect on water relations of all plants.

11.5 Community-to-Landscape-Level Impacts

11.5.1 Disturbance Regimes

The frequency, duration, and severity of disturbances to forests are changing and are expected to change further in coming decades. The most important disturbance regimes are wildfires, drought, and flooding. Each of these disturbances shapes the current forest ecosystems. As these disturbances change with a rapidly warming climate, the forest ecosystems will change too. For example, severe, repeated droughts associated with climate change can cause large-scale die-offs of canopy trees, which may be replaced with differing species composition.

11.5.2 Combined and Cumulative Impacts, and Feedbacks

Climate changes influence water, wind, soils, vegetation, and disturbance regimes. These changes, in turn, influence one another. A change in one factor results in a cascade of responses that in some cases counteract and in others magnify the initial change. These kinds of interactions make prediction of the likely effects of climate change difficult even if the nature of the climate change is known. Ordinarily we rely on the past for evidence needed to predict the future, but when the change is unprecedented, we must use our basic understanding of physical, ecological, and sociological processes and their interactions. At this point it is certain that changes will occur, but the mode, timing, spatial distribution or magnitude of changes or environmental responses is not yet known.

However, we can begin to identify the nature of changes that different types and magnitudes of climatic change are likely to cause. For example, we know that impacts to watershed processes are influenced by events following the activity. Erosion rates are particularly high if a major storm or wildfire occurs soon after logging. Climate change affects the frequency and magnitude of storms and wildfires, so the “typical” patterns of response—those based on land-use plans and practices—are likely to change in the future. If the changing conditions are identified early enough, land-use plans and practices can be adjusted to take the new conditions into account. In any case, we face increased uncertainty concerning the environmental outcomes of our activities. Maintaining and restoring intact and functioning ecosystems are the best hedge against these uncertainties.

11.6 Adaptive Responses in Forest Management

It is important to distinguish adaptation from mitigation in considering climate change. The Intergovernmental Panel on Climate Change (IPCC) defines adaptation as:

> *Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. (IPCC, 2007)*

However, while mitigation (reducing greenhouse gas [GHG] emissions) is distinct from adaptation, these should always be considered together in forest planning. Many overlaps occur, particularly in the identification, vulnerability assessment, and

planning for reserves, protected areas, and species refugia. Forest reserves sequester carbon. Although this is at the heart of mitigation efforts, this sequestration can also be among the most important adaptive responses. All forest operations can be monitored and adjusted to reduce emissions, including wherever adaptive work is done.

11.6.1 Adaptation is Complex and Must be Made Locally Applicable and Context Specific

Devising adaptation strategies for forests is complex because forest management itself is complex and context-dependent. Some of the factors complicating forest management include:

- Many forest types;
- Complex, interconnected, dynamic systems;
- Limited information and understanding (especially in the highly biodiverse tropical and subtropical ecosystems);
- Multiple, often competing goals;
- Multiple jurisdictions; and
- Multiple stressors with which climate factors interact.

The best option for a particular problem is context dependent and will vary among different locations. The best option should be based on a sound understanding of all components of the ecosystem, a current vulnerability assessment of ecosystem components and functions, and setting of priorities for those actions that are most likely to be successful and effective.

11.7 Adaptations and Responses to Climate Change

Many adaptation options exist, but their effectiveness varies over short-, medium-, and long-term time frames. Building resistance and resilience may succeed only over the short- to medium-term especially if the necessary mitigation targets (i.e., emission reductions) are not achieved. This slide suggests three general adaptation approaches/strategies and classifies them according to their temporal effectiveness as shown in Table 11.1.

TABLE 11.1: ADAPTATION APPROACHES AND STRATEGIES IN RELATION TO PURPOSE AND TIME SCALE

General Approach	Purpose	Time Scale
Increase Resistance	Improve forest defenses against effects of change. Forestall undesired effects of change (for example, wildfire, insects, disease)	Short-term
Increase Resilience	Improve the capacity of ecosystems to return to prior conditions after disturbance.	Medium-term
Enable Forests to Respond to Change	Accommodate rather than resist change. Facilitate non-catastrophic change where resilience thresholds are likely to be exceeded.	Longer-term

A menu of adaptation strategies applicable to forest ecosystems. (Swanston et al. 2016)

FIGURE 11.5: MENU OF ADAPTATION STRATEGIES AND APPROACHES

Menu of Adaptation Strategies and Approaches

Strategy 1: Sustain fundamental ecological functions.

1.1. Reduce impacts to soils and nutrient cycling.
1.2. Maintain or restore hydrology.
1.3. Maintain or restore riparian areas.
1.4. Reduce competition for moisture, nutrients, and light.
1.5. Restore or maintain fire in fire-adapted ecosystems.

Strategy 2: Reduce the impact of biological stressors.

2.1. Maintain or improve the ability of forests to resist pests and pathogens.
2.2. Prevent the introduction and establishment of invasive plant species and remove existing invasive species.
2.3. Manage herbivory to promote regeneration of desired species.

Strategy 3: Reduce the risk and long-term impacts of severe disturbances.

3.1. Alter forest structure or composition to reduce risk or severity of wildfire.
3.2. Establish fuelbreaks to slow the spread of catastrophic fire.
3.3. Alter forest structure to reduce severity or extent of wind and ice damage.
3.4. Promptly revegetate sites after disturbance.

Strategy 4: Maintain or create refugia.

4.1. Prioritize and maintain unique sites.
4.2. Prioritize and maintain sensitive or at-risk species or communities.
4.3. Establish artificial reserves for at-risk and displaced species.

Strategy 5: Maintain and enhance species and structural diversity.

5.1. Promote diverse age classes.
5.2. Maintain and restore diversity of native species.
5.3. Retain biological legacies.
5.4. Establish reserves to maintain ecosystem diversity.

Strategy 6: Increase ecosystem redundancy across the landscape.

6.1. Manage habitats over a range of sites and conditions.
6.2. Expand the boundaries of reserves to increase diversity.

Strategy 7: Promote landscape connectivity.

7.1. Reduce landscape fragmentation.
7.2. Maintain and create habitat corridors through reforestation or restoration.

Strategy 8: Maintain and enhance genetic diversity.

8.1. Use seeds, germplasm, and other genetic material from across a greater geographic range.
8.2. Favor existing genotypes that are better adapted to future conditions.

Strategy 9: Facilitate community adjustments through species transitions.

9.1. Favor or restore native species that are expected to be adapted to future conditions.
9.2. Establish or encourage new mixes of native species.
9.3. Guide changes in species composition at early stages of stand development.
9.4. Protect future-adapted seedlings and saplings.
9.5. Disfavor species that are distinctly maladapted.
9.6. Manage for species and genotypes with wide moisture and temperature tolerances.
9.7. Introduce species that are expected to be adapted to future conditions.
9.8. Move at-risk species to locations that are expected to provide habitat.

Strategy 10: Realign ecosystems after disturbance.

10.1. Promptly revegetate sites after disturbance.
10.2. Allow for areas of natural regeneration to test for future-adapted species.
10.3. Realign significantly disrupted ecosystems to meet expected future conditions.

11.7.1 Adaptation must be Context-Specific and Fit the System

Adaptation options differ by ecosystem, landscape, and the socioeconomic environment in which landscapes are embedded. No single approach will work in all ecosystems, and no single approach will work repeatedly over time in a changing climate. Rather, forest managers will need a portfolio of options, or a toolkit, from which a variety of tools and experiences can be used to match the current needs.

11.7.2 Building Resistance is usually a Short-term Strategy

Building resistance intends to:

- Improve forest defenses against direct or indirect effects of rapid environmental changes.
- Prevent or limit the likelihood of anticipated events and undesired effects of change (e.g., fires, insects, and diseases).
- Avoid irreversible impacts.
- Anticipate changes to invasive species and respond to them. Climate changes may catalyze conversion of native insects or disease species into invasive species in a new environment.

Factors to consider with resistance include:

- Most resistance options are best applied in the short-term and to forests of high value and, ideally, low sensitivity to climate.
- The combination of resistance and resilience is often called “resilience” in the common usage and in some of the literature on climate change.
- Building resilience is a short- to medium-term strategy.
- Resilience options are best applied to forest of ecosystem services values, and low sensitivity to climate changes.
- As changes in climate accumulate over time, resilience can become more difficult.
- Returning to previous states may not be possible, as the climatic context is changing. However, we can anticipate new climatic conditions and realign systems to adjust to them. This is another form of resilience (by looking forward, not back).

Examples of increasing resistance and resilience include:

- Maintain biological diversity--experiment with species and genotype mixes. Increase forest structural diversity.
- Conserve soils--soils are the heart of the ecosystem and fundamental to resilience (see soil section of this resource material).
- Use prescribed fires where appropriate to reduce fuel loading and restore disturbances that shape ecosystems.
- Repair degraded meadows.
- Remove or relocate high-impact roads.
- Restore floodplain connectivity.
- Stock seed banks and consider new species and mixes.

- Reforest degraded areas.
- Enhance fitness of rare species.
- Build redundancy and genetic diversity.
- Promote community forestry.
- Implement early detection and rapid response--monitor post-fire conditions, and eliminate or control exotic species early on.
- Promote landscape connectivity.
- Create larger management unit sizes.
- Lower fragmentation.
- Consider all-lands, landscape scale.
- Create continuous riparian zones.
- Have greater decision flexibility.
- Maintain and improve the resilience of watersheds and aquatic ecosystems by implementing practices that protect, maintain, and restore watershed processes and services.
- Develop regulations and policies that take climate change into account--raise awareness with stakeholders, and work with local stakeholders from the onset of projects.

Enabling forests to respond to climate change is a more generalized set of measures and involves a wide range of options, detailed in the following table.

TABLE 11.2: ENABLING FORESTS TO RESPOND TO CLIMATE CHANGE

Adaptation	Explanation/Example
Reduce anthropogenic stressors	Prevent human-introduced invasive plants and animals; reduce pollution; manage fuels and wildfire
Restore ecosystems	Restore “natural” hydrological regimes; use climate-resilient natives post-disturbance
Protect climate refugia	Identify and protect refugia for at-risk species
Manage for key ecosystem features	Facilitate dispersal by reducing fragmentation and maintaining landscape connectivity
Increase representation	Increase genetic and habitat diversity
Increase replication	Protect replicate populations; build redundancy and surpluses to assist post-disturbance recovery
Relocation	Assist species migrations
Conserve the stage	Identify areas based on geophysical traits that can support biodiversity in the future
Realign goals	Adjust goals when systems are beyond the range of natural variability

Reducing anthropogenic stressors is a key resistance-building action. Most existing adverse effects are due to human activity, and all future climatic impacts are amplified by impacting activities.

An example of managing for key ecosystem features is reducing fragmentation and maintaining habitat and landscape connectivity for all future plausible climate scenarios.

Building representation and replication refers to the benefits of maintaining or restoring multiple examples of key habitats, ecosystems, and landscapes. Forest reserves and protected areas should be reviewed to assess the degree to which they are representative and adequate for species persistence against climatic and other changes.

Examples of building surpluses so systems can rebound after disturbance include:

- Increase buffers and effective population sizes.
- Intensively reforest to maintain habitat types.
- Redundant planting across a range of environments—introducing species beyond the “preferable habitat” environment. Monitor and analyze the survival and the performance. Horticultural plantings of native species in landscaping, gardens, roadsides or parks gives clues on how species respond in different locations as climate change.
- Designate and protect riparian buffer zones to create small-scale but continuous and networked ecosystems that are diverse, productive, resilient and do not transmit damage downstream.
- Assist migration for species and populations blocked by fragmentation or insufficient time.
- Carefully select species that are considered most vulnerable to extirpation by drought and wildfire (and other effects). Collect seed or otherwise propagate and introduce to areas where they would normally migrate to adapt, but may be blocked.
- Establish “neo-native” forests--areas that supported the species in the past and similar climate conditions to the projected climatic conditions. These areas can be outside the current species range, in locations where the species would otherwise be considered exotic.
- Promote connected landscapes--restore and enhance the capacity for animals and plants to move in response to climate change. Assess and plan at large scales to maximize habitat connectivity.
- Anticipate extreme weather events.
- Establish and experiment with refugia.

Establishing refugia refers to identifying specific habitats within landscapes that may be buffered (at least in the short term) from climate change impacts. A sound approach at the planning level is to identify environments that are valuable for species persistence and are more buffered against climate change and short-term

disturbances than others. This strategy may be most important for particularly sensitive wildlife species, which would rapidly lose habitat as the climate changes.

Restoration is an essential and long-term strategy and the following should be considered in its application:

- Use for systems that no longer provide their potential function of ecosystem services. For example, where wet mountain meadows are degraded and dried out, restore groundwater levels though gully control and establishing suited vegetation cover.
- For systems that are far outside the natural range of variability. Apply treatments to move back to climatic conditions expected in coming decades (warmer, more variable rainfall). These conditions may be different than the past, so we are sometimes “realigning” the systems to a more suitable state, rather than strictly “restoring” prior conditions. It is important to think through the goals of any restoration program, keeping rapid warming and increased climatic variability in mind.
- Anticipate and plan for extreme events.

The following factors need to be considered when integrating climate in the planning processes:

- Evaluate projected climate and ecological changes in the context of potential adaptations.
- Address climate change during working forest management plan revisions in terms of “need for change” from current direction. Then the planning unit will continue contributing to social, economic, and ecological sustainability over the long term.
- Use scenarios to frame and plan for multiple plausible futures. This solves the uncertain future issue. There are multiple futures to frame, assess, and plan for.
- Assess vulnerabilities and set priorities based on overall values and vulnerabilities.
- Assess cumulative and irreversible effects and uncertainties.
- Plan adaptation options at province, district, and landscape scales, as well as localized, context-specific design, informed by larger-scale assessment and planning.

Employ adaptive management with the following considerations:

- Adaptation in practice refers to how practitioners are applying knowledge, skills, tools, and experience to generate adaptation strategies. Treat management activities as hypotheses.
- Success is enabled by sufficient ecological resilience and willingness to experiment.

- Monitor. Only use monitoring systems that can inform adaptation. Adjust management as indicated by results.

11.8 References and Additional Reading

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MODULE 5: FIVE APPROACHES TO IMPLEMENTING EAFM IN INDIA'S FOREST

To manage natural resources as an ecosystem requires managers to collect data and to plan differently. To enable this, this module presents five chapters on practical tools and methods useful for implementation of EAFM in India. Beginning with approaches to data collection, there is a chapter on EAFM in Working Plans for forests managed by Forest Department staff in the Working Plan and Territorial divisions, and a chapter on designing corridors for wildlife, targeted for the Wildlife Management Division of Forest Departments. The Module concludes with targets and silvicultural approaches for management designed to maintain continuous forest cover, and to restoration of forests to a more productive state or to a reference state.

LECTURE 12: COLLECTING, ORGANIZING, ANALYZING, AND REPORTING FOREST DATA USING MODERN TOOLS AND APPROACHES FOR ADAPTIVE MANAGEMENT CONNECTIVITY

This lecture covers the following:

- Ecosystem approach to forest management (EAFM); adaptive forest management, information needs, and overview of remote sensing (RS); geographic information systems (GIS); and global positioning systems (GPS)
- Forest cover monitoring, forest fire monitoring, and control
- Application of geospatial tools for forest resource inventory stratification

12.1 Ecosystem Approach to Forest Management

The concept of an ecosystem approach to forest management (EAFM) has emerged in the last two to three decades. This came about with the gradual realization that forest management on the principles of sustained yield, which had been practiced the world over since scientific forestry was adapted in the last several centuries, may not be the appropriate approach in facing the current challenges such as loss of biodiversity, degradation of ecosystems, climate change, and marginalization of indigenous tribal people and villagers dependent on forests. The approach was emphasized in the recommendations of Subsidiary Body on Scientific, Technical, and Technological Advice (SBSTTA) of the Convention on Biological Diversity (CBD) in 2003; and in detailed guidelines on the approach and adaptive forest management that have been issued. India is a signatory to CBD, and therefore in principle agrees to adaptive forest management. Apart from the CBD, EAFM should be seen as a holistic concept of natural resource management (NRM) which is beneficial in every situation and offers a powerful strategy for the integrated management of land, water, and living resources that promotes conservation and sustainable use in an equitable way.

CBD principles of the ecosystem approach:

- Principle 1: The objectives of management of land, water, and living resources are a matter of societal choice.
- Principle 2: Management should be decentralized to the lowest appropriate level.
- Principle 3: Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.
- Principle 4: Recognizing potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context. Any such ecosystem management program should (a) reduce those market distortions that adversely affect biological diversity, (b) align incentives to promote biodiversity conservation and sustainable use, and (c) internalize costs and benefits in the given ecosystem to the extent feasible.
- Principle 5: Conservation of ecosystem structure and functioning, to maintain ecosystem services, should be a priority target of the ecosystem approach.
- Principle 6: Ecosystems must be managed within the limits of their functioning.
- Principle 7: The ecosystem approach should be undertaken at the appropriate spatial and temporal scales.
- Principle 8: Recognizing the varying temporal scales and lag effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term.
- Principle 9: Management must recognize that change is inevitable.

- Principle 10: The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity.
- Principle 11: The ecosystem approach should consider all forms of relevant information, including scientific, indigenous, and local knowledge, innovations, and practices.
- Principle 12: The ecosystem approach should involve all relevant sectors of society and scientific disciplines.

The above principles provide guidance for formulating right policies; an implementation framework; and the need and role of institutions, methodologies, and monitoring. The ecosystem approach is based on applying appropriate scientific methodologies focused on levels of biological organization that encompass essential structure, processes, functions, and interactions among organisms and their environment. It recognizes that humans, with their cultural diversity, are an integral component of many ecosystems.

12.2 Adaptive Management of Forests

Implementation of EAFM requires adaptive management. Ecosystem processes are complex and dynamic and their understanding is often limited. Outcomes of management interventions in ecosystems are generally non-linear, and there is always a time lag between intervention and the outcome. There are also uncertainties in the cause and effect of the management interventions, as they not only deal with the biophysical constituents of the ecosystems but also with the humans and their socio-economic-cultural lives. Adaptive management, which is basically “learning by doing,” is therefore the most suitable working strategy to deal with the complexities of ecosystems. Significance of scientific data, research feedback, and monitoring is implied in the adaptive management.

Adaptive management is a formal process for continually improving management practices by learning from their outcomes. Management policies are deliberately designed to increase understanding about the effect of management activities on the system being managed. Increased understanding about how the system responds can lead to more effective and efficient management, and can allow managers to accommodate changes in social values and goals. Learning is most rapid when management activities are designed as controlled, replicated experiments that test alternative hypotheses about the response of the system to management activities (Taylor, Kremsater, Ellis, 1997).

However, where experiments in terms of hypothesis testing are impossible or impractical, information can still be gained from careful analysis of existing data to select the “best” alternative, followed by careful monitoring of the outcomes of implementing it. For learning to occur, actual outcomes must be compared with objectives and to predicted outcomes. Feedback loops for using information to modify management must be built into the plan from the outset. Outcomes that are unexpected or that differ from predictions then become opportunities to learn and improve rather than management “failures.”

Adaptive management involves:

- Explicitly recognizing that there is uncertainty about the outcome of management activities;
- Deliberately designing management policies or plans to increase understanding about the system, and reveal the best way of meeting objectives;
- Carefully implementing the policy or plan;
- Monitoring key response indicators;
- Analyzing the outcomes, considering the objectives and predictions; and
- Incorporating results into future decisions.

12.3 Adaptive Management of Forests in the Indian Context

Forest management in India has to deal with several challenges apart from the biophysical aspects and technical parameters of sustainable forest management (SFM) and ecosystem functions. Some of these challenges are enlisted below:

- Excessive dependence of people on forests;
- Unrecorded removal of fuelwood, timber, and non-timber forest products (NTFPs) from forests;
- Grazing;
- Encroachment;
- Low investment in the forestry sector;
- Low investment in forestry research;
- Shortage of manpower; and
- Low technical capability of field officials.

Forests have been managed under working plans since the advent of scientific forestry in the country more than 150 years ago, but over the years because of the above reasons, the science and technical inputs in managing forests could not be given due importance.

Under the orders of the Supreme Court of India and government notifications, forests must be managed under the approved working plans. Adaptive management of forests as compared with the working plans is not similar. Adaptive management is a dynamic concept, whereas the working plan, which is prepared for 10 to 15 years into the future, is not as dynamic. There is a provision for mid-term review of the working plan, but that too may occur after five years or so. The feedback of outcomes of the management practices and scientific observations are generally used when the working plan is rewritten after 10 to 15 years. In the working plan-based management of forests, the officer responsible for management is not actively

involved in scientific observations, research feedback, or monitoring of ecosystem functions.

In the Indian context, because of the reasons mentioned above, elements of adaptive management should be used with the working plan-based management of forests to strengthen the ecosystems and sustainability of the natural resources. In the long run, the working plan-based management of forests should also be modified to include elements of adaptive management of forests. This modification will require appropriate revision of National Working Plan Code (WPC).

12.4 Information Needs for Adaptive Management of Forests

Table 12.1 lists the parameters and scientific observations essential for adaptive management of forests.

TABLE 12.1: DATA AND INFORMATION NEEDS

SN	Data/Information	Periodicity	Remarks Methodology, Tools and Techniques
1	Delineation of ecosystems as management units	Once	Based on set of parameters and criteria, delineating functioning ecological units on any scale GIS, RS, Digital terrain model (DTM), habitats of species, watershed models
2	Monitoring of forest cover in different canopy density classes	Annual or biannial	1:12,500 or 1:25,000 scale Open forest (0.1 to 0.4), Moderately Dense Forest (0.4 to 0.7) and Dense Forest (>0.7) Using high resolution satellite data IRS P6 LISSIV, Google Earth
3	Forest types	10 years	Champion and Seth Classification or other scientifically developed regional classification Satellite image along with relevant spatial layers e.g., DTM, soil, rainfall, temperature, intensive ground truth
4	Land use and land cover (LULC)	5 years	Including forest, scrub agriculture, settlements, water bodies, culturable waste land, non-culturable waste land, vacant land High resolution remote sensing data, intensive ground truth, on-screen delineation
5	Forest Inventory - Growing stock of trees - Growing Stock (GS) of bamboo - Biomass in different pools - Floral biodiversity including herbs shrubs, climbers	5 years	Stratification using forest cover, forest types etc. in GIS Transect survey, laying out sample plots, enumeration, and measurements on sample plots
6	Regeneration of important tree and other important floral species	2 years	Stratification Survey on sample plots or along transect lines
7	Forest carbon - Above ground - Below ground - Soil Organic Carbon (SOC)	5 years or as per the schedule of forest carbon projects (if any)	may be clubbed with forest inventory Using forest type specific Biomass Expansion Factors (BEFs)
8	Socioeconomic profile of the villages within and on the	5 years	Questionnaire based socioeconomic survey

SN	Data/Information	Periodicity	Remarks Methodology, Tools and Techniques
	fringes of forests Dependence on forests NRM-based livelihood and income		Participatory rural assessment (PRA)
9	Forest fire monitoring, control and damage assessment	Detection - daily Fire-damaged area mapping—2 years	RS based near real time detection (using Forest Survey of India [FSI] or National Remote Sensing Center [NRSC] forest fire monitoring data on daily basis) Risk zonation and identifying fire-sensitive forest areas FSI's website gives detected forest fires in the entire country in the last 10 years. This data can be used in identifying fire sensitive forest areas RS, GIS, and ground survey
10	Disturbances (natural/anthropogenic) - Unauthorized removal of trees and firewood - Encroachment - Excessive collection of NTFPs - Grazing - Pests/diseases - Invasive species	2 years	Forest encroachment mapping by high resolution satellite data and ground truthing Forest cover monitoring using RS Ground survey with stratification
11	Water monitoring Flow Quality	Quarterly	Sites for flow monitoring may be identified Portable instruments Field measurement
12	Soil monitoring - Humus content - N, P, K - Texture and other physical properties	2 years	Soil map prepared by National Bureau of Soil Survey and Land Use Planning (NBSSLUP), Nagpur Stratification
13	Weather data	Daily	Automated Weather Stations (AWS) may be installed at suitable locations
14	Sustainable yield monitoring - Harvesting of timber - Harvesting of NTFP - Fuelwood	Annual	Field data, control forms
15	Afforestation activity - Nurseries - Afforestation	Annual	GPS Locations/boundary Field data, nursery and plantation journals

A closer look on the table above reveals that capacity building of Forest Departments in the following areas is necessary, to meet the data and information needs for adaptive management of forests:

- Remote sensing and GIS applications,
- Stratification and sampling-based data collection, and
- Socioeconomic survey.

Other information needs can be met by designing simple forms and gathering the information in the desired frequency in the course of routine management. Use of information and communication technology (ICT)-based management information

systems (MIS) can make the database organized, easy to access, and efficient. For soil and water testing, laboratory services of nearby institutions can be utilized. Easy-to-use, simple instruments can also be procured in the departments for soil testing and water quality monitoring. AWS have become affordable recently; a network of such weather stations can be created in Forest Departments with identified locations (approximate frequency of one AWS per 100 square miles) for applications such as forest fire alerts, afforestation activities, and ecological observations. Time-series weather data over a period of time would also be useful in climate change-related uses such as impact studies, modeling of vulnerable areas, etc.

12.5 Spatial Database

Geospatial tools such as RS, GIS, and GPS have a wide range of applications in forest management like forest cover mapping in different canopy density classes, change detection (degradation as well as improvement), forest fire detection, fire-damaged area mapping, growing stock, biomass and carbon assessment, afforestation planning, wildlife habitat suitability mapping, boundary demarcation, working plan preparation, encroachment mapping, and so on. For many of these applications, there are no practical alternatives to these tools and techniques. RS-GIS based methods are effective for an exercise like working plan preparation, which involves forest resource assessment and analysis of several spatial layers for arriving at management prescriptions. The techniques and methods based on **geospatial tools add to the precision, objectivity, and scientific analysis into the process and lead to significant saving of cost and time.**

A spatial database on forest in GIS is a set of geo-referenced layers of spatial data on different themes for a management or administrative unit. In each spatial layer, attribute data that may be text or figures is attached with every feature appearing as point, line, or polygon (e.g., a forest patch, compartment, village, plantation, etc.). A spatial database with all relevant data attached to its features in the spatial layers (maps) is useful in analyzing management alternatives, creating scenarios, and building queries. Indicative layers for spatial database of a forest division are given in Table 1. Many of these layers need not be created by the department; these can be procured from concerned agencies. Starting with a few essential layers, the spatial database can be expanded and enriched over a period of time. Such a spatial database of a Forest Departmenet is not only of immense use in preparing management plans, but also of significant value for day-to-day forest management decisions.

12.6 Possible Applications

Applications of remote sensing, GIS, and GPS in forest management can be grouped in the following categories:

Synoptic Overview and Visual Analysis

- Expanse
- Distribution

- Compactness and fragmentation
- Quick idea of quality
- Other features like rivers, hills, roads, canals, etc.
- Nearby habitations

Quick Measurements

- Area, perimeter, and distances
- Bearing
- Altitude
- Slope
- Aspect
- Surface area

Resource Mapping

- Forest cover
- Forest type
- Stock map

Zonation

- Forest fire risk
- Biotic interference
- Habitat suitability of wildlife

Change Analysis

- Point out areas of degradation
- Encroachments
- Illegal felling of trees
- Impact of afforestation
- Fire-damaged areas
- Improvement in canopy density
- Impact of Joint Forest Management (JFM)
- Submergence due to dam
- Damage due to natural disasters like cyclones, floods, tsunami, etc.

Stratification

- Inventory
- Census
- Regeneration status

Decision Support

- Day-to-day forest management/administration
- Possible afforestation sites
- Possible JFM areas
- Verification of claims under Forest Rights Act (FRA)
- Watershed identification

Boundary Demarcation

- Using Differential Global Positioning System (DGPS) and high resolution imageries
- Geo-referencing of cadastral maps

Map production

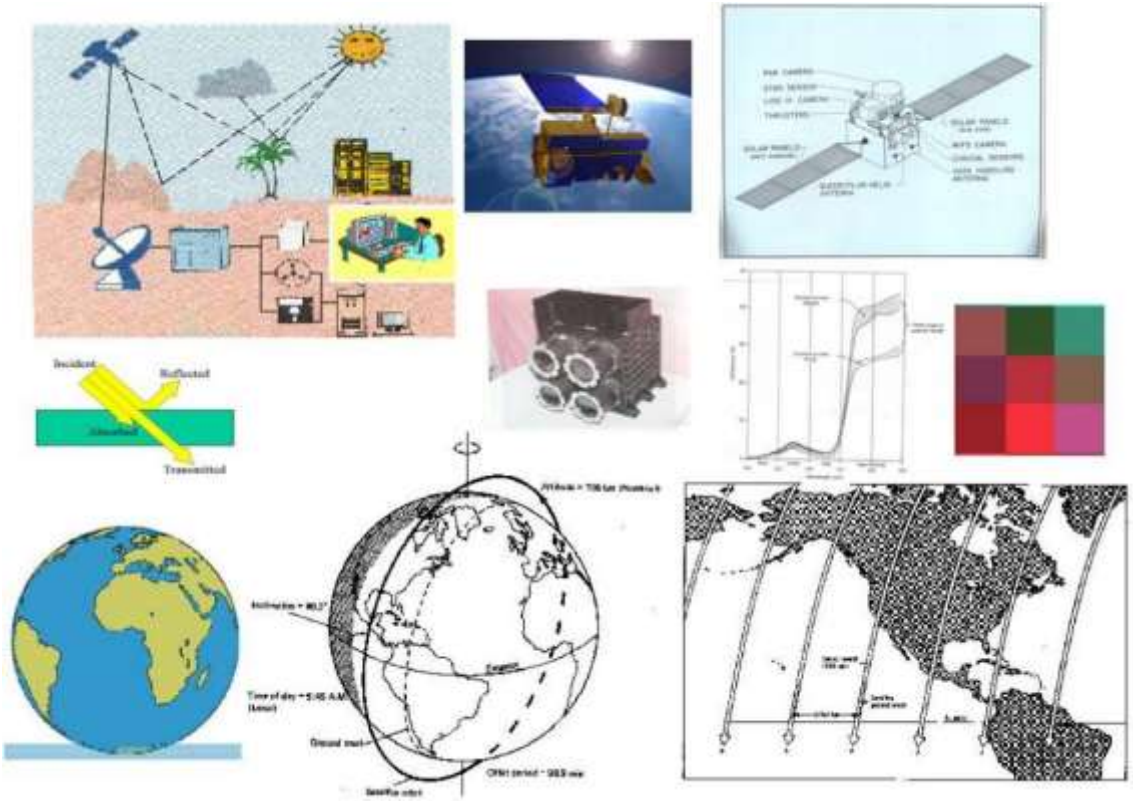
- Different themes
- Different scales
- For various management units

Efficient field work planning, data collection

- Direct integration with the spatial database

12.7 Basic Concepts of Remote Sensing, GIS, and GPS

FIGURE 12.1: BASIC CONCEPT OF REMOTE SENSING, GIS AND GPS

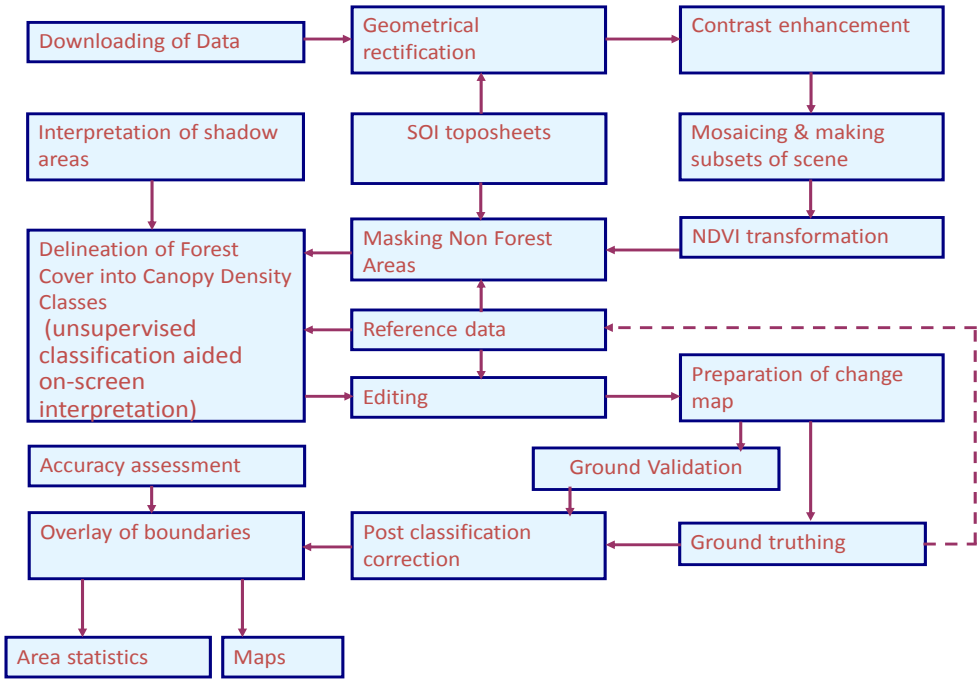


Explanation in the Lecture

12.8 Forest Cover Mapping and Monitoring Changes Periodically

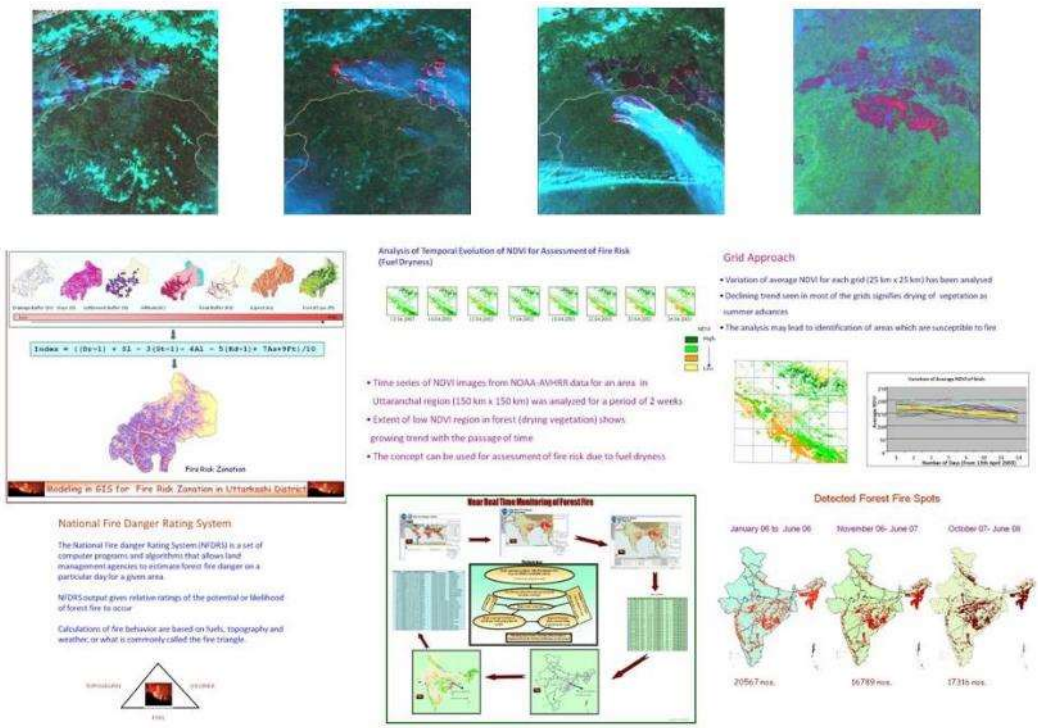
This is an essential and foremost requirement for scientific management of forests. A forest manager should necessarily know distribution of forests, and its stocking (in terms of canopy density) at a sufficiently large scale. Observing changes is also an important requirement, which is made possible with periodic monitoring. Forest cover mapping cannot be accomplished without satellite images. Forest cover can be mapped in four or more canopy density classes. The number of canopy density classes is directly proportionate to ground truthing. Therefore, intensive ground truthing would be required alongwith high resolution satellite data. It is suggested that IRS P6 LISS IV data with 5.8 m. resolution is suitable for forest cover mapping on 1:12,500 scale in four canopy density classes.It is also cost effective.Forest cover mapping may be done periodically in annual or biannial cycles. Change analysis using forest cover maps of two consecutive cycles lead to change maps highlighting areas of degradation as well as improvement in the forest cover in the intervening period.

FIGURE 12.2: FLOWCHART OF FOREST COVER MAPPING



Explanation in the Lecture

FIGURE 12.3: FOREST FIRE MONITORING & CONTROL



Explanation in the Lecture

12.9 Forest Fire Detection and Monitoring

Geospatial technology along with weather data and ICT can be very useful in forest fire management and control. Important applications which can be adopted in the Forest Departments include:

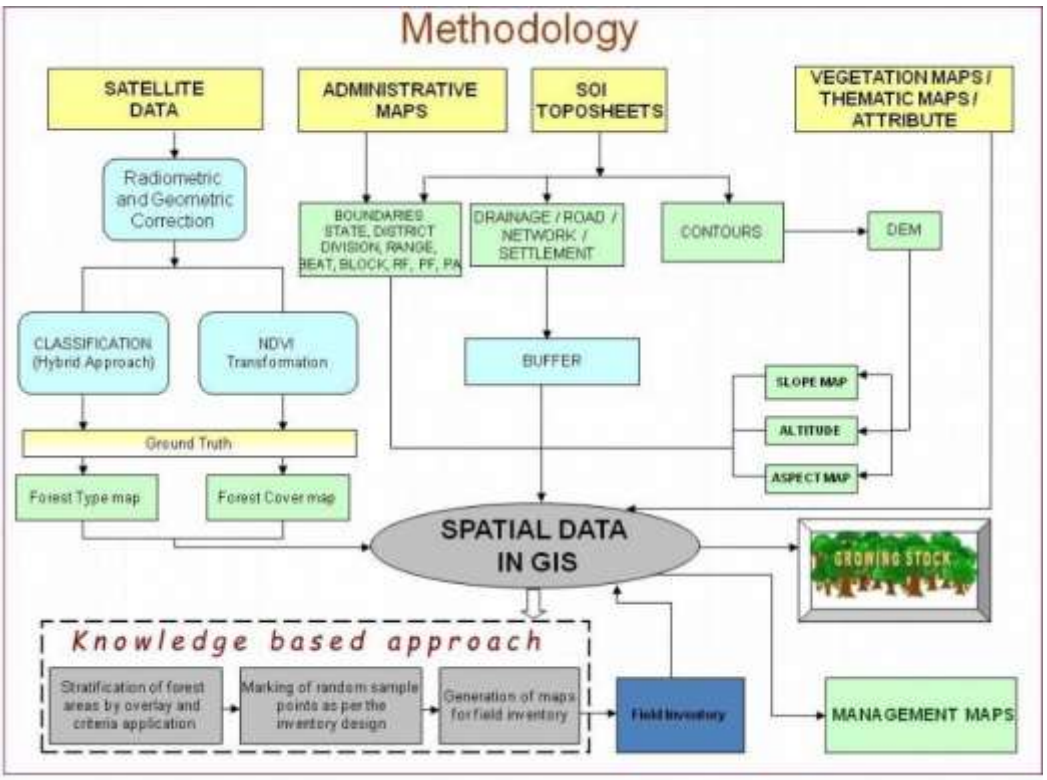
- Detection of active fires in near real time (within 24 hours),
- Fire risk zonation,
- Fire risk based on dryness assessment using temporal analysis of Normalized Difference Vegitation Index (NDVI)—early warning,
- Forest Fire Danger Rating System, and
- Fire-damaged area mapping—impact assessment.

12.10 Concept and Framework

Forest resources are characterized by features such as vast spatial distribution; vast population of innumerable trees and plants; dynamic biological entity; and exposure to many uncertainties and threats like fire, disease and pest attack; and anthropogenic disturbances. Assessment of forest resources therefore involves methodologies and approaches to address these characteristics. Some of the elements in connection with the forest resource assessment are as follows:

- Statistical estimation instead of total enumeration,
- Periodicity in assessment,
- Mapping, and
- Change detection and assessment

FIGURE 12.4: CONCEPT AND FRAMEWORK FOR ASSESSMENT OF FOREST RESOURCES



Statistical estimation of parameters such as growing stock, number of trees, diameter class distribution, and forest carbon involves steps such as sampling design, measurement of sample plots, standard error, etc. Forest inventory involves significant expenditure of money and takes time.Therefore, it is important to ensure efficiency in implementation of forest inventories without compromising the limits of precision and accuracy of the estimates.

There are several sampling techniques like simple random sampling, systematic sampling, stratified random sampling, and multistage sampling. Each sampling technique has merits and suitability with respect to the nature of population and circumstances. For assessment of forest resources, generally systematic sampling and stratified random samplings are followed. With the advent of RS and GIS techniques, stratified random sampling (SRS) design has emerged as the appropriate sampling method, which provides efficiency. SRS involves creation of maps of homogeneous strata within the forest area, which are zones of lesser variability as compared with the whole forest area. RS and GIS provide methods to create homogenous strata with relative ease. As a matter of statistical principle, within a homogeneous stratum, even a low sampling intensity yields estimate of growing stock with high precision.

12.11 Stratification

Stratification is a statistical (or geo-statistical) method for creating homogenous segments or sub-populations of a population, e.g., dense and open forests, forests of different forest types, forests in different altitude zones, etc. Stratification can be

done for different purposes, like identifying forest areas in proximity of habitations that may be prone to biotic interference; identifying fire-prone forest areas that meet criteria such as proximity to roads, high slopes, forest types having inflammable debris on the floor, and so on; and stratifying villages based on criteria such as literacy, wood consumption pattern, or tribal population. Stratification makes data collection objective and efficient. It minimizes the work of data collection, thus saving time and money without compromising precision and accuracy. Stratification thus provides significant advantage in data collection and analysis suitable for adaptive management of forests. Remote sensing and GIS are effective tools for creating strata with respect to different attributes or set of criteria. In most forestry applications, stratification implies strata in the form of maps.

12.11.1 Basis or Criteria of Stratification

Stratification is based on the need of information or analysis. The purpose of stratification may be simply to organize the objective data collection on certain parameters or it may be a detailed exercise of forest inventory or working plan preparation. A basis of stratification therefore is need-based. Some of the basis or criteria for stratification of forests are listed below (could be a combination of criteria):

- Forest cover (canopy density);
- Forest type;
- Altitude zone;
- Slope;
- Aspect;
- Soil type;
- Spatial proximity to habitation, road, etc.;
- Damage by insects and pests;
- Fire damaged area; and
- Biotic interference.

12.12 Stratified Random Sampling

Stratified random sampling can be described as follows:

- A heterogeneous population is divided into sub-populations (i.e., strata, each of which is internally homogeneous with respect to the attribute or parameter which is to be estimated for the population).
- Random sample points are generated in a manner such that the number of sample points falling in each strata is in proportion to the area of the respective strata.

Yields are estimated at higher precision and accuracy with low sampling intensity, and with significant savings to both cost and time.

12.13 Sampling Design: Sampling Intensity, Confidence Limit, and Standard Error

Sampling design includes determining sampling intensity and allowable standard error; confidence level should be pre-decided. It also includes shape and size of plots and the method of distributing the plots in the forest area (i.e., population).

For determining the sample size required for the estimation (e.g., growing stock), a pilot survey is first undertaken, which involves measurement or observations on the sample plots. Shape and size of the plot is also pre-decided. The main considerations in determining the shape and size of the sample plot ae the nature of population, homogeneity within the strata, ease of measurement, and parameters to be estimated. Per the FSI's inventory manual, square plots of size 0.1 ha. are laid for the forest inventory, and these plots are nested with small plots for other measurements like biodiversity, forest carbon, etc.

The following steps should be followed for determining the number of sample plots for a SRS approach:

- Determine the allowable margin of error (e.g., 5 percent or 10 percent).
- Determine the confidence level (e.g., 95 percent).
- Carry out a pilot study with 40 to 60 points in such a manner that the points are distributed in all strata.
- Calculate each stratum size, mean, and standard error of the sample (pilot study).
- Use the following formula finding optimum sample size.

  $$n = (t/\mu E)^2 \times (1/N) \times \sum N_h \times S_h^2$$

  where "n" is the number of sample plots for the inventory exercise

  "t" is the student t statistic for a confidence level say 95 percent, its value for a sample size more than 30 is 1.96 for (for confidence level 95 percent), Student "t" table gives the value for different confidence level

  "E" is the permissible error say 5 percent (or 10 percent) to be pre-decided

  "μ" is the mean of the pilot study sample

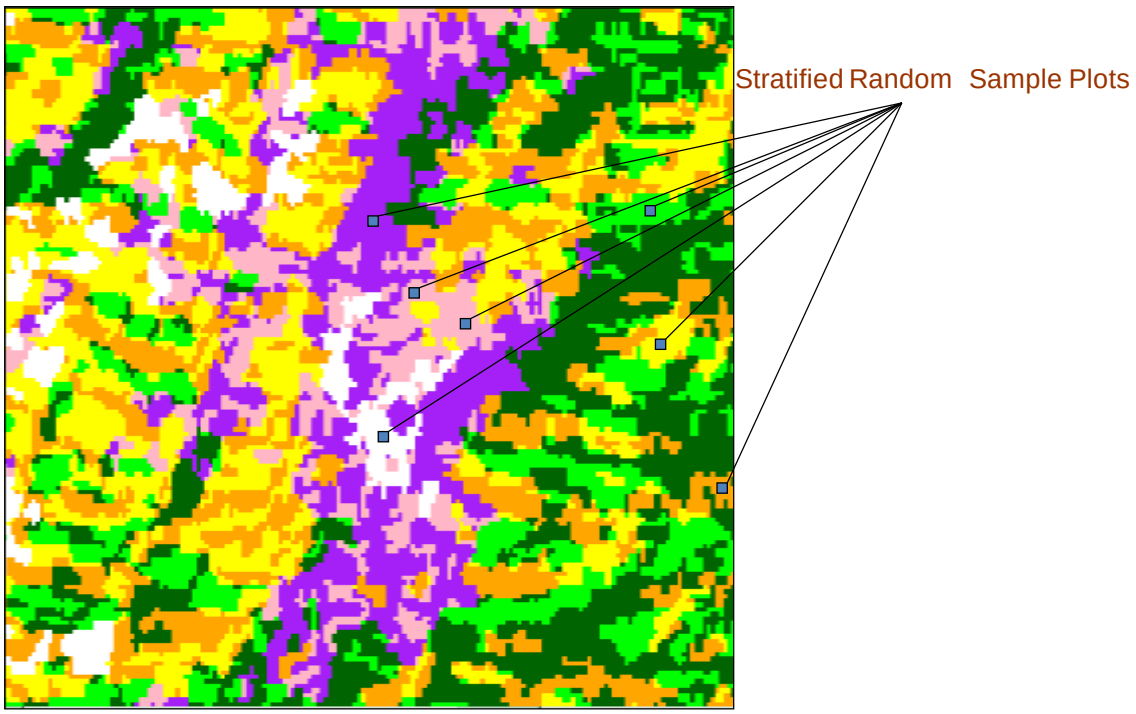
  "N_h" is the stratum size i.e., total area under the stratum divided by the plot area (0.1 ha.)

  's_h^2" is the variance of hth stratum based on pilot study

  "N" is the population size i.e., total area (of the Estate) divided by the plot area (0.1 ha.)

GIS software has the ability to randomly distribute the sample plots (determined above) in a manner so that they randomly fall in different stratum in probability proportion to size (PPS). The software gives coordinates of all the distributed sample plots which can be reached with the help of GPS. Observations and measurements are taken on predesigned forms on each sample plots according to the objectives of the inventory. Synthesis of data using statistical formula yields the desired results (example Figure 12.6).

FIGURE 12.5: SAMPLE SRS PLOTS



12.14 References and Further Readings

Taylor, B., Kremsater,L., and Ellis, R. (1997). “Adaptive Management of Forests in British Columbia.”

LECTURE 13: INCORPORATION OF AN ECOSYSTEM APPROACH TO FOREST MANAGEMENT IN THE WORKING PLAN SYSTEM IN INDIA

This lecture covers the following:

- Current working plan system
- Gaps in data collection and interpretation
- Strengthening of focus areas
- Desirability of improved management

13.1 Introduction

Traditional forest management was based on two basic principles: (i) sustained yield, based on (ii) normal forests. Over 100 years, the forest management based on these principles gradually evolved to the principles of sustainable management of forests (SMF), which now guide forest management in India. Internationally, the 15 SMF principles were recognized and adopted at the United Nations Conference on Environment and Development (UNCED) in 1992.

The ecosystem approach to forest management (EAFM) was adopted under the Convention on Biological Diversity (CBD) in 1992. This approach establishes 12 general principles for the management of an ecosystem. Both approaches, SMF and EAFM, are oriented to conservation of flora and fauna. SMF principles are broad-based while the ecosystem approach principles are directed toward local-level forest management with focus on the forest ecosystem.

In this lecture, the present status of writing working plans is given briefly followed by the salient points of the 12 principles of an ecosystem approach to management. After each principle, the provisions of the National Forest Policy (1988) and National Working Plan Code (2014) (WPC), which support the implementation of the principles, are mentioned. After identifying the gaps in the present system briefly, suggestions for the further improvement of working plans have been made. Annex 1 reproduces the 15 principles of SMF as adopted at the UNCED Conference in 1992.

While no claims regarding the completeness of the document are made, it is hoped that this document gives sufficient insight for further improvement of the working plan document.

13.2 Current Working Plan System

India has a long tradition of more than 100 years of preparation of forest working plans. The nature, the contents, and the legality of these documents have undergone metamorphic changes, especially over the last two decades. It started as a well thought written plan for systematically harvesting forests keeping in view the concept of sustained yield and normal growing stock. (Please define normal Growing Stock (GS). As the general awareness regarding multiple-use forestry grew, new technologies were made available for collecting necessary data, and the society in general became more aware about environmental needs, the contents of such plans underwent many changes. The first common WPC was formulated in 1891 and revised in 2004, after over 100 years. The next revision was felt necessary soon thereafter, and the revised WPC was adopted in 2014. SMF principles were adopted in the Rio Conference followed by the 12 principles adopted by CBD in 2003 after the Malawi Conference. In view of climate change, the newer technologies, especially the remote sensing technologies, and better knowledge of ecosystem conservation necessitated these changes. At present, the working plans made by the working plan officers are discussed in the state forest departments and are approved by the Regional Chief Conservators of forests of Government of India. The approval of the management plans became necessary after the directions of the Hon”ble

Supreme Court of India to that effect, the forest being on the concurrent list of the Constitution of India.

As per the current WPC, the working plan is broadly divided into two parts, as in the previous version. The first part contains 12 chapters and is the summary of facts on which proposals are based. The second part, which prescribes the future management, has as many chapters as the number of working circles plus a chapter on the general constitution of working circles and the justification of making working circles. The 12 chapters of the first part describe the area, locality factors, forests and their vulnerability, composition, past management and the effect of on forests, growth and yield, socioeconomic status of the people living in and out of forests and their relationship with forests etc. Each chapter on working circle gives general status, management prescriptions, and demand limits which can be put on the resource considering various factors etc.

Although the contents of the working plans have improved, there are gaps which are necessary to be filled for successful EAFM.

13.3 Salient Points of the 12 Principles of EAFM

In this section, the salient points of the 12 principles drawn from the Annotations and the Implementation Guidelines given by CBD are mentioned. The salient points are as follows.

13.3.1 Principle 1. Objectives of Management is a Matter of Societal Choice

- Involve all stakeholders including the poor, landless, and women.
- Define the boundaries in time and space.
- Clarify decision making: who makes the decision, informed decision making, consider policy and laws of the land.
- Assess effect of EAFM practices on society, at national level.

Constitutional Provision

- The Constitution of India provides in Article 48 A:
  - Protection and improvement of environment and safeguarding of forests and wildlife.
  - The State shall endeavor to protect and improve the environment and to safeguard the forests and wildlife of the country.

Article 51 A (g) Fundamental Duties

It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife, and to have compassion for living creatures.

The government owns most forest resources in India. Although management of the forests vests with the State Governments, these are managed within the framework of the national policy.

National Forest Policy, 1988 in the Preamble cites ‘serious depletion” of forests which has resulted from relentless pressure “for fuel wood, fodder, timber, inadequacy of protection measures, diversion of forest lands to non-forest uses without ensuring compensatory afforestation and essential environmental safeguards and the tendency to look upon forests as revenue earning resource. Preamble of policy is the key to open the minds of the policy makers. The NFP 1988 starts with the statement on the depletion of forest resources and ends with strategies for conservation of forests, maintenance, sustainable utilization, restoration, and enhancement of the natural environment.

The National Forest Policy lays down the Basic Objectives, the Essentials of Forest Management and the Strategy for the conservation, restoration, and sustainable utilization of the forest resource.

It is thus clear that the National Forest Policy 1988 is generally oriented toward restoration of depleted forests. The Preamble to the National WPC (2014) focuses on the environmental stability, biodiversity monitoring and management, restoration of ecological balance of the disturbed areas, and protective and socio-economic functions.

In a major departure from the previous policies, the new Policy of 1988 made the revenue from forests subordinate to the ecological security, forest conservation, and restoration. The new policy lays lot of stress on people’s participation, including of those living near forests, in the management of the forests.

To restore the forests and reduce pressure on natural forests, the policy emphasizes “...increasing substantially the forest/tree cover in the country through massive afforestation and social forestry programs, especially on all denuded lands and unproductive lands.” The policy also emphasizes “…creating a massive people’s movement with the involvement women, for achieving the policy objectives and to minimize pressure on existing forests.”

The WPC of 2014 in paragraph 4 says “ There has been a paradigm shift in the objectives of management of forests and forest management has become more people centric and oriented to provide the goods and services from forests on sustained basis ...”

Paragraph 8 of the WPC states, “Joint Forest Management is sharing of responsibilities, authority, and usufruct between the village community or the forest user group and the Forest Department on the basis of a memorandum of understanding between the two.

Paragraph 5 of the WPC deals with the involvement of stakeholders, PRA exercise, and the preparation of micro plans.

Paragraph 9 of the WPC deals with the community forest rights recognized under the provisions of Forest Rights Act 2006 exercised within the frame of sustainable management.

Paragraph 53 of the WPC, regarding consultation with local stakeholders requires "head territorial circle during Preliminary Working Plan Report (PWPR) will hold consultation with local people's forum, Joint Forest Management (JFM) committees, village Panchayats and Forest Development Agency (FDA) about the expectations of people dependent on forests and try to accommodate the same as far as possible to the extent they are compatible with the technical feasibility of sustainable management of forests."

It is thus clear that both the National Forest Policy 1988 and the National Working Plan 2014 lay full emphasis on people's involvement in the management of forests.

13.3.2 Principle 2. Decentralize the Management to the Lowest Level

- Decision of decentralization is made at the highest/governmental level.
- Authority and responsibility should go hand in hand.
- The level to which decentralization is done should have sufficient expertise to fulfill the responsibility—(capacity building of frontline staff, community).
- Institutional mechanism must be in place.

The National Forest Policy 1988 states that the basic objectives that govern the National Forest Policy, inter alia, include "meeting the requirements of fuel wood, fodder, minor forest produce, and small timber of the rural and tribal populations."

The policy requires management work to "creating a massive people's movement with the involvement of women, for achieving these objectives and to minimize pressure on existing forests."

The strategy under the National Forest Policy (paragraph 4.10, Forest Extension), states that forest conservation program cannot succeed without willing support and cooperation of the people. It is essential, therefore, to inculcate in the people a direct interest in forest, their development and conservation, and to make them conscious of the value of trees, wildlife, and nature in general. The strategy further directs involvement of farmers and interested people in providing them opportunities to learn agri-silviculture and silviculture techniques to ensure optimum use of their land and water resources.

Paragraph 4.6 of the National Forest Policy directs the management to associate the tribal population in the protection, regeneration, and development of the resource.

Paragraph 4 in Chapter I of the WPC (2014) states that there has been a paradigm shift in the objectives of management of forests and forest management has become more people centric and oriented to provide the goods and services from forests on sustainable basis..." The working plan should be in consonance with general

planning which is village based. Therefore, the working plan should encompass the village as a unit and realign the compartments accordingly."

Paragraph 5 the WPC directs preparation of micro plans and eco-development plans. The micro plans are to be approved by the Working plan officer/DFO/FDA and the implementation of the micro plans is to be reviewed at least once in two years by FDA.

Paragraph 8 in Chapter II of the WPC states that JFM is sharing of responsibilities, authority and usufruct between the village community or the forest user group and the forest department on the basis of a Memorandum of Understanding (MOU) between the two.

Paragraph 53 of the WPC regarding consultation with local stakeholders requires, "Head territorial circle during PWPR will hold consultation with local people's forum, JFM committees, village Panchayats and FDA about the expectations of people dependent on forests and try to accommodate the same as far as possible to the extent they are compatible with the technical feasibility of sustainable management of forests."

13.3.3 Principle 3. Ecosystem Managers to Consider the Effects of Their Activities on the Adjacent and Other Ecosystems

- Ecosystems are not closed; activities in one affect the other.
- There is time lag in what you do and its effect on others. This needs to be understood and the management systems need to be redesigned.
- Environment impact assessment needs to be carried out of activities and feedback mechanism to monitor effects to be effective to be kept in place.

The National Forest Policy 1988 basically deals with restoring the depleted forests, increasing the tree cover for maintaining the ecological balance. This is in view of what has been stated in the preamble—*'serious depletion of forest resources in the country."*

Paragraph 4.3.1 of Management of State Forests in the National Forest Policy states. "The schemes and the projects which interfere with forests that clothe steep slopes, catchments of rivers, lakes, and reservoirs; geographically unstable terrain and such other ecologically sensitive areas should be severely restricted."

Paragraph 4.3.1 addresses the use of forest land for non-forestry purposes. This requires the users of forest land to pay for regeneration and compensatory afforestation.

Paragraph 4.3.2 addresses the requirement of miners, who are allowed to mine in forests, to repair and revegetate the areas affected.

Paragraph 4.3.3 restricts introduction of exotic species "unless long-term scientific trials undertaken by specialists in ecology, forestry, and agriculture have established

that they are suitable and have no adverse impact on native vegetation and environment."

Paragraph 4.5 addresses the care for wildlife and provision of corridors for maintaining the genetic diversity of the populations.

Under the policy provision of creating massive people's movement for regenerating and developing forestlands, the Ministry of Forests and Environment has issued extensive guidelines for JFM on good forestlands, micro plans, relationship with panchayat institution etc.

The eco-development activities around protected areas include the assessment of man-animal conflict damage to life, crop domestic animals, etc. These have been incorporated in the National WPC 2014.

13.3.4 Principle 4. Economic Context of Ecosystem Management

- Reduce market distortions that affect biodiversity conservation and give incentives to biodiversity conservation.
- Internalize cost and benefits of ecosystem management in the general accounting system to the extent possible. Develop social and economic context of ecosystem management.
- Economic valuation of goods and services---ecosystem services in accounting system at national and regional/state level.

In India, the conversion of forestland to non-forestry uses is controlled by the Forest Conservation Act (FCA) 1980. FCA is a regulatory act, not prohibitory. Generally, the will of the government prevails; the media and the activism on the part of judiciary play their own role depending upon the circumstances.

The forest policy requires the users of the forestland pay for the land and the cost of afforestation besides going through a rigorous process of justification for alternate land use.

The forests have rich biological resources of high market value. Timber-like teak, sall, and other species like sandalwood and red sanders and a host of medicinal plants and wildlife products (such as tiger skin, bones, and rhino horns) have great market value with poor people living around such valuable resource. Grazing and free fuel wood requirements of the rural community are mostly met from forests. The price the country pays for the free use is the degradation of the site and direct loss of the resource. Incentives to conserve resources are too costly. The forest policy and the management, therefore, have always promoted strong protection mechanisms in addition to involvement of people for the conservation by giving them sources of livelihood. The whole national forest policy is built around the main theme of restoration of the depleted forest resource of the country. Efforts have been made to incorporate the value of the goods and services into national accounting. So far, only the estimated values of direct benefits of timber, small wood, and firewood have

been incorporated. The values of intangible benefits have not been accounted for in the national accounts.

13.3.5 Principle 5. Ecosystem Structure and Composition to Maintain the Ecosystem Services is a Priority Target

- Understand the ecosystem structure, composition, and functioning and try to assess ecosystem services.
- Define and explain conservation. Include the social and economic benefits of conservation to guide the policies.
- Assess how disturbance affects ecosystem integrity (fire, grazing, human interference or management, climate change and variation).
- Apply instruments/techniques to maintain/restore ecosystem services, in short and long-term.
- Monitor the population of vulnerable species in management plan and consider response measures and actions.

Basic Objectives 2.2 of the National Forest Policy states that the “maintenance of environmental stability” and “restoration of ecological balance” as one of the basic objectives governing the national policy.

Paragraph 3 - Essentials of Forest Management of the National Forest Policy states that the “existing forests and forest lands should be fully protected and their productivity improved”

Paragraph 4.3.2 of the National Forest Policy states, “No forest should be permitted to be worked without the Government having approved the management plan…”

Paragraph 4.14 on the Forest Survey and Data Base of the National Forest Policy states, “The inadequacy of data regarding forest resources is a matter of concern…” and “Priority needs to be accorded to completing the survey of forest resources in the country on scientific lines and to updating information.”

Paragraph 6 in Chapter 2 of the WPC 2014 says, “The objectives for attaining this goal include conservation of forest and reducing forest degradation, maintenance and enhancement of ecosystem services including eco-tourism, enhancement of forest productivity together with establishment of regeneration to improve forest health and vitality as per ecological and silvicultural requirements of the species, progressively increasing the growing stock and carbon sequestration potential.”

Paragraph 7 Biodiversity Conservation and Development of theWPCstates, “Functional diversity is considered to be one of the main factors determining the long-term stability of an ecosystem and its ability to recover from major disturbance. Assessment of status of plants and faunal species and their periodic monitoring can be helpful in formulating strategies for conservation, maintenance, and enhancement of overall biodiversity through sustainable management and use practices.”

However, the methodology for studying the structure, composition, and functionality of the forest ecosystem has not been elaborated. These types of studies are generally not found in the working plans written in the country. Occasionally, N-D curves for forests of one of the working circle are drawn but its further analysis and its relationship with the prescriptions is not elaborated.

The criteria and indicators of SMF evolved in Bhopal, India process also do not incorporate the study of the structure, composition, and functionality of the forest ecosystems as important to assess the health of the forest ecosystem.

13.3.6 Principle 6. Manage Ecosystems within the Limits of Their Functioning

- Know limits of natural productivity/harvesting; if the knowledge is limited apply precautionary principle.
- Adaptive management—Understand the limits of ecosystem functioning.
- Harvest within limits and monitor. Use a regular feedback mechanism.
- Develop/formulate and implement regulatory mechanism.

The National Forest Policy of 1988 was a major departure from the previous policies and made the revenue from forests subordinate to attainment of ecological security of the country. The whole policy revolves around restoring the seriously depleted forests of the country. The National Forest Policy recognizes that the ecosystems have been harvested beyond their capacity.

“The principle aim of National Forest Policy must be to ensure environmental stability and maintenance of ecological balance”

Paragraph 3.1 of the National Forest Policy states, “Existing forests and forest lands should be fully protected and their productivity improved.”

Paragraph 3.4 states, “Provision of sufficient fodder, fuel, and pasture, especially in areas adjoining forests, is necessary in order to prevent depletion of forests beyond sustainable limit…”

Paragraph 4.3.3 states, “In order to meet the growing needs for essential goods and services which forests provide, it is necessary to enhance forest cover and productivity of the forests through the application of scientific and technical inputs.”

Paragraph 4.3.4 on Rights and Concessions states with provision of fuel, fodder, construction timber, and minor forest produce to meet the bona fide requirements of the tribal, scheduled castes, and other poor living near forests.” However, the area which such consideration should cover, would be determined by the carrying capacity of the forests.”

Paragraph 4.3.4.1 addresses the rights and concessions, including grazing should always remain related to the carrying capacity of forests.

Paragraph 4.6 the states that one of the major causes of degradation of forests is illegal cutting and removal by contractors and their labor. Protection, regeneration, and optimum collection of minor forest produce.

Paragraph 4.8 on Grazing states, “Grazing in forest areas should be regulated with the involvement of community.”

Paragraph 4.8 also directs prevention of forest fires and arresting the encroachment of forests.

Paragraph 4.12.1 on Forestry Research states, “Increasing the productivity of wood and other forest produce per unit area per unit time by the application of modern scientific and technological methods.”

The Policy has not used the terms like harvestable limits or sustainable limits, although this is the policy’s intention.

Paragraph 3 of the WPC states that all forests are to be ‘sustainably managed under the prescriptions of a working plan/scheme.

Paragraph 6 of the WPC states the objectives of Forest Management Planning. It states attainment of “progressively increasing the growing stock and carbon sequestration potential, maintenance of biological diversity, sustainable yield of forest produce …”

Paragraph 25 of the WPC on Growth Data and Carbon Sequestration recommends establishment of a grid based network of permanent sample plots to provide necessary data base for growth/increment.”

Paragraph 68 of the WPC on Maintenance, Conservation and Enhancement of Biodiversity states forest composition and distribution, plant species diversity, status of biodiversity conservation of forests, status of species prone to over exploitation…”

Optimization of Forest Resource Utilization- Recorded removal of timber, fuel wood bamboo/rattans, and locally important non-timber forest products (NTFPs) including Medicinal and Aromatic Plants (MAPs)...

Paragraph 69 of the WPC on Growing Stock Estimation states, “The growing stock of trees must be so managed that it regularly provides the greatest quantity of the desired products including intangible benefits…”

Paragraph 70 and 71 of the WPC on Assessment of Non-timber Forest Products (Including MAPs) recommend the Working Plan Officer (WPO) undertake survey, sampling, and assessment for estimation of few prioritized species of NTFPs to start within the selected grids. The paras further state the methodology for estimating the production of fruits, flowers, leaves, etc., of NTFPs.

Paragraph 84 of the WPC describes chapter-wise and paragraph-wise format for writing working plan. In part one of the WPC, there are 12 chapters giving general description of forests, the tract dealt with, past system of management, working of joint forest committees, policy and legal provisions, growth and yield, and statistics of

carbon stocks. Part 2 of the WPC gives the details of the formation of various working circles and para-wise details of the format for the prescriptions and their basis.

Paragraph 87 of the WPC gives the details for the evaluation of the potential for sustainable NTFP management.

Paragraph 88 of the WPC incorporates the steps for the management of wildlife outside the protected area (PA). It also includes steps to promote and regulate ecotourism with regard to tourism influx and carrying capacity.

Paragraph 90 (N+3) 4 NTFP plot—This lays down the methodology for developing safe harvesting protocol for NTFP species.

It can be seen that various steps have been enumerated in the WPC of management of forests within sustainable limits. There is requirement of further research on ideal structure and composiion in view of depleted nature of stocking of forests and composition in view of climate change; and optimum carbon sequestration needs. These can help in incorporating them into the system.

13.3.7 Principle 7. Management to Consider Appropriate Spatial and Temporal Scales

- Connectivity between areas should be promoted (corridors, and for gene flow, integration and interaction of genes, species, and ecosystems).
- In the short term, things may appear fine but could go haywire in the long run. Bureaucratic delay may cause disruption. Making quick management decisions also may hinder proper management response.
- Regional coordination is required to sort out inter-sectoral and cross sectoral issues.
- Enhanced understanding of ecosystem processes at spatial and temporal scales is important.

The National Forest Policy stresses improving and restocking the forests for future and in paragraph 4.5 highlights the need for the provision of corridors to maintain the genetic diversity of the artificially separated parts of the system. The National Forest Policy references the spatial and the temporal scale on which the forests should be managed are not direct but remotely made.

The WPC talks of writing working plans for the forests of a division.

Paragraph 4 of the WPC states, “The working plan should be in consonance with general planning, which is village based. Therefore, the working plan should encompass the village as a unit and realign the compartments accordingly.”

Paragraph 89(vi) states that the WPO may make suggestion for changes in the establishment, including administrative set up and man power, if the current arrangements are not found to be satisfactory.

Paragraph 9 of the WPC recommends establishment of permanent preservation plots and sample plots for monitoring the growth and to study the changes with time.

Paragraph 81 the WPC states that the socioeconomic survey be carried out to know the dependence of locals on forests; villages falling within 3 km distance from forests have to be considered.

The Supreme Court had to intervene to provide guns to protection staff in the Forest Departments in 1996. The thinning in the congested crop in some forest patches of pine and deodar forests are not undertaken due to ban on felling of green trees and that bureaucracy has not taken up the case to the court. Research in ecosystem health may be included in part of working plan management documents and the Forest Survey of India (FSI)/State Forest Resource Survey units may include health parameters in forest inventories.

13.3.8 Principle 8. Temporal Scale and Lag Effect—Objectives of Management Be Set for Long term

- Long-term trends are difficult to measure/detect.
- Study of ecological processes is time consuming and takes a long time to reach conclusion.
- Adaptive management will help consider trade off between short-term gain against the long-term loss or gain in decision making.
- Build capacity to monitor low frequency/minor changes in ecosystem structure/functioning be strengthened.

The National Forest Policy 1988, or the WPC 2014 explicitly do not state anything regarding the time frame of management, but it is implied that the forests are to be managed for all time to come unless used partly for non-forestry purposes following the due process of law. The forests have been seriously depleted and all efforts are to be made to restore them. The management plans are prepared generally for a period of 10 years and then revised.

Paragraph 9 of the National WPC reiterates the definition of sustainable use as defined in Biodiversity Act which inter alia states ‘sustainable use means the use of the components of biological diversity in such a manner and at such a rate that does not lead to the long-term decline of the biological diversity thereby maintaining its potential to meet the needs the and aspirations of the present and the future generations.”

Paragraph 53 of the Code Consultation with local stake holders requires “head territorial circle during PWPR will hold consultation with local people’s forum, JFM committees, village Panchayats and FDA about the expectations of people dependent on forests and try to accommodate the same as far as possible to the extent they are compatible with the technical feasibility of sustainable management of forests.”

Paragraph 84 Chapter 1, item 1.4 recommends, “A midterm review of Working Plan should be undertaken for mid-course correction by the consultative committee under the chairmanship of Principal Chief Conservator of Forests (PCCF) Head of Forest Force (HOFF) with representation from Regional Additional Principal Chief Conservator of Forests (RAPPCF) Ministry of Environment and Forests (MoEF). It further adds that based on the performance of the working plan prescription the plan period may be extended up to 5 years...”

Time required to cross the 4” diameter class in wet evergreen forests highlights this issue. Time required to cross a diameter class varies with species and the site quality. It is generally not less than 20-30 years; in some species it is more than 50 years. The growth is slow. Felling without the knowledge of the stocking level is incorrect.

Temporal changes—Sal trees damaged due to borer attack in Kanha were to be felled. This was prevented on the grounds that such attacks of borers are part of the system and dies off in short time. The attack subsided within 2-3 years with mortality of few sall trees.

13.3.9 Principle 9. Management to Recognize That Change Is Inevitable

- Traditional disturbance regime may be important for ecosystem structure and functioning but long-term changes like the climate change may bring about significant changes in the ecosystem.
- Long-term inflexible decisions are likely to be ineffective/ detrimental.
- Use traditional knowledge/practices to enable better detection of ecosystem changes so as to develop adaptive measures.

Paragraph 4.12 of the National Forest Policy emphasizes the need to carryout research in various aspects with the intention of improving forest management incorporating the results obtained through the research.

Strategy 4.13, Forest Education, of the National Forest Policy states that the ‘specialized and orientation courses for developing better management skills by in service training need to be encouraged taking into account the latest development in forestry and related disciplines.

Paragraph 9 of the National WPC reiterates the definition of sustainable use as defined in Biodiversity Act which inter alia states ‘sustainable use means the use of the components of biological diversity in such a manner and at such a rate that does not lead to the long-term decline of the biological diversity thereby maintaining its potential to meet the needs the and aspirations of the present and the future generations.”

Paragraph 25 of the WPC states that a “network of grid based permanent sample plots should be identified and established in different strata of the forest to provide necessary data base for growth/increment. These permanent sample plots are necessary to assess the role of forests as source or sink for greenhouse gases on a

long-term basis and to study carbon sequestration .....”It is clear that code wants the long-term changes in the structure and composition of the forests should be monitored so that the results of the studies could be incorporated in the management of the forests.

Paragraph 80 and 81 of the WPC deal with socio-economic surveys to be conducted by WPO to assess the dependence of the people living on the fringe, within 3 km distance of forests, on forests. These surveys are repeated at the time of the revision of the working plan, since socioeconomic changes also take place at a rapid rate influencing forests positively or negatively. These are to be reflected in the working plan. As stated earlier, the WPO is required to have meeting with the people or their committees to know the requirements of the people and try to accommodate them to the extent possible in the management of forests falling within the boundaries of their village.

Paragraph 90 of the WPC, Biodiversity Conservation and Development (BDC) Working Circle (N+3)1 states that ‘sufficient number of preservation plots be created and maintained for preserving represented patches of existing forests as far as possible in their present form and preserving such selected plots from all forms of disturbance so as to allow progression toward climax forms and to study and correlate vegetation change matrix with the impact of climate change.”“

Paragraph 98 Appendix IV of the WPC requires the list of the research plots/preservation plots to be recorded in the working plan.

13.3.10 Principle 10. Evolve Balance Between Conservation and Use of Biodiversity

- Management for conservation and sustainable use are not inherently incompatible and can be integrated both at spatial and temporal scales
- Biodiversity resources are important in providing goods and services; they are critical because they have a key role in providing ecosystem services and other services upon which we depend
- The approach should be bounded by spatial and temporal scales that are appropriate to integrate conservation and use of biodiversity diversity.
- The key pillors of sound environmental governance i.e., access to information, access to public participation and access to justice should be well integrated.

The Preamble to the National Forest Policy reiterates the meaning of conservation as “Conservation includes preservation, maintenance, sustainable utilization, restoration, and enhancement of the natural environment.”

The Basic Objectives stated in the policy include “2.1 Restoration of ecological balance that has been adversely disturbed by serious depletion of the forests of the country.”

The Basic Objective in paragraph 2.2 states, “The principal aim of Forest Policy must be to ensure environmental stability and maintenance of ecological balance...” and

“The derivation of direct economic benefit must be subordinated to this principal aim.”

The whole of the National Forest Policy is built around the premise that the forests of the country are depleted and there is need to restore these for the environmental stability and the ecological security of the country. Detailed strategies in all the aspects of the forest resource management have been enumerated and briefly described. The forest policy recommends as a strategy to create a massive afforestation movement, including undertaking agro-forestry, to reduce pressure on the forests.

Paragraph 53 of the National WPC regarding consultation with local stake holders requires tha the “Head territorial circle during PWPR will hold consultation with local people’s forum, JFM committees, village Panchayats and FDA about the expectations of people dependent on forests and try to accommodate the same as far as possible to the extent they are compatible with the technical feasibility of sustainable management of forests.”

This, thus, tries to integrate the expectations of the people in the management of resources to the extent it is technically feasible.

13.3.11 PRINCIPLE 11. EA TO CONSIDER ALL SORTS OF KNOWLEDGE/ INFORMATION SCIENTIFIC, INDIGENOUS, LOCAL Innovations, and Practices

- No single organization can understand and optimize management and ecosystem functioning and address all issues.
- Consider all information available to all stakeholders and treat local knowledge with respect.
- Implications of different world views should be evaluated.
- Promote and implement application research and integrate indecision making.

The National Forest Policy drafted before 1992 CBD has no reference of local knowledge and practices.

In the National WPC of 2014, Paragraph 84-Chapter vii sub paragraph 8.4 requires the documentation of the indigenous traditional knowledge and incorporation of the same in the micro plans and other prescriptions of the plan. Sub paragraph 8.5 requires the details of the cultural sacred groves along with ownership, status of management and interventions to conserve them may be provided in the appendix. Sub paragraph 8.6 requires the areas inside and adjoining designated forests, which have eco-tourism potential, are being visited by tourists, to be identified and documented for effective eco-tourism management.

Sub paragraph 8.7 requires recording of prevalent social customs relevant to forests.

Paragraph 53 of the National WPC regarding consultation with local stake holders requires “Head territorial circle during PWPR will hold consultation with local people’s forum, JFM committees, village Panchayats and FDA about the expectations of

people dependent on forests and try to accommodate the same as far as possible to the extent they are compatible with the technical feasibility of sustainable management of forests."

During the meeting with the local stakeholders, the discussions may not be limited only to sharing or restrictions on the use of resource but may be broad-based to record local relevant knowledge for use in the management of the forest concerned.

13.3.12 Principle 12. Involve All Sectors of Society

Biodiversity conservation management is complex and has side effects and implications, so involve all expertise at international, national, regional, local levels as appropriate. It requires a wide range of management skills, including the skills of those not directly involved in biodiversity conservation and management.

- Incorporate agriculture, fisheries etc.; sectors other than involved in primary production may have major role but not recognized traditionally.
- Evolve mechanism to involve all through decision explicitly.

In view of the serious depletion of forest resources, the National Forest Policy in paragraph 2 (Basic Objectives) requires "increasing substantially the forest/tree cover in the country through massive afforestation and social forestry programs, especially on all denuded, degraded, and unproductive lands. This implies afforestation on lands outside forests there by requiring synergy/coordination with other sectors of economy. The Policy further requires "Creating a massive people's movement with the involvement of women for achieving these objectives and to minimize pressure on existing forests."

Strategy 4.2 of the National Forest Policy Afforestation, Social Forestry and Farm Forestry recommends undertaking massive plantation on all denuded and degraded lands; plantation on roads, railway lines, rivers and streams and canals and on other unutilized lands under state/corporate, institutional, or private ownership. Green belts should be raised in urban/industrial areas as well as in arid tracts..."

The Policy requires "under taking plantation of tree crops on village and community lands not required for other productive uses and the revenue generated through such programs should belong to the panchayats where such lands vest in them; ... beneficiaries would be entitled to usufruct and would in turn be responsible for their security and maintenance." These provisions require coordination with other sectors of general state administration. The Policy further recommends amendment/modification to land laws to facilitate/motivate individuals and institutions to undertake tree farming.

The Policy restricts/cautions the use of exotic tree species "unless long-term scientific trials undertaken by specialists in ecology, forestry, agriculture have established that they are suitable and have no adverse impact on native vegetation and environment." These efforts also call for inter-sector discussion and decision making.

The provision of restriction of use of forestlands for non-forestry use has multi sectoral linkages with all other sectors of economy. The provision of supply to industrial units, incorporation of forestry as a discipline in agriculture universities implies coordination with corresponding departments.

Paragraph 27 of the National WPC 2014 states, “Trees outside forests (TOF) emphasizes the important role played by trees outside forests” The focus of forestry/forest area is on production forestry, revitalization of rural economy, and expanding economic opportunities through innovations. This requires inter-sector synergy and convergence. WPO may, therefore, prepare a separate strategy as a new chapter not being part of general prescription of working plan to address the concepts and issues related to TOF. Inter-sectoral coordination is required from various line departments- such as agriculture, industry, animal husbandry, transport, etc. For example, transport department directs for not plying through forest during certain period of the day/night or for limiting the speed of vehicles through forest.

13.4 Strengthening of Focus Areas

13.4.1 Focus on the Functional Relationship and Processes within Ecosystems

Biodiversity conservation and the maintenance of human well-being depend on the functioning and resilience of natural ecosystems. Ecosystem functioning and resilience in turn depend on inter-relationships within and among species, between species and their abiotic environments, and on the physical and chemical interactions within these systems.

To restore the key structures and ecological processes rather than just individual species it is necessary to understand, to the extent possible, the mechanism of ecosystem functioning.

Given that the loss of genetic diversity predisposes populations and species to local extinction, the conservation of ecosystem composition and structure requires monitoring of population sizes of vulnerable and economically important species. Management of ecosystem processes has to be carried out despite incomplete knowledge of ecosystem functioning.

13.4.2 Enhance Benefit Sharing

Many stakeholders with strong interests in the ecosystem but having limited political and economic influence may be marginalized from the relevant economic systems. To counter this, more equitable sharing of benefits is advised.

National and sub-national policies, laws, and regulations including subsidies may provide incentives for unsustainable management of ecosystems. Economic systems, therefore, need to be redesigned to accommodate environmental management objectives. Deriving economic benefits is not necessarily inconsistent with attaining biodiversity conservation and improvement of environmental quality.

13.4.3 Use Adaptive Management Practices

Change in ecosystems is both natural and inevitable; therefore, management objectives should not be construed as fixed outcomes but rather the maintenance of natural ecological processes. In this regard, it should be noted that ecosystems change constantly as a result of natural processes. Those changes include shifts in species composition, population abundance, and physical characteristics. Such changes are not necessarily constant and are usually difficult to predict at any point in time.

It is, therefore, difficult to select an appropriate outcome or future state of an ecosystem as a static management goal. Instead, in addressing this, management should focus on maintaining the natural processes, which drive those changes.

Ecosystem management must therefore involve a learning process that will help to adapt methods and practices to improve the ways in which these systems are being managed and monitored. Flexibility is also needed in policy-making and implementation. Long-term, inflexible decisions are likely to be ineffective or detrimental.

To the extent that the adaptation to climate change in forest management is concerned, the broad principles adopted are as follows:

- Increase tree species richness. Degradation of forests generally results in decrease in species diversity. Past management has generally favored economically important species at the cost of others.
- Increase structural diversity using uneven aged silvicultural system.
- Maintain and increase genetic variation within tree species through tending and thinning practices or through enrichment planting of tolerant provenances of native species.
- Increase resistance of individual trees to biotic and abiotic stress, for example vigorously growing dominant and codominant are resistant to biotic stress and individuals with well-developed big crowns are resistant to wind damage.
- Replace high-risk stands with less vulnerable ones.
- Keep growing stocks low. This generally recommended in plantations to reduce the financial losses.

13.4.4 Carry Out Management Actions at the Scale Appropriate for the Issue Being Addressed with Decentralization to the Lowest Level as Appropriate

The decisions of decentralization are taken at highest/governmental level in which there is less influence of local community. When done, it should allow authority and responsibility to go hand in hand. The level to which decentralization is done should have sufficient expertise to fulfill the responsibility. Where necessary, capacity building of the frontline staff/community needs to be undertaken so that they are able to take informed decisions. An institutional mechanism need to be put in place.

13.4.5 Ensure Inter-Sectoral Cooperation

The integrated management of land, water, and living resources requires increased communication and cooperation between sectors at various levels of government (national, provincial, local) and private sector stakeholders. Further incorporation of EAFM as an integral part of planning in, among others, the agriculture, fisheries, forestry, and other natural resources management sectors potentially affecting biodiversity and ecosystem functioning, should be encouraged. Sectors other than the primary production sectors may also have major effects but are often less recognized in this respect. These include sectors such as the judicial sector, which affects governance, as well as those such as energy and transport, which are managing or affecting resources either directly or indirectly. For example, the cultivation of soya beans as a principal crop in place of Arhar/cotton of which the agriculture residue was used as fuel in rural areas of Hoshangabad in the past has increased dependence of rural communities on forests for fuel wood.

Procedures and mechanisms should be established to ensure effective participation of all relevant stakeholders and actors during the consultation processes, decision making on management goals, and actions.

The effective implementation of EAFM may require involving multidisciplinary professional and scientific expertise, including such disciplines as economic, social, and natural sciences. When assessing the costs and benefits of conserving, maintaining, using, and restoring ecosystems, the interests of all relevant sectors should be taken into account for equitable sharing of the benefits according to national law. Addressing the issue of market distortions that adversely affect biodiversity will require establishing dialogue with other sectors.

In India, laws regulating forests have been amended from time to time to consider the interest of forests and wildlife but inter-sectoral dialogue with agricultural sector or transport sector who have fragmented the important biodiversity habitats has not been initiated.

13.5 Gaps in Data Collection and Interpretation

The required data for forest management on ecological basis needs to be collected, analysed and used. The following data needs are identified.

Structure and composition of forest ecosystem (trees). Different forest types have different species composition. Composition also changes with site quality to some extent. At the time of making enumeration, which is done at the time of revision/preparation of working plan, the data of composition of different forest types by site quality may be compiled. The genetic variation of the species may also be recorded to the extent possible. From the tables of diameter distribution of different species, structural and compositional studies can be carried out for reflecting on the past management and making future management prescriptions. Sukachev (1954) at the World Forestry Congress in his paper “Forest types and their significance for forest economy” said forest types should form the basis of study and classification.

Climate change is going to affect or has already started affecting the composition of forests. The rate of change may be different for different species in different forest types. Some species may go locally extinct. The mortality rate of different species by different diameter classes has to be compiled for making management prescription.

For the comparison of present composition and structure, the data of preservation plots which reflect the true natural structure and composition of the forest type can be used.

Benefit sharing socioeconomic data is generally collected at the time of revision of working plan. The dependence of various strata of society on the forest resources may be quantified for equitable sharing of benefits and for monitoring the trends of forest dependence.

Intersectoral cooperation: Developments outside forests in other sectors of economy impact forest resources. Government schemes to promote goat farming/rearing may have adverse impact while the schemes promoting high yielding milch animals, which generally are stall fed, have positive impacts on forests by way of reduction of animal grazing pressure.

The government schemes to promote Liquid Petroleum Gas (LPG) in rural areas to reduce fuel wood collection pressure on forests. Changing principal agriculture crop too have effect on fuel wood collection from forests. In last about three decades the cultivation of Arhar/Tur and cotton has reduced drastically in Hoshangabad district of Madhya Pradesh. The agriculture waste from Arhar/Tur and cotton was used as fuel in the rural areas. The decrease in the area under their cultivation has increased pressure of fuel wood collection from forest of the district. At the same time, this increase on pressure has been compensated to some extent by increase in LP gas consumption in the rural areas of the district.

Similarly, the promotion of agro-forestry/tree cultivation has positive impact on the conservation of forests in the neighborhood. The data relating to such developments outside forests are necessary for studying the impacts on forest resources and their management.

13.6 Desirability of Improved Management

It is quite often stated that fire and grazing are two most serious degrading locality factors. This is undoubtedly true. However, how far our systems of forest management have contributed to the site degradation is difficult to determine. Some of our good forest areas, measured on the basis of the basal area, are depleted. They appear well stocked because of the presence of relatively larger proportion of young and pole crop. The number of big trees is very small. It seems that most forests had been harvested at shorter intervals like the forests that have been worked under especially the coppice systems. Normally, the job of a working plan officer ends at calculating the increment the forest puts on and recommending removal of equal to or less than the gross increment accrued. However, it may be remembered that even the depleted forests put on some increment. It is incorrect to recommend removal of increment if the forest is depleted. In fact, the forest growing

stock needs to be built up and the site conditions allowed to recuperate in the case of depleted forests. Such decision can be made if the WPO knows the level of stocking. However, that is where the problem starts. In case of mixed forests there are no yield tables to compare the existing stocking and the level of depletion. Generally knowing that a forest is depleted and so recommending removal of only part of increment, intuitively, is incorrect and unscientific. This is where the role of preservation plots data and the study of structure and composition of the forest under management that is at the heart of ecosystem-based forest management is factored in. The analysis of the forest stand, which is generally written in the chapter on the forests or in the chapter on the statistics of growth and yield, needs to incorporate such studies on which management prescriptions can be based.

Another important aspect, which needs to be made part of working plan, is the study of inter-sectoral linkages. Developments outside forests have influence on the forest resources and their management. Some examples of inter-sectoral linkages which have been mentioned earlier in this write up need to be placed in the working plans.

Normally working plans are written for the management of forests of a forest division. However, there is a need to look beyond the boundaries of a forest division. This is due to the following reasons.

Developments outside forest influence the forest resource condition. Some examples have been mentioned earlier.

The National Forest Policy aims at increasing forest and tree cover to 33 percent, which is possible if tree cultivation takes place outside forest boundary. It is also known that if agro-forestry is promoted, the pressure on natural forests is reduced. The promotion of agro-forestry as a tool to conserve forest resource therefore should be included in the working plans.

Under the direction of the Supreme Court of India, licensing of saw mills has been limited to the wood production capacity of the division/district. These sawmills/wood-based industries may or may not use wood obtained from forests. It is therefore necessary to undertake survey of wood resource outside forest boundaries in the division/district to monitor the pressure on forests. In view of this, it is quite often pleaded that working plans be written for the geographical area of the forest division and be called the Natural Resource Management Plan.

13.7 References and Suggested Reading

Convention on Biological Diversity. (2004). Ecosystem Approach–(Secretariat of the Convention on Biological Diversity: The Ecosystem Approach.

Government of India. (1988). The National Forest Policy of India.

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United Nations Department of Economic and Social Affairs. (1992). Sustainable Forest Management Principles. SMF United Nations Conference on Environment and Development.

Annex

Non-Legally Binding Authoritative Statement of Principles for a Global Consensus on the Management, Conservation, and Sustainable Development of All Types of Forests

PREAMBLE

a) The subject of forests is related to the entire range of environmental and development issues and opportunities, including the right to socio-economic development on a sustainable basis.

b) The guiding objective of these principles is to contribute to the management, conservation, and sustainable development of forests and to provide for their multiple and complementary functions and uses.

c) Forestry issues and opportunities should be examined in a holistic and balanced manner within the overall context of environment and development, taking into consideration the multiple functions and uses of forests, including traditional uses, and the likely economic and social stress when these uses are constrained or restricted, as well as the potential for development that sustainable forest management can offer.

d) These principles reflect a first global consensus on forests. In committing themselves to the prompt implementation of these principles, countries also decide to keep them under assessment for their adequacy with regard to further international cooperation on forest issues.

e) These principles should apply to all types of forests, both natural and planted, in all geographical regions and climatic zones, including austral, boreal, sub temperate, temperate, subtropical, and tropical.

f) All types of forests embody complex and unique ecological processes which are the basis for their present and potential capacity to provide resources to satisfy human needs as well as environmental values, and as such their sound management and conservation is of concern to the governments of the countries to which they belong and are of value to local communities and to the environment as a whole.

g) Forests are essential to economic development and the maintenance of all forms of life.

h) Recognizing that the responsibility for forest management, conservation, and sustainable development is in many States allocated among federal/national, state/provincial and local levels of government, each State, in accordance with its constitution and/or national legislation, should pursue these principles at the appropriate level of government.

PRINCIPLES/ELEMENTS

1. (a) States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies and have the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.

(b) The agreed full incremental cost of achieving benefits associated with forest conservation and sustainable development requires increased international cooperation and should be equitably shared by the international community.

2. (a) States have the sovereign and inalienable right to utilize, manage and develop their forests in accordance with their development needs and level of socio-economic development and on the basis of national policies consistent with sustainable development and legislation, including the conversion of such areas for other uses within the overall socio-economic development plan and based on rational land use policies.

(b) Forest resources and forest lands should be sustainably managed to meet the social, economic, ecological, cultural, and spiritual needs of present and future generations. These needs are for forest products and services, such as wood and wood products, water, food, fodder, medicine, fuel, shelter, employment, recreation, habitats for wildlife, landscape diversity, carbon sinks and reservoirs, and for other forest products. Appropriate measures should be taken to protect forests against harmful effects of pollution, including air-borne pollution, fires, pests and diseases, in order to maintain their full multiple value.

(c) The provision of timely, reliable and accurate information on forests and forest ecosystems is essential for public understanding and informed decision making and should be ensured.

(d) Governments should promote and provide opportunities for the participation of interested parties, including local communities and indigenous people, industries, labor, non-governmental organizations, individuals, forest dwellers, and women in the development, implementation, and planning of national forest policies.

3. (a) National policies and strategies should provide a framework for increased efforts, including the development and strengthening of institutions and programs for the management, conservation, and sustainable development of forests and forest lands.

(b) International institutional arrangements, building on those organizations and mechanisms already in existence, as appropriate, should facilitate international cooperation in the field of forests.

(c) All aspects of environmental protection and social and economic development as they relate to forests and forest lands should be integrated and comprehensive.

4. The vital role of all types of forests in maintaining the ecological processes and balance at the local, national, regional and global levels through, inter alia, their role in protecting fragile ecosystems, watersheds, and freshwater resources, as rich

storehouses of biodiversity and biological resources, and as sources of genetic material for biotechnology products as well as photosynthesis should be recognized.

5. (a) National forest policies should recognize and duly support the identity, culture, and the rights of indigenous people, their communities, other communities, and forest dwellers. Appropriate conditions should be promoted for these groups to enable them to have an economic stake in forest use, perform economic activities, and achieve and maintain cultural identity and social organization as well as adequate levels of livelihood and well-being, though, inter alia, those land tenure arrangements which serve as incentives for the sustainable management of forests.

(b) The full participation of women in all aspects of the management, conservation, and sustainable development of forests should be actively promoted.

6. (a) All types of forests play an important role in meeting energy requirements through the provision of a renewable source of bio-energy, particularly in developing countries, and the demands for fuel wood for household and industrial needs should be met through sustainable forest management, afforestation, and reforestation. To this end, the potential contribution of plantations of both indigenous and introduced species for the provision of both fuel and industrial wood should be recognized.

(b) National policies and programs should take into account the relationship, where it exists, between the conservation, management, and sustainable development of forests and all aspects related to the production, consumption, recycling and/or final disposal of forest products.

(c) Decisions taken on the management, conservation, and sustainable development of forest resources should benefit, to the extent practicable, from a comprehensive assessment of economic and non-economic values of forest goods and services and of the environmental costs and benefits. The development and improvement of methodologies for such evaluations should be promoted.

(d) The role of planted forests and permanent agricultural crops as sustainable and environmentally sound sources of renewable energy and industrial raw material should be recognized, enhanced, and promoted. Their contribution to the maintenance of ecological processes, to offsetting pressure on primary/old-growth forest and to providing regional employment and development with the adequate involvement of local inhabitants should be recognized and enhanced.

(e) Natural forests also constitute a source of goods and services, and their conservation, sustainable management, and use should be promoted.

7. (a) Efforts should be made to promote a supportive international economic climate conducive to sustained and environmentally sound development of forests in all countries, which include, inter alia, the promotion of sustainable patterns of production and consumption, the eradication of poverty, and the promotion of food security.

(b) Specific financial resources should be provided to developing countries with significant forest areas which establish programs for the conservation of forests

including protected natural forest areas. These resources should be directed notably to economic sectors which would stimulate economic and social substitution activities.

8. (a) Efforts should be undertaken toward the greening of the world. All countries, notably developed countries, should take positive and transparent action toward reforestation, afforestation, and forest conservation, as appropriate.

(b) Efforts to maintain and increase forest cover and forest productivity should be undertaken in ecologically, economically, and socially sound ways through the rehabilitation, reforestation, and re-establishment of trees and forests on unproductive, degraded, and deforested lands, as well as through the management of existing forest resources.

(c) The implementation of national policies and programs aimed at forest management, conservation, and sustainable development, particularly in developing countries, should be supported by international financial and technical cooperation, including through the private sector, where appropriate.

(d) Sustainable forest management and use should be carried out in accordance with national development policies and priorities and on the basis of environmentally sound national guidelines. In the formulation of such guidelines, account should be taken, as appropriate and if applicable, of relevant internationally agreed methodologies and criteria.

(e) Forest management should be integrated with management of adjacent areas so as to maintain ecological balance and sustainable productivity.

(f) National policies and/or legislation aimed at management, conservation, and sustainable development of forests should include the protection of ecologically viable representative or unique examples of forests, including primary/old-growth forests, cultural, spiritual, historical, religious, and other unique and valued forests of national importance.

(g) Access to biological resources, including genetic material, shall be with due regard to the sovereign rights of the countries where the forests are located and to the sharing on mutually agreed terms of technology and profits from biotechnology products that are derived from these resources.

(h) National policies should ensure that environmental impact assessments should be carried out where actions are likely to have significant adverse impacts on important forest resources, and where such actions are subject to a decision of a competent national authority.

9. (a) The efforts of developing countries to strengthen the management, conservation, and sustainable development of their forest resources should be supported by the international community, taking into account the importance of redressing external indebtedness, particularly where aggravated by the net transfer of resources to developed countries, as well as the problem of achieving at least the replacement value of forests through improved market access for forest products,

especially processed products. In this respect, special attention should also be given to the countries undergoing the process of transition to market economies.

(b) The problems that hinder efforts to attain the conservation and sustainable use of forest resources and that stem from the lack of alternative options available to local communities, in particular the urban poor and poor rural populations who are economically and socially dependent on forests and forest resources, should be addressed by Governments and the international community.

(c) National policy formulation with respect to all types of forests should take account of the pressures and demands imposed on forest ecosystems and resources from influencing factors outside the forest sector, and inter-sectoral means of dealing with these pressures and demands should be sought.

10. New and additional financial resources should be provided to developing countries to enable them to sustainably manage, conserve, and develop their forest resources, including through afforestation, reforestation, and combating deforestation and forest and land degradation.

11. In order to enable, in particular, developing countries to enhance their endogenous capacity and to better manage, conserve, and develop their forest resources, the access to and transfer of environmentally sound technologies and corresponding know-how on favorable terms, including on concessional and preferential terms, as mutually agreed, in accordance with the relevant provisions of Agenda 21, should be promoted, facilitated, and financed, as appropriate.

12. (a) Scientific research, forest inventories, and assessments carried out by national institutions which take into account, where relevant, biological, physical, social, and economic variables, as well as technological development and its application in the field of sustainable forest management, conservation, and development, should be strengthened through effective modalities, including international cooperation. In this context, attention should also be given to research and development of sustainably harvested non-wood products.

(b) National and, where appropriate, regional and international institutional capabilities in education, training, science, technology, economics, anthropology and social aspects of forests and forest management are essential to the conservation and sustainable development of forests and should be strengthened.

(c) International exchange of information on the results of forest and forest management research and development should be enhanced and broadened, as appropriate, making full use of education and training institutions, including those in the private sector.

(d) Appropriate indigenous capacity and local knowledge regarding the conservation and sustainable development of forests should, through institutional and financial support and in collaboration with the people in the local communities concerned, be recognized, respected, recorded, developed and, as appropriate,

introduced in the implementation of programs. Benefits arising from the utilization of indigenous knowledge should therefore be equitably shared with such people.

13. (a) Trade in forest products should be based on non-discriminatory and multilaterally agreed rules and procedures consistent with international trade law and practices. In this context, open and free international trade in forest products should be facilitated.

(b) Reduction or removal of tariff barriers and impediments to the provision of better market access and better prices for higher value-added forest products and their local processing should be encouraged to enable producer countries to better conserve and manage their renewable forest resources.

(c) Incorporation of environmental costs and benefits into market forces and mechanisms, in order to achieve forest conservation and sustainable development, should be encouraged both domestically and internationally.

(d) Forest conservation and sustainable development policies should be integrated with economic, trade, and other relevant policies.

(e) Fiscal, trade, industrial, transportation, and other policies and practices that may lead to forest degradation should be avoided. Adequate policies, aimed at management, conservation, and sustainable development of forests, including, where appropriate, incentives, should be encouraged.

14. Unilateral measures, incompatible with international obligations or agreements, to restrict and/or ban international trade in timber or other forest products should be removed or avoided, in order to attain long-term sustainable forest management.

15. Pollutants, particularly air-borne pollutants, including those responsible for acidic deposition, that are harmful to the health of forest ecosystems at the local, national, regional, and global levels should be controlled.

16. Sustainable forest management: It is the stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biological diversity, productivity, regeneration capacity, vitality, and their potential to fulfill, now and in the future, relevant ecological economic and social functions, at local, national and global levels, and that does not cause damage on other ecosystems.

LECTURE 14: CONNECTIVITY CONSERVATION: MAINTAINING WILDLIFE MOVEMENT

This lecture covers the following:

- Why landscape connectivity is important for wildlife conservation
- How connectivity analysis can identify conservation priorities and guide land management actions

Michael Heiner

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14.1 Introduction

Landscape connectivity, or the ability to move or disperse across the landscape, is necessary for the survival of both animals and plants, both on a short time frame of the life spans of individual animals, but also across longer time scales that are relevant to populations, such as Tigers in Central India, and for evolution and adaptation of both animals and plants adapting to climate change. So maintaining landscape connectivity is critical to successful conservation, but it requires specific types of analysis and management. This lecture includes 1) a brief discussion of the science and practice of connectivity conservation, 2) overview of existing tools and methods, 3) a case study of Tiger habitat in Central India, and 4) a list of useful resources. Most of the materials presented here were developed by Dr. Brad McRae, a wildlife biologist and expert on wildlife movement and habitat connectivity. He developed a set of tools for modeling and mapping wildlife habitat and movement that have been applied around the world and recently in India by Dr. Trishna Dutta to study Tiger habitat and movements.

14.2 What is Landscape Connectivity?

In 1993, a Canadian landscape ecologist named Phillip Taylor was one of the first to write about landscape connectivity as a critical process and element of landscape structure, and offered this definition: “Landscape connectivity is the degree to which the landscape facilitates or impedes movement among resource patches.” Or “an animal’s ability to use a resource patch will also be dependent upon its ability to get there.”

14.3 Why is Habitat Connectivity Necessary?

Connectivity is important for

- Daily movements to access food and water and avoid predators, pests, and other environmental stressors
- Seasonal movements or migrations to breeding, birthing, summer, and winter habitats.
- Dispersal and colonization of vacant habitat.
- Gene flow to maintain genetic fitness. The new field of landscape genetics are focused on understanding how multiple populations of a given species interact and pass genes across a landscape and how that affects fitness, adaptation and survival.

14.4 Connectivity and Climate Change

Range shifts have been the most important adaptive response to climate change in the past. Species are moving upward and poleward, in particular bird species (Parmesan & Yohe, 2003; Chen et al., 2011). Maintaining landscape connectivity is the most often-cited recommendation for climate adaptation, to allow species to move to track shifts in habitat.

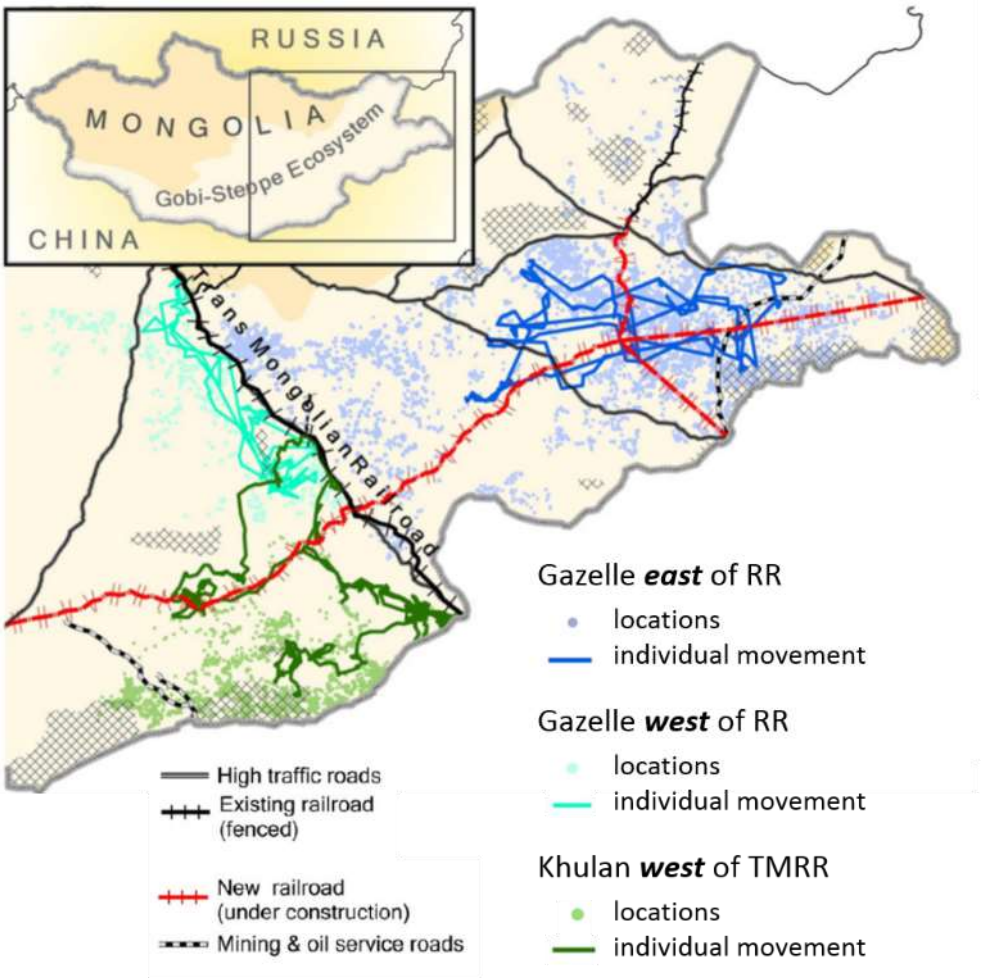
14.5 Impacts of Transportation Infrastructure on Wildlife Movement

Land use and infrastructure impede species movement in different ways.

Roads and transportation have several types of impacts on wildlife and habitat:

1. Direct loss of habitat in the roadway
2. Barrier effect—for some species, this may have the greatest impact
   - Insfratructure = physical barrier
   - Traffic (avoidance)
3. Road mortality
4. Decrease in habitat quality adjacent to the roadway, from increased dust noise, altered hydrology and other impacts.
5. Increased human access via the road.

FIGURE 14.1: EXAMPLE OF INFRASTRUCTURE BARRIERS TO WILDLIFE MOVEMENT IN MONGOLIA



Batsaikhan et al., *2014*

The Mongolian Gobi-steppe systems are one of the world's largest remaining grasslands that supports long-distance animal migrations and traditional nomadic pastoralism. Because this is a desert grassland, several native wildlife species, including Asiatic wild ass and Mongolian gazelle, cover large ranges to find forage and water, and depend on long-distance movements for survival. The railway (black) between the capital and Beijing is fenced, and a very effective barrier to wildlife movement. Wild ass have become effectively extinct east of the railway, though suitable habitat exists there. The high traffic on coal roads to China has also limited wildlife movements, and there many new mining roads and railways under construction to support a mining boom. The barrier effect of this infrastructure may be the most urgent threat to wildlife in Mongolia today. This figure shows evidence that collared gazelle and wild ass are generally unable to cross the railway, and also where planned new railways (red) may affect habitat and movement.

14.6 How to Conserve Connectivity?

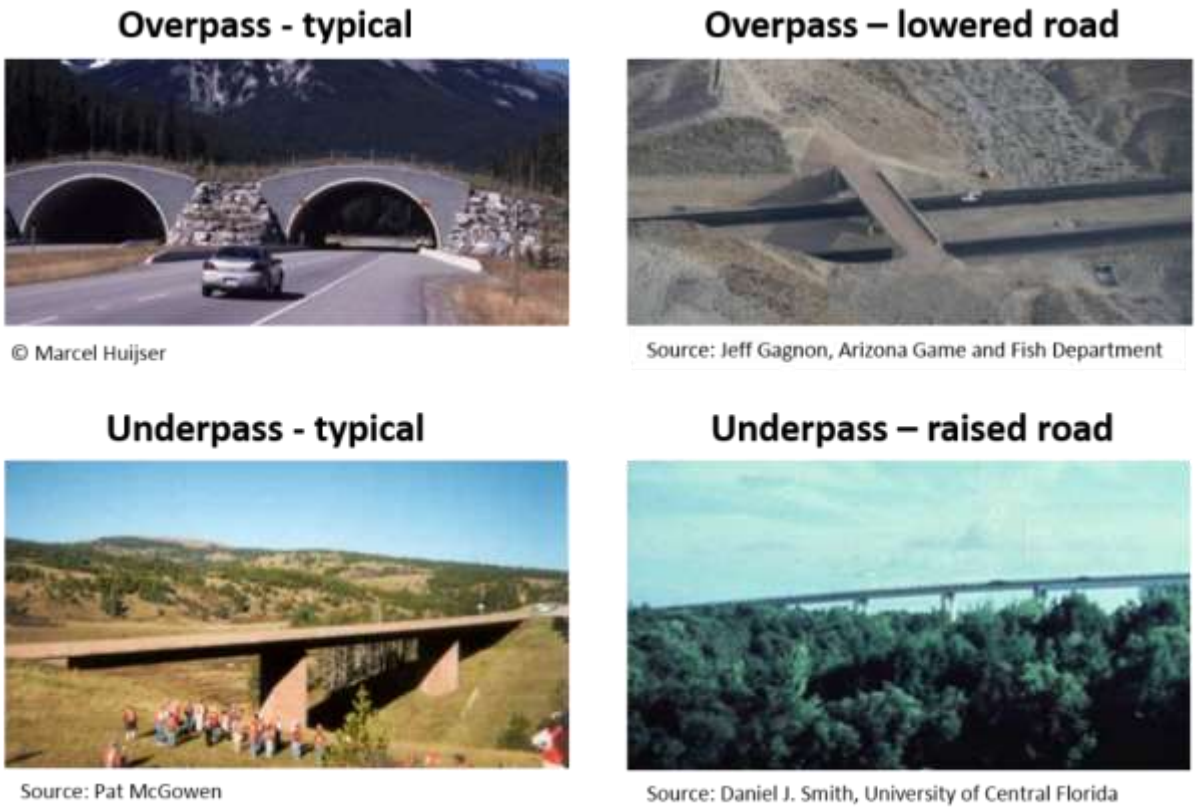
Connectivity conservation focuses on

- Protection of movement habitat or routes that link isolated patches
- Restoration of movement habitat or routes that link isolated patches
- Mitigation of barriers with passage structures such as overpasses or underpasses or traffic curfews.
- Protection of primary habitat as part of a connected network

14.7 Mitigation of Barriers

Options for mitigating the barrier effects of transportation routes and other linear infrastructure include wildlife passage structures - overpasses and underpasses, and also traffic controls. The figure below shows examples of wildlife passage structures (source: Pat McGowen, Western Transportation Institute, Montana State University). These engineering solutions are expensive and require specific design features, so to be effective must be included in scoping and design of new infrastructure.

FIGURE 14.2 : MODELS OF CREATING CORRIDOR FOR WILDLIFE



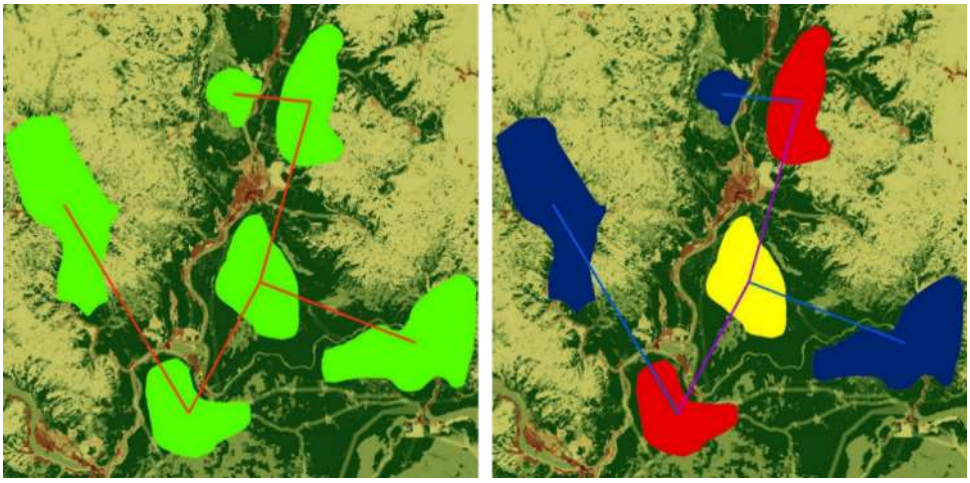
Traffic controls include traffic curfews that can be scheduled to avoid periods of the day or seasons when wildlife are most active or most likely to cross roads or railways. Truck traffic can be scheduled or operated as “platoons” or groups of trucks that create larger, longer gaps between platoons.

There is a growing body of research into design and function of wildlife passage structures and traffic controls. The recent “Handbook of Road Ecology” (van der Ree et al., 2016) is one of the most complete and most recent compilation of research and recommendations re: mitigation of transportation barriers.

14.8 Protection of Primary Habitat as Part of a Connected Network

Primary habitat patches may have different importance within a network of habitat patches. The figure below (McRae and Kavanagh, 2011) shows individual habitat patches ranked by “centrality.” The left side shows habitat patches occupied by Sharp-tailed grouse (*T. phasianellus*) in green, and the lines show which pairs are connected. The right side shows the patches ranked by centrality. The yellow patch has the highest “centrality,” connecting four neighboring patches. The red patches have less “centrality” but still connect neighboring patches. High-centrality cores and corridors are critical to maintaining connectivity across the network of habitat patches, and should be considered as possible conservation priorities.

FIGURE 14.3: FIGURE A: OCCUPIED HABITAT PATCHES, FIGURE B: PATCHED RANKED BY "CENTRALITY"



Source: Mcrae & Kavanagh (2011)

14.9 Where to Conserve Connectivity?

All these strategies require tools and methods to identify optimal places to protect or restore movement habitat and where to mitigate barriers. The best way to decide where is with movement data. Spatial modeling is a tool to support the analysis and identification of movement routes.

Different species and planning questions require different methods and modeling tools. For example, the following three wide-ranging species all cover large ranges but with different movement and habitat use behavior:

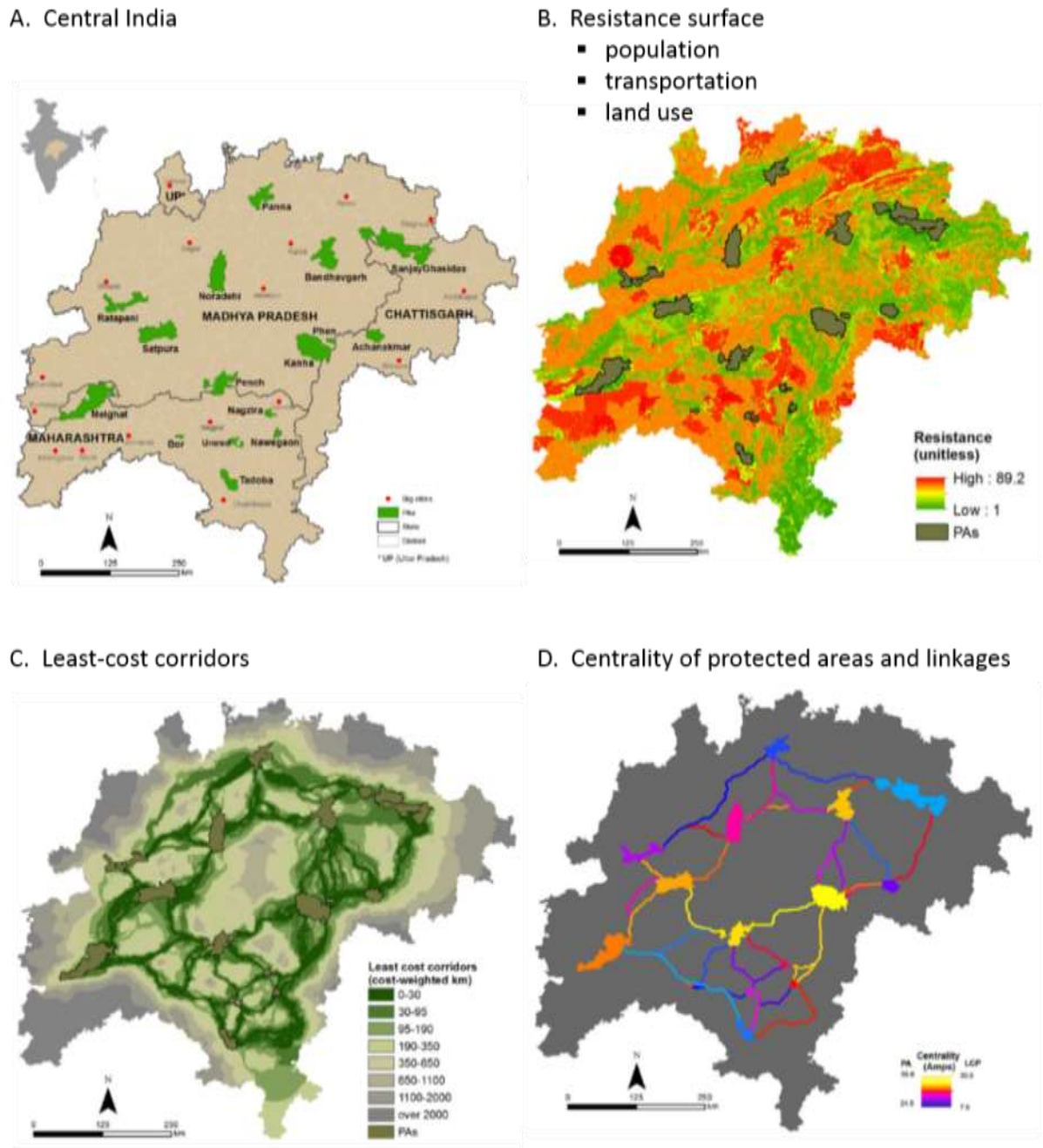
- Elk or Red Deer (North America): follow regular migrations that are predictable in time (season) and space (route).
- Wolverine (North America) continually explore new habitat.
- Mongolian gazelle (Mongolia) is a nomadic migrant that follows variable water and forage resources that vary by season, and between years, so annual movements are also irregular inter-annually and between seasons depending on the location and availability of water and forage.

14.10 Connecting the Dots: Mapping Habitat Donnectivity for Tigers in Central India

The figures Figure 14.4 below are taken from a study of tiger habitat connectivity in central India (A), conducted by Dr. Trishna Dutta et al. (2015). They first developed a map of landscape resistance (B) to movement based on population, transportation and land use. Resistance represents the difficulty for tigers to move, and also the likelihood of conflicts or mortality. With this information, using animal movement models, they analyzed possible movement patterns between the PAs. The results Identify both PAs and areas outside PAs that are important for tiger movements and overall habitat connectivity and viability of the larger tiger population across Central India. Least-cost corridors (C) are possible movement corridors between PAs, or the

routes where tigers are most likely to travel, based on the source data and model design. “Centrality” of PAs and corridors (D) is a measure of the importance for maintaining movement across the network. Yellow PAs and corridors are most import for allowing movement across the network.

FIGURE 14.4: TIGER HABITAT CONNECTIVITY IN INDIA



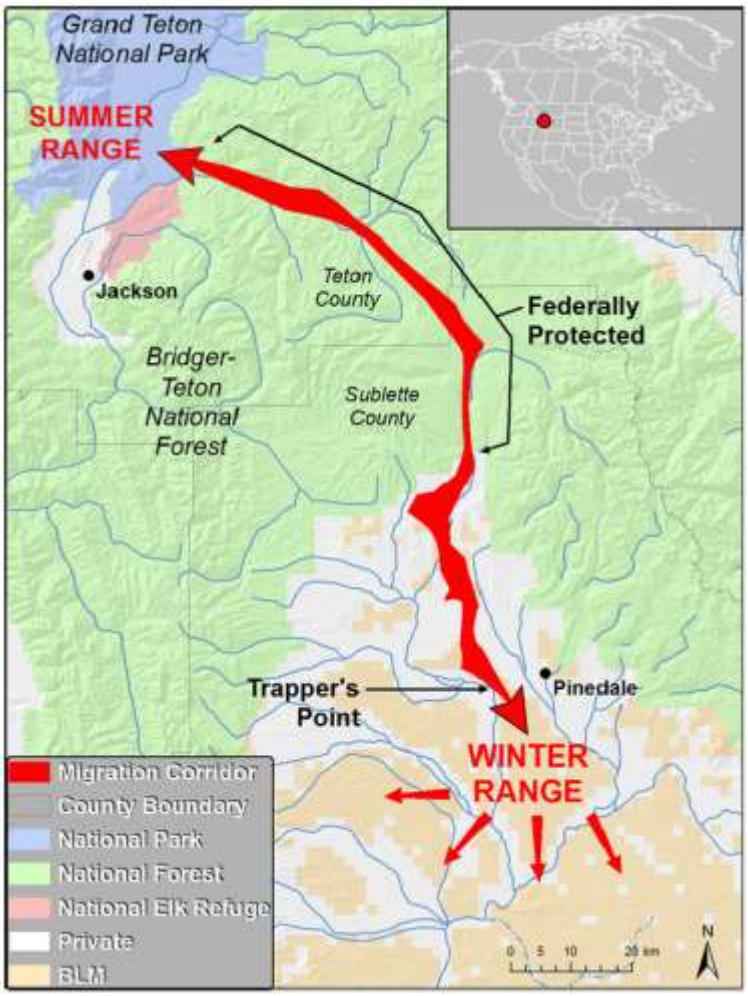
Source: Dutta et al.*, 2015*

14.11 Connectivity Protection Policy

A Pronghorn (*Antilocapra americana*) Migration Corridor was recently designated in the Western United States by a consortium of Federal and State agencies, NGOs and private land owners. This protects a 150 mile (270 km) migration corridor across

an area of mixed public and private lands that has experienced rapid growth of oil and gas development and related roads and fences. On Federal and State lands, the designation specifically requires that future infrastructure projects and management plans be compatible with Pronghorn migration (USFS, 2008; Berger and Cain, 2014).

FIGURE 14.5: MIGRATION CORRIDORS IN THE WESTERN UNITED STATES



Source: Berger and Cain, 2014

14.12 Connectivity Conservation Resources

14.12.1 Examples of Successful Connectivity Conservation in Policy and Practice

Ament, R., R. Callahan, M. McClure, M. Reuling, and G. Tabor. (2014). Wildlife Connectivity: Fundamentals for conservation action. Center for Large Landscape Conservation: Bozeman, Montana. http://largelandscapes.org/media/publications/Wildlife-Connectivity-Fundamentals-for-Conservation-Action.pdf

Aune, K., Beier, P., Hilty, J., & Shilling, F. (2011). Assessment and planning for ecological connectivity: a practical guide. Wildlife Conservation Society. Bozeman, Montana. Available online: http://www.wcsnorthamerica.org/Admin-Plus/Docustore/Command/Core_Download/EntryId/7292.aspx

EU Green Infrastructure Strategy: http://ec.europa.eu/environment/nature/ecosystems/index_en.htm

Infra Eco Network Europe (IENE): http://www.iene.info including the handbook: http://www.iene.info/wp-content/uploads/COST341_Handbook.pdf

Jecami: analysing and mapping ecological connectivity online: http://www.alpine-ecological-network.org/information-services/mapping-services

Lacher, I. and Wilkerson, M. L. (2014), Wildlife Connectivity Approaches and Best Practices in U.S. State Wildlife Action Plans. Conservation Biology, 28: 13–21. doi: 10.1111/cobi.12204 http://onlinelibrary.wiley.com/doi/10.1111/cobi.12204/abstract

Pronghorn Migration Corridor (USFS, 2008; Berger and Cain, 2014). See http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev3_063055.pdf

The Norwegian Institute of Nature (NINA). renewable reindeer project and their special issue in Journal of Animal Ecology, see http://www.nina.no/english/Research/Projects/Renewable-Reindeer

The Western Governors Association Crucial Habitat and Corridors Initiative**:** http://www.westgov.org/wildlife-corridors-and-crucial-habitat.

Washington Wildlife Habitat Connectivity Working Group http://waconnected.org

14.12.2 Mitigation of Road Barriers

Van der Ree et al. (2015). have recently produced the Handbook of road ecology, a comprehensive collection of recent case studies, research and other resources that represent the current science and best practices to mitigate landscape fragmentation by roads. http://www.wiley.com/WileyCDA/WileyTitle/productCd-1118568184.html

Western Transportation Institute, Montana State University http://www.westerntransportationinstitute.org/default.aspx

14.12.3 Connectivity Modeling Resources

Beier P, Spencer W, Baldwin RF, McRAE BR. Toward best practices for developing regional connectivity maps. Conservation Biology. 2011 Oct 1;25(5):879-92. Available online: http://consbio-static.s3.amazonaws.com/media/publications/files/Beier_etal_2011_RegionalConnectivityMaps_2.pdf

CIRCUITSCAPE: http://www.circuitscape.org/
Core areas and resistance layers: Gnarly Landscape Utilities
Least-cost corridors: Linkage Mapper
Circuit theory: Circuitscape
|Pinchpoints within corridors and restoration opportunities: Linkage Mapper

Conservation Corridor blog http://www.conservationcorridor.org/

GIS tools and information for designing wildlife corridors
http://www.corridordesign.org/

14.13 References and Other Reading

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McRae, B.H., V.B. Shah, and T.K. Mohapatra. (2013). Circuitscape 4 User Guide. The Nature Conservancy. http://www.circuitscape.org.

Parmesan, C., & Yohe, G. (2003). A globally coherent fingerprint of climate change impacts across natural systems. Nature, 421(6918), 37-42.

United States Forest Service. (2008). Decision Notice and Finding of No Significant Impact: Pronghorn Migration Corridor Forest Plan Amendment. Bridger-Teton National Forest, Wyoming. Available online from http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev3_063055.pdf (accessed September 2016).

LECTURE 15: ECOSYSTEM MANAGEMENT - UNEVEN AGED, MIXED AND CLOSE TO NATURE FORESTRY

This lecture covers the following:

- Stand structure—evenly and unevenly aged
- *de Liocourt* function and construction of a balanced stand structure, BDq method using preservation plot data
- Comparison with the present stand structure

15.1 Introduction

The National Forest Policy 1988 states in the preamble that the country's forests are 'seriously depleted." To restore the degraded forests, the policy made revenue from forests subservient to the ecological security of the country and incorporated the involvement of people as important stakeholders. The policy further suggests various steps for restocking the depleted forests, including a step to make afforestation a mass movement. The recently prepared National Working Plan Code of 2014 (WPC) also reemphasizes the commitment to sustainable forest management (SFM).

The principles of SFM have been guiding forest management in India. In 2004, the Forest Survey of India (FSI) published a report on the sustainability of forest management in India. As per the report, sustainability of forest management scored only 56 on the scale of 100. The health and vitality and the socioeconomic functions rendered by forests scored less than 50. The structure and composition of forest, which form one of the primary components reflecting the integrity or the health of the ecosystem, have not received the importance they deserve. This has become important under the REDD+ climate change scenario, wherein efforts are required to enhance carbon sequestration while conserving biodiversity of the forest ecosystems.

15.2 Close to Nature Forestry

The disadvantages of densely packed single-species plantations of different ages on different plots (i.e., clear felling with plantation) were observed in the last quarter of nineteenth century in Europe. Such evenly aged plantations were more prone to significant damage by disturbances, like wind, fire, and insect attack. The damage to the unevenly aged mixed forests was less. This resulted in the advocacy of mixed forests with heterogeneous structure. Today, mixed forests with unevenly aged structures is a general forest management paradigm in Europe. Generally called *close to nature forestry*, it is also known by various terms such as *close to nature silviculture, free style silviculture, eco-forestry, continuous cover forestry,* etc. The principles, generally, adopted are (1) promotion of natural and/or site-adopted tree species, often based on the assumed potential of natural vegetation, (2) promotion of mixed forests, (3) promotion of diverse vertical and horizontal stand structures, (4) promotion of natural regeneration, (5) silvicultural practices that focus on individual trees, and (6) avoidance of clear cuts. Different principles are given different weightage on different sites depending upon the local circumstances (Brang et al., 2014). Many foresters also believe that the selection system along with its variations (the group selection system and shelter-wood system) are also close-to-nature forestry systems because there is no clear felling, soil is not exposed, and there is continuous canopy cover.

To propagate close-to-nature forestry, the European federation of foresters established an institution named Pro Silva in 1989 in Slovenia. This institution advocates forest management based on "the principles grounded on the processes found in natural forests." They believe that conservation of ecosystems is necessary for forests to provide all necessary benefits to the society. For this to be achieved,

they recommend “paying serious attention to (i.e., maintaining or restoring) the natural forest vegetation pattern, while making use of the forest; maintaining soil productivity, through continuous cover, and through the maintenance of biomass in the forest (including dead wood); propogating mixed forest with special attention to rare and endangered species; restricting the use of exotics to cases where this is an economic necessity, and then only if the exotics can be mixed with the indigenous vegetation pattern within certain quantitative and qualitative limits; In special cases, forgo any harvest.”

The type of close-to-nature forestry advocated here recommends using the data of preservation plots. These preservation plots, “nature miniatures were established in supposedly undisturbed forests. The composition and structure of these preservation plots reflects the ideal crop composition and the structure to be achieved by the forest under management.

For forest ecosystem to provide intended goods and services, the ecosystem must remain in a healthy condition. “For the purposes of biodiversity conservation, functionality or integrity of a conservation area can perhaps best be judged by the extent to which the structure and composition of the focal ecosystems and species are within their natural ranges of variability.” (Poiani et al., 2000). The meaning of the structure and composition referred to here is quite broad, involving herbs, shrubs, and all floral components as well as faunal and abiotic components. The quantitative data of all these is quite often not available. Even if it is made available, it may not be possible to evolve any simple practicable model of forest management incorporating all these. Therefore, we confine ourselves to the structure and composition of tree species of forest ecosystem of which we may have relevant data. In this write up, an attempt has been made to present a methodology to understand how far away a forest is from being healthy, judged from the structure and composition of tree species, and what can be done to improve their health by the officer responsible for writing the forest working plan.

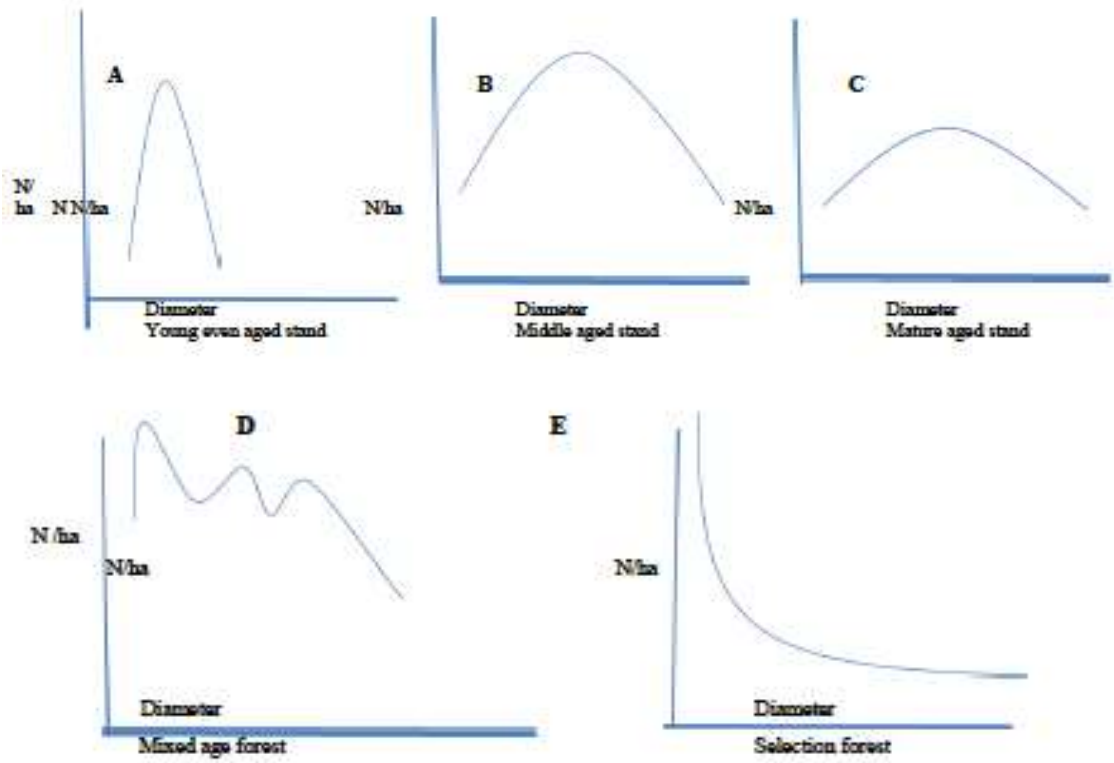
15.3 Tropical Forests and Their Characteristics

About two-thirds of world forest resources are of the tropical mixed forest type. These tropical forests are characterized by a large number of species in each unit of area. For example, in the four preservation plots belonging to tropical wet evergreen forest type of Uttara Kannada District of Karnataka, studied by G. S. Mathauda (Indian Forester, 1953), the per hectare average number of species was 131. The literature on the growth and increment of tropical mixed forests, generally, is quite limited. In India, preservation plots were established in different forest types of the country to study the ecological succession, increment, crop composition, etc. in the relatively less disturbed and well-stocked forests. The majority of these plots were established after the Third Silvicultural Conference held at Dehra Dun in 1929, which recommended establishment of such plots. Although the intentions of establishing these plots were good, the maintenance of these at a later date did not match these intentions. Neither were they maintained properly nor were regular measurements recorded afterwards. There were, however, some exceptions to this.

15.4 Stand Structures and the Forests

When the number of trees per hectare of a forest stand is plotted against the diameter, the resultant number of trees-diameter curves (n-d curves) are vastly different in case of evenly aged stands versus unevenly aged stands. On one extreme is the pure one aged stand whose curve is essentially a narrow inverted bell shape. On the other extreme, as in case of a selection forest, the curve takes the shape of reverse J. Between these two extremes there is a spectrum of different shapes depending upon the presence of different age or diameter classes. The following diagrams demonstrate this.

FIGURE 15.1: NUMBER OF TREES PER HECTARE IN EVENLY AND UNEVENLY AGED FORESTS



In Figure 1, A, B, and C represent young, middle-aged, and mature evenly aged stands, respectively. As the age increases, the diameter of the bell increases. D indicates a stand that mainly has about three age classes. It is a mixed-age forest where three age classes dominate. E is a true selection forest where all age classes are represented every unit area. The n-d curve of any stand/forest provides a powerful tool to reflect on the past treatment meted out to forests and ensure future prescriptions, keeping forest management objectives in mind.

15.5 Selection Forests and de Liocourt's Q Ratio

In nature, the number of trees in younger age classes is higher than those in higher age classes. This is true of populations in all natural ecosystems. In 1898, de Liocourt observed that in an undisturbed selection forest, the number of trees in successive diameter classes maintain a definite proportion. The ratio of the number

of trees in lower to that in the next higher diameter class is constant and termed as "q." The value of q may be different for different selection forests. A lower value of q is seen in forests with old growth or selection forest with a higher proportion of larger diameter classes, and a higher q value is seen in managed forests with a higher proportion of middle and lower diameter classes.

> *"The constitution of uneven aged forest crops has not been studied to any considerable extent for the forest types of our country. Our appreciation of the fundamental laws underlying balanced uneven aged crops which are capable of giving sustained yields in perpetuity is inadequate and is a serious hindrance in the efficient management of such crops. The Working Plan officer usually tries to judge whether different size and age groups are properly represented. His efforts, however, seldom go beyond making general qualitative statements, (involving a certain degree of subjective element) about the deficiency or excess of the particular classes." (Mathauda, 1955).*

> *"The law (the law of de Liocourt) thus forms a convenient yard stick for determining whether the size classes in a particular tropical moist deciduous irregular crop are present in correct proportion from the management and silviculture view-points. It can also form a very reliable guide for determining future yields and the distribution of future fellings over various size classes. In the present case the test has been applied to all species taken together but the test should be equally applicable if only a few species were taken into consideration as has normally to be done in the case of tropical forest." (Mathauda, 1955).*

15.5.1 Growth in evenly aged and unevenly aged forests

The graphs depicting the growth of average diameter with age in case of evenly aged and unevenly aged stands are different. In case of the evenly aged stands, the growth curve show a continuous rise as the age increases, but in the case of unevenly aged stand, the growth curve of younger trees shows slow rise initially but the growth increases rapidly with increasing diameter. This is because under the shade of older trees, the younger trees grow slowly but as the trees grow and start receiving overhead light, they pick up rapidly.

Another important aspect to remember is that the volume growth (increment) of a stand is proportional to the stocking level. If the stand is depleted, the total volume growth is less than what it would be if the stand were fully stocked. The data of preservation plots which are in the vicinity of forest under management and similar site conditions, soil depth, and moisture conditions can be used to know about the stocking level.

15.6 Preservation Plots in India—Using Their Data to Construct Balanced Stand Structure

This is the case study from Hoshangabad in Madhya Pradesh (MP). The data of preservation plot established at Bhopali forest in North Betul Forest Division on the border of Hoshangabad district is used to compare the stand parameters of the

Selection cum Improvement Working Circle of Hoshangabad Forest Division. The procedure adopted is explained below.

The forests of Hoshangabad Division mostly belong to tropical dry deciduous type. The current working plan was written by H. U. Khan and is valid until 2023. The Selection cum Improvement working circle covers a 72 percent area of the forest division. This forest type is important because about 42 percent of the country's forests belong to this type and about half of it is "open forest" (i.e., canopy density less than 0.4).

TABLE 15.1: LINEAR INCREMENT PLOT OF HOSHANGABAD CIRCLE

Diam Mid pt	<10 5	10-20 15	20-30 25	30-40 35	40-50 45	50-60 55	60+ 65
No. of trees/ha	168.5	187.88	82.92	36.12	7.15	1.18	0.87
BA/tree Class	.001964	.01768	.049106	.096248	.159104	.23765	-
BA x n	.3309	3.3217	4.0718	3.4764	1.1376	.2804	(12.565)
Q	0.9	2. 27	2.3	5.05	6.06		

Hoshangabad: Selection-cum Improvement working circle enumeration data (based on 288 plots)-Tropical Dry Deciduous forests

The Permanent Preservation plot, No. 2, was established in 1947 in Compartment No. 327 at Bhopali in North Betul Forest Division of Hoshangabad Circle. The area of the plot was 75 acres. Total (100 percent) enumeration was, however, done later in 1954. This data was provided by FRI Dehra Dun for studying the stand structure of the forests of Hoshangabad Forest Division. The enumeration data of the plot is reproduced below.

TABLE 15.2: PLOT DATA FOR PERMANENT PRESERVATION PLOT

	Species	<10	Oct-20	20-30	30-40	40-50	50-60	60-70	70-80	80+	Total	LIP %	PRESENT %
1	Teak	1081	998	469	342	158	60	34	14	11	3167	23.8	22.95
2	Tinsa	865	760	66	6	-	-	-	-	-	1697	12.8	0.3
3	Saj	94	296	423	444	233	98	54	20	-	1680	12.7	8.62
4	Haldu	-	-	1	1	2	1	-	1	2	8	0.06	0.19
5	Bahera	-	2	2	2	2	2	-	-	2	12	0.09	
6	Dhaora	404	273	127	65	16	7	-	-	-	892	6.72	3.95
7	Malam	1	7	8	8	1	-	1	1	-	27	0.2	
8	Moyen	18	130	170	115	32	14	1	-	-	480	3.61	2.74
9	Lendia	73	195	212	124	63	13	3	3	-	685	5.16	4.43
10	Jamun	307	286	95	35	23	18	4	4	8	730	5.5	
11	Kari	949	553	76	5	1	-	-	-	-	1534	11.6	2.96
12	Kasai	-	4	10	5	17	5	-	-	1	42	0.32	
13	Padar	2	9	5	-	-	1	1	-	-	18	0.14	
14	Tendu	63	75	19	2	1	-	-	-	-	160	1.2	9.62
15	Mahua	7	20	14	3	2	2	2	-	1	51	0.38	3.88
16	Semal	-	2	1	-	-	-	-	1	1	5	0.04	
17	Chincholla	3	9	10	-	-	1	-	1	1	25	0.19	
18	Dhaman	30	80	15	4	1	-	-	-	-	130	0.98	
19	Aonla	24	99	50	13	5	1	-	-	-	192	1.45	0.39
20	Achar	61	116	52	10	4	1	-	-	-	244	1.84	3.45
21	Palas	89	347	344	173	69	22	2	-	-	1051	7.91	2.1
22	Kusum	11	30	6	-	-	-	-	-	-	47	0.35	0.71
23	Kumbhi	5	21	12	30	27	8	1	4	-	139	1.05	
24	Bhilwa	3	8	9	4	-	-	-	-	-	24	0.18	
25	Rohan	-	-	1	-	-	-	-	-	-	1	0.01	0.59
26	Mokha	3	5	9	3	1	-	-	-	-	21	0.16	
27	Kullu	6	15	1	-	-	-	-	-	-	22	0.17	
28	Rinza	-	1	4	-	1	-	-	-	-	6	0.05	
29	Bel	11	18	9	-	-	-	--	-	-	38	0.29	1.25
30	Harra	-	2	1	2	-	-	--	-	-	5	0.04	
31	Pipal	1	-	-	-	2	1	--	2	15	21	0.16	
32	Gular	1	4	7	2	1	2	2	1	9	29	0.22	
33	Kahu	-	-	-	-	1	-	-	-	-	1	0.01	
34	Am	-	-	-	-	-	1	-	-	-	1	0.01	
35	Baranga	-	10	8	-	1	-	-	-	-	19	0.14	
36	Panjra	-	2	1	-	-	-	-	-	-	3	0.02	
37	Phansi	5	9	4	6	5	-	-	-	-	29	0.22	0.44
38	Bad	-	-	1	-						1	0.01	
	Total	4117	4386	2242	1404	669	258	105	52	46	13279	100	
	Total per ha	137	146.2	74.73	46.8	22.3	8.6	3.5	1.73	1.55			

The q value is found out by dividing the number of trees per hectare in lower diameter class to that in the next higher class. This is given in Table 15.3.

TABLE 15.3: DATA FROM PERMANENT PRESERVATION PLOT OF HOSHANGABAD CIRCLE

Species	<10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80+
Total per ha	137.2	146.2	74.73	46.8	22.3	8.6	3.5	1.73	1.55
q values	0.93	1.95	1.59	2.09	2.59	2.45	2	1.12	AV 1.84

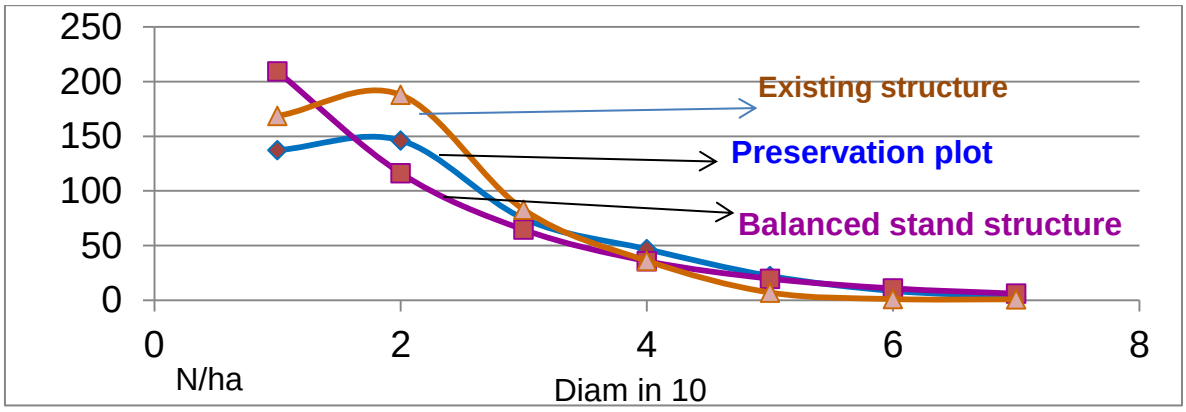
TABLE 15.4: ENUMERATION DATA FROM PERMANENT PRESERVATION PLOT OF HOSHANGABAD CIRCLE

Using the value of q to be 1.8 and basal area 17.7 m2 balanced stand structure is constructed. Presuming that the value of n at say 70-80 diam is one we get the numbers in other diameter classes by multiplying next lower classes by 1.8. The basal area of this structure with n=1 at diameter 70-80 is found out which is 5.1808 m2. Then we divide 17.7, the basal area of the preservation plot, by this no 5.1808. We get 3.419. We then multiply the stand structure with n=1 at diameter 70-80 with this number to arrive at the balanced stand structure. Constructing a balanced stand structure with data of preservation plot -desired q, D and BA.

	<10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80+
N	137.2	146.2	74.73	46.8	22.3	8.6	3.5	1.73	1.55
	0.93	1.95	1.59	2.09	2.59	2.45	2	1.12	AV 1.84
if n =1at d=75	61.2	34.02	18.9	10.5	5.8	3.2	1.8	1	
	0.001968	0.01538	0.04529	0.0924	0.159	0.2341	0.332	0.442	
Basal Area (BA) P PLOT	0.27001	2.248556	3.384522	4.32432	3.5457	2.01326	1.162	0.76466	
If n=1,d=75	0.120442	0.523228	0.855981	0.9702	0.9222	0.74912	0.5976	0.442	
N reqd = 1*17.713/5.18 08	209.2428	116.3144	64.6191	35.8995	19.8302	10.9408	6.1542	3.419	
Or N =	209.2	116.3	64.6	35.9	19.8	10.9	6.1	3.4	
	<10	10---20	20-30	30-40	40-50	50-60	60-70	70-80	
Ppp	137.2	146.2	74.73	46.8	22.3	8.6	3.5	1.73	
Bal St str	209.2	116.3	64.6	35.9	19.8	10.9	6.1	3.4	
Existing	168.5	187.9	82.92	36.12	7.15	1.18	0.87		

BA of balanced structure = 17.7 m^2 BA of the existing structure = 12.6 M2

FIGURE 15.2: BALANCED STAND STRUCTURE OF PRESERVATION PLOT



The curves show the distribution of trees per hectare as per constructed balanced stand structure (pink line, square points), the structure of preservation plot (blue line, diamond points), and the distribution of trees in the selection cum improvement working circle by brown line.

It can be seen that the present growing stock of the selection cum improvement working circle is much below optimum level indicated by the balanced structure in the diameter classes above about 40 cm. These higher diameter classes contribute significantly to the basal area. At present in the existing forest the number of trees of lower diameter classes, about 20 cm, is more than that of the balanced structure but their contribution to basal area per hectare is marginal. This pole crop gives a feeling of forest being dense and is seen so in the satellite imagery.

15.7 Crop Composition Studies

In the preservation plot at Bhopal there are 38 species which have been enumerated. There were a few other small trees which were not recorded at the time of first enumeration. Of these 38 species, a few occur frequently in the area and contribute significantly to the BA and the total growing stock. If we presume that the preservation plot is true representative of the type of forest of the working circle, then comparing the crop composition of the preservation plot and that of the working circle today can reveal the changes brought about by past management and/or other reasons like climate change. Let us attempt this with the available data.

In Figure 15.2, the last two columns on the right show the species and the percentage of that species by number, with respect to the total number of stems per hectare in the plot. It can be seen that the percentage of some species has reduced drastically while some are missing in the present stocking of the working circle. There could be many reasons for such a situation. One can be that the preservation plot may not be a true representative of the forests of the working circle. Presuming that the preservation plot represents the forest, being adjacent to the forest under management, the glaring difference in the two lists may indicate that the crop composition has undergone changes either because of our management or some other reason one such as climate change. Such species whose percentage contribution in the growing stock has changed significantly could be put in a list of

‘suspects” which could be investigated to learn why their proportion has increased or decreased. In the present case, the species to be monitored are Tinsa, Kari, Jamun, etc., to learn why their percentage has reduced so drastically.

The exercise done here is only to demonstrate the methodology as to how the data can be used to compare the model stand structure or composition with that of the forest under consideration and draw inferences for making future prescriptions.

15.8 Method of Calculating the Increment by Carrying Out Periodic Enumeration

Enumeration is done when the working plan is under revision. Every compartment should be enumerated, by adopting appropriate sampling design so that incremental growth of the wood can be calculated. It is presumed that the record of trees removed between two enumerations is maintained. The following table gives the method of calculating the incremental growth of the stock, the incremental growth of initial stock, and the increment of in-growth separately. In this example, it is assumed that the trees in lower diameter class pass over only to next diameter class and that there is no double jump between the two inventory periods (i.e., the species do not go to the third diameter class during the period of inventory from their existing diameter class).

TABLE 15.5: CALCULATING INCREMENTAL GROWTH

Diam class	Number of trees			Basal Area Per tree m^2	Basal Area of trees (m^2)		
	1st Inventory	No. of trees Removed	2nd inventory		1st inventory	BA of trees Removed	2nd Inventory
10-20	74	4	99	0.0177	1.3098	0.0708	1.7523
20-30	42	3	56	0.0491	2.0622	0.1473	2.7496
30-40	22	2	30	0.0962	2.1164	0.1924	2.886
40-50	11	1	13	0.159	1.749	0.159	2.067
50-60	7	0.7	10	0.2376	1.6632	0.16632	2.376
60-70	4	0.3	4	0.3318	1.3272	.09954	1.3272
70-80	2	0.3	1	0.4418	0.8836	0.1325	0.4418
80-90	1	0.2	1	0.5674	0.5674	0.1135	0.5674
Total	163	11.5	214		11.6788	1.08136	14.1673

Periodic basal area growth including ingrowth = (14.1673+1.08136-11.6788) =3.5698 m2

In growth (no.of trees attaining 10+ diam.) = (214 + 11.5 – 163) = 62.5

Basal area (BA) of in growth 62.5 x .0177 =1.10625

Periodic growth of initial basal area (3.5698 – 1.10625) =2.4635 m2

Per unit growth of initial basal area = 2.4635/area of plot m2

Average basal area increment with ingrowth 3.5698/ no. of year’s m2

(In growth means the trees, which attain measurable diameter between the first and second inventory.)

(By replacing the parameter basal area by volume, we can study volume increment.)

(This exercise can be done separately for each species of the compartment for studying volume increment species-wise using local volume tables.)

15.9 References and Additional Reading

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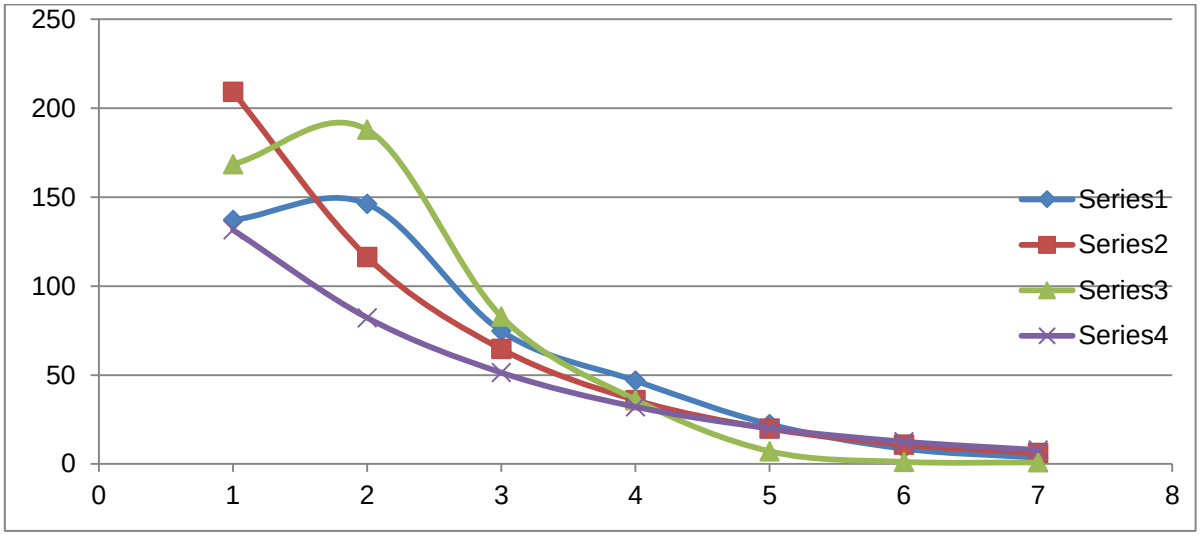
15.10 Group Exercise

Construct a balanced stand structure with q=1.6 and q=1.8 basal area (same as that of the Bhopali preservation plot) and compare with the stand structure of the selection-improvement working circle of Hoshangabad forest division. Offer your comments.

TABLE 15.6: GROUP EXERCISE TABLE

	<10	10-20	20-30	30-40	40-50	50-60	60-70
Preservation plot	137.2	146.2	74.73	46.8	22.3	8.6	3.5
Balanced q 1.8 of ppp	209.2	116.3	64.6	35.9	19.8	10.9	6.1
Existing	168.5	187.9	82.92	36.12	7.15	1.18	0.87
Balanced q =1.6	131.6	82.22	51.38	32.11	20.08	12.55	7.84

FIGURE 15.3: GROUP EXERCISE GRAPH



LECTURE 16: RESTORATION OF DEGRADED FOREST ECOSYSTEMS

This lecture covers the following:

- Definition of forest degradation
- Objectives of forest ecosystem restoration
- Principles of forest rehabilitation
- Planning for restoration

16.1 What is Ecological Restoration?

“Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed” (SER, 2004). It is a management intervention that takes action to recover an ecosystem’s structure and function, i.e., its integrity. In the context of a protected area, restoration may aim to recover a single species.

16.2 Inclusion of an Ecosystem Approach to Forest Management in the 2014 National Working Plan Code

Each territorial forest division in India is managed by a working plan that covers a period of 10 years. They are revised every 10 years The Ministry of Environment and Forests issued the National Working Plan Code (WPC) in 2014 to replace the national WPC of 2004. The new code came into effect on April 1, 2014, and all new working plans after this date are to follow it. The code’s preamble acknowledges a recent national and global paradigm shift in the approach to forest management, wherein focus is now on sustainability of ecosystem goods and services.

Chapter II of the new code defines forest management planning objectives to achieve sustainable forests and biodiversity, incorporating environmental, economic, and social considerations. The management objectives, subject to existing policies and laws relating to forests, are as follows:

- Conservation of forests,
- Reduction of forest degradation,
- Maintenance and enhancement of ecosystem services,
- Enhancement of forest productivity through regeneration to improve health and vitality,
- Progressively increased growing stock and carbon sequestration potential,
- Sustained yield of forest produce,
- Maintenance of biodiversity,
- Prevention of soil erosion and stabilization of terrain,
- Improvement and regulation of hydrological regime,
- People’s involvement in planning and management of forests, and
- Meeting people’s livelihood needs.

The forest management objectives contained in the WPC encompass the overarching principle of managing forests holistically through an ecosystem approach to forest management (EAFM). In view of recent developments and the increased importance of forests not only to produce wood but also to provide ecosystem services (in the form of biodiversity conservation, climate change mitigation, and combating desertification), this approach is gaining ground. EAFM is

a departure from traditional approaches to forest management that focused on a single objective of timber production.

The objectives of forest management and principles of EAFM must be fully understood during preparation of a new working plan and before planning field work. Field work is generally taken up to collect data and information for Part I of the working plan and future management is proposed in Part II of the plan, based on the field work. This should be presented before discussing development of the content.

A working plan may have more than one production working circle (WC), a designation used primarily to manage harvesting of forest produce and follow-up regeneration. On the extreme end is a protection WC, an area to be left untouched. WCs may overlap, for example, non-timber forest products (NTFPs), wildlife, and bamboo WCs. If a division has a sizeable area of degraded forests, a rehabilitation or restoration WC may also be considered.

This lecture offers a framework for restoring degraded forest ecosystem through EAFM. It addresses identification, classification, and categorization of degraded forests and approaches to restoring their integrity and structure to achieve increased flow of goods and ecosystem services for the benefit of society.

16.3 India's Forest Resources

India has 77 million hectares (ha) of recorded forest area (RFA), but only 54 million ha with forest cover (FSI, 2013). The main objectives of the earlier system of forest management were to conserve forests, soil, and wildlife; sustain timber yields; and meet the needs of local people consistent with the first two objectives. The working plan approach to forest planning was initiated with the sole purpose of timber extraction, and it involved resource surveys, mapping, and preparation of timber inventory.

Systematic forest management began in the middle of the nineteenth century in British-ruled colonial India with forests carved out from areas considered to be "wastelands." Prince-ruled forests also initiated some kind of organized management. Settlement of rights in many areas left tenure disputed. Nevertheless, there are still many cases of traditional forest conservation, especially in the western part of India. Kings or princes preserve certain forest areas for recreational purposes like hunting. This kind of forest preservation not only helps to conserve ecological diversity in the region but also provides a permanent supply of fodder and small timber for the peasants. A classic example was reported from the state of Rajasthan where Rajput princes had preserved a vast area of forest for hunting (Guha, 2002). Here it can be seen that a traditional hierarchical system of forest management, with power concentrated in the hands of a single person, can result in very effective management and use of forest resources over a long period of time.

In the post-colonial period too, the Indian government continued with the same legacy of forest management. The trend continued as the forest department assumed more and more power to manage forests for economic and ecological reasons. The main objective of forest management was harvesting wood and

introducing management practices borrowed from Europe. Despite the establishment of the Forest Department in the 1860s, which officially brought Indian forests under state control, communities in many parts of the country have continued to informally manage forests that are close to their villages (Saxena, 1997; Poffenberger and McGean, 1996). Government owns around 97 percent of the forest area and rest 3 percent is owned by private entities and communities in India (MoEF, 2006). However, out of the government-claimed forest area, 18 percent is un-classed land on which claims of the communities and individuals are yet to be settled. Majority of this un-classed area lies in the north-eastern states of India. Ownership claims are contested in many other parts of the country.

Though ownership of forests is largely with the government, there has been an increasing involvement of communities in the management of forests over the years. It is reported that 28 percent of forest area is managed in collaboration with communities under the JFM program. Similarly there have been efforts by companies and individual farmers to manage vegetative cover mainly outside forest area. After the 1980 Forest Conservation Act, which substantially reduced the supply of raw material from state forest lands to wood based industries, the government has been promoting plantation of trees under various agroforestry and social forestry plantation schemes. However, the majority of the forest area, about 69 percent continues to be managed by the government alone, predominantly by forest departments; 28 percent by government and communities; and 3 percent by communities and private entities. (MoEF and WII, 2005, MoEF, 2006).

Management systems included clear-cutting, shelter wood system, selection system, and a coppice system.

- Clear-cutting system: The crop is cleared by a single felling at the end of the rotation.
- Shelter wood system: May take place throughout the lifetime of the crop. Thinning may be systematic (e.g., every third tree) or selective (e.g., the 20 percent of trees with the poorest form).
- Selection system: Stands managed on a selection system are, at all times, an intimate mixture of trees of all age classes. There is no concept of a rotation length, or of a regeneration period, as both harvesting of produce and reestablishment takes place regularly and simultaneously throughout the stand.
- Coppice system: in which the crop originates mainly from stools of vegetative origin and the rotation is short is called coppice system.

At the time, it was assumed that harvested forests would grow naturally and yields would be sustained in perpetuity. After independence from the United Kingdom in 1947, the same management approach i.e., wood harvest focus was maintained with increased demand for revenues for the State Exchequer. As forests were under provincial control (beginning in 1935), revenue targets were set for forest departments with little investment in regrowing forests and replenishing harvested areas.

Beginning in the nineteenth century, forest management in India focused on increasing the proportion of those tree species that commanded higher prices: Sal (*Shorea robusta*), teak (*Tectona grandis*), deodar (*Cedrus deodara*), rosewood (*Dalbergia latifolia*), and sissu (*Dalbergia sissoo*). Mixed forests with a predominance of Sal or teak were converted to even-aged, single-species forests. The objective was to obtain normal and regular forests, where natural regeneration did not show promise, Sal or teak were encouraged through coppice. Large-scale teak plantations were established in many states after the clearing of mixed forests. Thousands of hectares were clear-felled, not only to plant teak but also to raise large-scale plantations of exotic species such as eucalyptus, poplar, wattle, tropical pine, *Acacia mangium*, *Prosopis, Casuarina, Cryptomeria, Sesbania, Leucaena, Jatropha, Robinia pseudoacacia,* and *Salix tetrasperma*. On the basis of Growing Stock forest classification- a normal forest is an ideal forest with regard to growing stock, age class distribution and increment and from which the annual or periodic removal of produce equals to the increment and can be continued indefinitely without endangering future yields.

Wherever plantations of exotic species were established after natural forests had been cleared, native vegetation and stable ecosystems were lost. Mixed forests with commercially unattractive species were subjected to clear-felling, without biodiversity conservation, ecological stability, and dependence of local people being taken into account. Thousands of hectares of exotic species-producing plantations often resulted in thousands of hectares of failed plantations and barren land—in many instances, due to the local people's need for fuel wood or a place to graze livestock.

Sal's natural regeneration became a serious issue—a subject of research and a matter of debate that still remains unresolved. The germination rate is very high (over 90 per cent), provided the seed gets rain within a week. A large number of seeds germinate annually. The seed loses its viability within a week, and so if the monsoon, which usually starts in late June, is delayed, the seed may fail to germinate. Sal is a light-demanding species, and complete overhead light is needed in most cases from the earliest stages of its development (Champion and Seth, 1968; Kayastha, 1985). After clear-cutting or cutting in shelter wood or selection teak also require plantation activities. In the Himalayas, natural regeneration of fir forests proved problematic, and research on this issue did not yield positive results.

Forest harvesting decisions were increasingly politically motivated, with vested interests (e.g., politicians, contractors, and forest officers) influencing decisions and triggering illegal logging (e.g., in northeast India). The national forest policies of 1952 and of 1988 failed to achieve their objectives by raising steadily the area under forests to 100 million hectares or 33 percent of the total geographical area in the country. It would require additional 29.5 mha of area to be vegetated. This target seems to be more theoretical than practical and achievable. There has been an increase of only 5.71 mha in forest cover over last 28 years (i.e., from 1987 to 2013 due to financial, technical, and land availability issues [Aggarwal et al., 2009; FSI, 2013]). Forest and tree cover for last ten years have stabilized with a very marginal increase. Hence, it is very difficult to achieve a target of 33 percent. The judiciary

came to the forests" rescue in 1995 with Godavarman vs. Union of India, which concerns implementation of the Forest Conservation Act of 1980 (still pending adjudication). This case has given rise to a number of Supreme Court directives with far-reaching effects on forest management. These include a ban on green tree-cutting in the Himalayas in areas higher than 1,000 meters above sea level, compensatory afforestation, and implementation of working plans for territorial forest divisions. This pattern of ownership and management of forests is representative for many States of the country except the northeast states where forests predominantly are owned and managed by local communities.

16.4 Forest Characteristics

India's variety of forests is the result of different altitudes, rainfall amounts, and soil diversity. The country contains 16 forest types, varying from moist tropical littoral forests to temperate and sub-alpine forests, from temperate Himalayan forests to swamp forests, and from dry and moist deciduous forests to evergreen and semi-evergreen forests.

The legal status of recorded forest area in India (FSI, 2015) is as follows:

TABLE 16.1: LEGAL STATUS OF INDIA'S RECORDED FOREST AREA

Legal Status	Area (Million Hectares)
Protected Forests	20.94
Un-classed Forests	42.50
Reserved Forests	13.01
Total	**76.45**

Eighty percent of India's forests are natural forests that grew from seeds. Plantations make up only 5.3 percent of India's forests (unlike in Europe where the bulk of managed forests are of plantation origin).

TABLE 16.2: ORIGINS OF INDIA'S FORESTS

Origin	Percentage of RFA
Seed origin	80.7 %
Coppice	14.0 %
Plantations	5.3 %

16.5 Forest and Tree Cover Classification and Extent

The Forest Survey of India (FSI, 2015) divides all forests, based on crown cover, into four categories:

- **Very dense forests**—Canopy density above 70 percent;
- **Moderately dense forests**—Canopy density between 40 and 70 percent;
- **Open forests**—Canopy density between 10 and 40 percent; and
- **Scrub forests**—Canopy density below 10 percent.

Total forest cover includes both Recorded Forest Area (RFA) (52.76 million ha) and outside RFA (17.4 million ha).

The total forest cover is thus 70.10 million ha - 21.34 percent of the country's total geographical area. The proportions of the density categories are presented in Table 16.3.

TABLE 16.3: INDIA'S FOREST AND TREE COVER

Category	Area (Million ha)		
	Within RFA	Outside RFA	Total
Very dense forests	7.22	1.37	8.59
Moderately dense forests	25.52	6.01	31.54
Open forests	20.91	10.02	30.04
Total forest cover	**52.77**	**17.40**	**70.17**
Trees outside forest (TOF)			**9.26**
Total forest and tree cover			**79.41**
Scrub	4.14		

Source: FSI, 2015

Trees outside forest (TOFs) occupy 9.26 million ha, which is 2.82 percent of the country's geographical area. TOFs are patches of trees in areas smaller than 1 ha that cannot be captured in satellite images.

16.5.1 Growing Stock

The estimated total growing stock in RFA is 4, 195 million m^3, which results in an average growing stock of 54 million m^3. The highest average growing stock is in the western Himalayas (985.5 million m^3), followed by the east Deccan (698.5 million m^3) and the eastern Himalayas (410.5 million m^3). The lowest average i.e., 10.26 million m^3 growing stock is in the country's western plains.

16.5.2 Natural Regeneration

Natural regeneration is estimated to be adequate in 48 percent of forests, inadequate in 24 percent, and absent in 10 percent; data are not available for 18 percent of India's forests.

16.5.3 Grazing

Most forest areas are subject to unregulated and heavy grazing by local and migratory livestock beyond the land's carrying capacity. Adverse impacts of heavy and unregulated grazing include:

- Crushing of tree seedlings with grasses;
- Reduced porosity of soil (poor aeration);
- Increased soil compactness;
- Increased runoff;
- Depletion of nutritive palatable grasses; and
- Severe land degradation.

16.5.4 Forest Soil

About 30 percent of India's forests have soil depths that are very shallow or shallow (30 cm or less from the surface). About 70 percent of forests have medium to deep soil depths (30 to 90 cm), including 34 percent of forests with soil depths of more than 90 cm.

TABLE 16.4: INDIA FOREST SOIL DEPTHS

Soil Depth (cm)	Depth Class	Forest Percentage
0	No soil	0.52
Up to 15	Very shallow	7.72
Up to 30	Shallow	23.06
Up to 90	Medium	35.14
90 to 120	Deep	33.56

Source: FSI, 2015

16.5.5 Humus Cover and Organic Carbon Content

About 17 percent of India's forests have medium to deep humus depths, about 53 percent have shallow humus, and the remaining 30 percent of forests are devoid of humus. The degraded state of sites are reflected from poor soil under ongoing sheet soil erosion.

TABLE 16.5: INDIA FOREST HUMUS DEPTHS

Humus Depth (cm)	Depth Class	Forest Percentage
0	No humus	29.72
5	Shallow	52.96
10	Medium	14.92
>10	Deep	2.40

Source: FSI 2015

Soil organic matter is mainly composed of carbon, hydrogen, and oxygen but also contains small amounts of nutrients (e.g., nitrogen, phosphorous, sulphur, potassium, calcium, and magnesium) within organic residues. Organic matter makes up no more than 10 percent of soil mass, but it plays a critical role in physical, chemical, and biological functioning of the soil. Carbon is a measureable component of soil organic matter. According to FSI (2015), the highest organic carbon contents are found in soils in the Himalayan Temperate (types 11, 12, 13), Sub-Alpine Forests (type 14), and Alpine Scrub (type 15), Subtropical Broadleaved Hill Forests (type 8), and Wet Evergreen Forests (type 1). Organic carbon levels are lowest in Tropical Thorn Forests (type 6), Tropical Dry Deciduous Forests (type 5), Tropical Moist Deciduous Forests (type 3), and Littoral and Swamp Forests (type 4).

16.5.6 Soil Erosion

The highest levels of erosion are found in wet temperate (type 1) and montane wet (type 8) forests. Himalayan temperate forests do not have heavy erosion. Tropical dry deciduous forests experience moderate erosion (FSI, 2015). The FSI (2015) states the current status of soil erosion classes in the country as heavy (2.82 percent), moderate (16.54 percent), mild (67.66 percent), and no erosion (12.98 percent).

16.5.7 Other Characteristics of India's Forests

- ***Ground flora and undergrowth.*** According to FSI (2015), about 50 percent of India's forests have scant or no grass or undergrowth.
- ***Forest fires.*** India's forests are affected by fire each year: in 2.40 percent of forests, the fires are heavy; in 7.49 percent, they are moderate; and in 54.40 percent, they are mild. 35.71 percent of forests experience no fires annually.
- ***Illegal felling and lopping.*** 68.12 percent of forests are subject to illegal felling, girdling, and lopping; 26.72 percent are top tree drying of blazing of trees & other injuries. However, only 5.06 percent are with no injuries..
- ***Biodiversity.*** India is one of 17 mega-biodiversity countries in the world. However, the forest biodiversity is characterized by forest fragmentation and structural complexity.

16.6 Forest Ecosystem Degradation

About 80 percent of forest in India is under-stocked and/or degraded. Present forest conditions are the cumulative effect of more than 150 years of active forest management centered on exploitation of commercially important tree species. About 80 percent of forests are natural or high forests that have seed origin. These were primary forests before large-scale disturbances took place. Some forests areas were spared disruption because of remote locations, inaccessibility, or lack of market demand for the resources within them.

Degraded forests are the result of logging, whether legal or illegal (i.e., conducted by government agencies for revenue generation, local people trying to meet their domestic needs, or timber thieves).

Scrub forests and open forests can be included in the degraded forest category. Forests with 40-70 percent crown density are classed by the FSI as "moderately dense." The extent to which forest areas have crown densities of 40-50 percent, 50-60 percent, and 60-70 percent is unknown. However, it is apparent that these areas are under-stocked and are producing sub-optimally. According to one estimate, 35 million ha of India's forests are degraded (Khan, 1987).

Crown density assessed from satellite images is not a reliable indicator of forest stocking, health, and productivity. Spaced out trees tend to have bigger crowns and are often closer to other crowns. In a dense forest, crowns are constricted, elongated, self-pruning, and intertwined with neighboring trees. Secondly, crown cover seen from satellites cannot provide information on second story or multiple layers of canopies or undergrowth. A ground survey is needed to obtain a true picture of forest conditions.

16.7 What is Degradation?

Forest ecosystem degradation can be defined as changes that affect the structure, composition, functioning, and productivity of a forest stand or site, thereby lowering its capacity to supply products or services.

Degraded forests are forest areas that:

- Have reduced capacity to produce goods and services;
- Deliver a reduced supply of goods and services from a given site;
- Maintain only limited biological diversity; and
- Have lost the structure, function, species composition, and/or productivity normally associated with the natural forest type expected at that site.

Land resource degradation is a result of vegetation degradation, fragmentation, biodiversity loss, and reduced cover due to overexploitation for wood, heavy and unregulated grazing, invasion of alien exotic species, etc. Land degradation is also caused by erosion, soil compacting, nutrient mining, salinity, sand cover, and contamination.

Clear indicators of degraded forests in India are shallow, very shallow, and deep soils in 70 percent of forests; shallow or nil humus in 80 percent of forests; low organic soil carbon; and sheet, rill, and gully erosions.

16.7.1 Drivers of Ecosystem Degradation

The following are drivers of forest ecosystem degradation:

- Excessive and unregulated grazing,
- Destructive and heavy fuel wood extraction by local communities,
- Manmade fires (mostly) and natural wildfires (rarely),
- Illegal tree-cutting,
- Heavy logging in the past,
- Unclear land tenure in some areas,
- Encroachment by local people, and
- Land and soil degradation.

16.8 Primary, Secondary, Degraded, and Depleted Forests

16.8.1 Primary Forest

A primary forest can be defined as “forests that have never been disturbed by human beings or these have had negligible hunting or removal of wood so as not to change structure, composition, and biogeochemical processes.” Such forests exist in remote areas far away from human habitation and access.

16.8.2 Modified Natural Forests

Primary forests are modified through management interventions or exploited for timber, fuel wood, NTFPs, wildlife, or other purposes.

Modified natural forests fall into two categories:

- **Managed primary forests:** These forests have been subjected to sustainable harvesting (of forest products and silviculture operations), wildlife management, and other uses, resulting in changes in structure and composition. They have more or less lost their original form, although the main products and services are intact and ongoing.
- **Degraded primary and secondary forests:** These forests and forest lands have been changed due to human action. In these forests, the natural primary forest processes do not exist due to either natural causes (e.g., lightning, fires, landslides, storms, or floods) or over use.

  These forests may be categorized into three types:

  a. ***Degraded primary forests.*** These are primary forests where forest cover has been reduced due to overexploitation for wood, NWFPs, or heavy grazing, altering its structure, functions, and biogeochemical processes and surpassing ecosystem resilience (i.e., loss of capacity to recover in the short or medium term).

  b. ***Secondary forests.*** These are forests that have grown in areas where primary forests were cleared, and the primary forests areas therein are 10-12 percent or less. Secondary forests commonly develop naturally on lands abandoned after agriculture, pastures, mining, shifting cultivation, or failed tree plantations.

  c. ***Degraded forest land.*** Forest land that is badly damaged due to excessive woodcutting (like clear-felling), extremely heavy grazing, successive forest fires, or other disturbances or land use changes that make recovery difficult or prolonged.

There are following categories of secondary forests:

1. Clearcut and replanted with a few commercially important species,
2. Harvested selectively or under shelter wood system with natural regrowth,
3. Clear cut or left with some seed trees for managing under coppice system,
4. Harvested to promote single species monoculture for economic objectives,
5. Failed plantations, and
6. Heavily grazed areas with middle aged trees.

16.8.3 Planted Forests

Planted forests are raised through afforestation, reforestation, or enrichment planting, through assisted natural regeneration (ANR) or gap planting.

According to Planing Commission, GoI (2008) the degraded forest area can be divided into lightly degraded, moderately degraded and highly degraded depending upon the age and density of the rootsock. In the “lightly degraded forests”the density of root is more than 2000 live root stumps per hectare and the age of the rootstock is

not more than 40 years. Natural regeneration through coppice is the main stay of this treatment practice. In the “moderate degraded forests”degradation process starts normally 20-30 years back.The density in such category of forests is less as compared to lightly degraded forests the age of the live rootstock is not more than 60 years and natural regeneration is completely absent. The gap planting is done with 500 trees per hectares. In each areas two types of treatments carried out during October-December months to prevents damage to the growing stock during ranining season. The “highly degraded forest areas” are devoid of existing rootstock but if it exists ots age is more than 100 years. More plantation of multiple species including 30 percent fodder species is the major treatment with 750 trees per hectare along with intensive soil and moisture conservation work.

Degraded forests can also be, based on crown density, categorized as follows:

1. Slightly degraded density 70-90 %
2. Moderately degraded density 40-70%
3. Very degraded density 10-40%
4. Highly degraded (scrubs) density 0-10%

In India, primary forests are rare as all forest has been subject to some kind of disturbance. Domestic livestock have reached inaccessible locations, particularly hilly areas that cannot be cultivated in an organized manner. The protected WCs have undergone heavy grazing and fuel wood harvesting, including lopping. Forests in protected areas have been logged in the past and some even hold exotic tree species plantations. Thus, almost all of India’s forests are secondary forests. Secondary forests are prone to desertification in the long term.[1]

16.8.4 Coppice Forests (Potential Degradation)

In some areas, tree species such as Sal and teak have been regenerated by coppice. In locations where harvested areas have been abandoned, stumps often give out multiple, competing shoots. Active management interventions, where all shoots are cut except for those that are the most promising and vigorous, have yielded green and even-aged stands. These forests yield poles but not good quality timber. Coppice forests have poor soils, low organic matter and humus layers, and poor undergrowth. These forests need to be replaced by seed origin plantations.

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[1] Desertification is land degradation in arid, semi-arid, and sub-humid areas. (rainfall 0-300 mm; 300-600 mm; 600-1000 mm). Many areas are prone to desertification in tropical dry forests. Further degradation of these ecosystems will lead to desertification.

16.8.5 Degraded Plantations (Poorly Stocked and Failed Plantations)

"Degraded plantation" is a class of forests where mixed species forests were clear-felled or where barren lands were planted to establish plantations and then the plantations failed or became degraded and poorly stocked. Reasons for degradation include poor maintenance and protection, site species mismatch, poor soil working, poor planting stock, illegal harvesting by local people, heavy grazing, and fires caused by human activity.

16.9 Characteristics of Degraded Forest Ecosystems

Due to continued stress and disturbances, many forest ecosystems in India have become degraded. Whereas some biogeochemical processes are still ongoing in secondary forests with degraded ecosystems, they often are not in equilibrium and operate at a low level. Secondary forests have lost much biodiversity in terms of species composition and structure.

Degraded forests differ in overall biomass, climatic conditions, soil depth and fertility, erosion intensity, causes for degradation, grazing incidence, vulnerability to fire, and previous vegetation type. A degraded forest ecosystem may have tree density between 20 and 40 percent, at 10 percent, or may have no trees at all. There may be shrubs and invasive alien species. The site may be badly eroded or be prone to drought. Rehabilitation strategies will need to respond to site conditions, necessitating preparation of site-specific plans.

Many degraded forest ecosystems have different tree densities and contain large gaps. Even-aged forest stands, a result of manipulation by management under working plan guidelines, may be the result successive cutting of mature trees or a selection system to remove large trees in 20–25-year cycles. In these forests, new young trees are missing or are scarce. These types of forests are seen in many regions of the country.

Poor undergrowth is an indication of heavy grazing and cutting of woody shrubs for fuel wood. Natural regeneration in degraded forests is inadequate or missingThousands of hectares of forests are covered with invasive alien species such as Lantana and Eupatorium. Heavy grazing also encourages survival of non-palatable grasses and shrub species.

People living in many areas of Western Ghats, West Bengal, and Orissa remove fallen leaves from forest floors. They use leaves as fuel for their households or to boil Areca nuts or conduct other commercial activities.

Lopping of trees is common for animal fodder and fuel wood. Girdling is also common in many areas. Girdling, also called ring-barking is the complete removal of a strip of bark (consisting of cork cambium, phloem, cambium and sometimes going into the xylem) from around the entire circumference of either a branch or trunk of a woody plant. These activities have also caused degradation.

Degraded forests are also characterized by poor biodiversity, in that species numbers have declined from original forest levels. Heavy and indiscriminate

exploitation of NTFPs can damage producer plants, resulting in degraded forests. Protection WCs spared from commercial logging may become degraded if situated near sites of human habitation due to grazing and fuel wood and illegal timber exploitation.

16.10 Tropical Dry Deciduous Forests: Vulnerability and Management Challenges

Of the 16 forest types tropical dry deciduous forests account for the largest share (38.2 percent of the total forest area). India has 29.40 million ha of tropical dry deciduous forests. These forests are subjected to:

- Water scarcity or drought,
- Climate change and variability,
- Intense heat waves,
- Occasional heavy monsoon precipitation, and
- Strong hot breezes, wind storms.

The results of this stress include:

- Massive top dying or dieback,
- Pest attacks,
- Low water retention capacity, and
- Large-scale floods.

16.11 An Ecosystem Approach to Restoration and Rehabilitation of Degraded Forest Ecosystems

It is possible to rehabilitate and restore ecosystems that have been damaged by human actions. If not all, at least some of the harm the human species has inflicted on nature is reversible through ecological restoration.

16.11.1 Traditional Response

Rehabilitation of degraded forests has been attempted in the past through the following methods. These have met with both successes and failures.These responses include the following:

- Plantations of
  - Commercially valuable monoculture species, and
  - Exotic species such as eucalyptus, acacia, *Cryptomeria,* and *Robinia pseudoacacia;*
- Assisted natural regeneration; and
- Enrichment planting or gap planting.

16.11.2 Ecological Restoration

Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed (SER, 2004). It is a management intervention that takes action to recover an ecosystem's structure and function, i.e., its integrity. In the context of a protected area, the restoration may aim at recovering a single species.

16.12 Restoration, Rehabilitation, and Reclamation or Replacement

16.12.1 Restoration

The dictionary's definition of *restoration* is "the action of returning something to a former owner, place, or condition." This implies that a building, position, or, in our case, an ecosystem has to be brought to an unimpaired and healthy state. Restoration thus means to recreate an ecosystem similar to that which originally existed at the site. A site so restored will contain most of its original flora and fauna species, and its structure and productivity levels will matches those originally present.

16.12.2 Rehabilitation

Rehabilitation is the action of restoring something that has been damaged to its former condition, e.g., the rehabilitation of the mangrove forests. The terms rehabilitation and restoration are used interchangeably although their technical meanings vary. The term "rehabilitation" is used where the original productivity or structure is recovered as well as some of the original biodiversity.

16.12.3 Reclamation or Replacement

Reclamation is the recovery or retrieval of something, i.e., bringing wasteland under cultivation. The term is used in situations where productivity is recovered but biodiversity is not (in fact, native species may not be used at all). There are few, if any, benefits to landscape biodiversity when reclamation is implemented, but there may be social or economical advantages, or functional gains such as improved watershed protection.

All three of these approaches differ in the degree to which they affect biodiversity (structure and composition) compared to the original ecosystem. However, they do serve to restore productivity, production of goods, and some services like watershed protection (Lamb and Gilmour, 2003).

16.13 Is Ecological Restoration Possible?

Restoration is a difficult undertaking both in principle and in practice. The definition of restoration implies that the identity and population sizes of various plants and animal species once present at particular sites are known. This rarely is the case. In most cases, the best that can be done is to infer the nature of the original ecosystem from previous descriptions or remnants of ecosystem communities. The definition also implies that these communities were static and would have remained unchanged over time. However, this is also unlikely to be the case. Many communities undergo

successional change, often over hundreds of years. Even mature ecosystems commonly exist in a state of dynamic equilibrium; changes occur in their composition, even in the absence of degradation.

In addition, our knowledge of ecological processes is imperfect and our capacity to predict, let alone direct, ecological succession is limited. In many cases, chance events such as weather or timing of flowering and seeding have a major effects on the way successions develop. This means it might be difficult to achieve a particular outcome even if the target could be ascertained. Further, the large numbers of plant and animal species present in many communities mean that the ecology of species is poorly known. This makes it difficult to assist or encourage them to re-enter a degraded site.

The target might also become unattainable because some of the original species have become extinct. Exotic species may have become naturalized after a long period of human intervention. Such is likely to be the case, for example, with the ecosystems of Europe and the Mediterranean basin or in China. In these cases, simply fostering species-rich communities might be a more appropriate goal. In other situations, the extent of topsoil loss, site exposure, or changing salinity levels may be so great that restoration would be too expensive even if the technical means were available.

Social constraints may also apply. Traditional owners or users of degraded lands may be unwilling to agree to restoration because it is not a goal they share or because they believe that it will lessen their rights to future use. In such cases, intervention from outside persons or organizations is unlikely to succeed. These problems mean that attempts to “ecologically restore” forests may at times be unrealistic. It may be more appropriate to aim at more modest goals, such as recreating a forest with a large species diversity and a structure and function similar, but not necessarily identical, to that originally present (Lamb and Gilmour, 2003).

Restoration may not be easy. Restore missing functions fairly completely is possible, but reverting to the original structure of an ecosystem may be more difficult (Bradshaw, 1996). Recreating the original ecosystem, according to some experts, can be achieved by observing a virgin forest in the vicinity, or similar ecological zone, and copying it. Some people also suggest that data from preservation plots should be used to see what kind of composition existed in a similar area. However, preservation plot measurements indicate only tree species that existed at the time the plot was laid out. Information on all ecosystem elements like shrubs, herbs, climbers, grasses, and biodiversity is not going to be available. Secondly, forest ecosystems are always changing, and the composition of biotic elements that existed in the past may not be present. Proportion of species may have changed as some species become extinct, new species migrated, and populations changed with natural succession and evolution processes.

Restoring a degraded ecosystem to the original condition is neither practical nor desirable, and any attempt to mimic it may be extremely costly. However, attempts

can be and should be made to bring damaged ecosystems close to their natural states.

16.14 Close to Nature Forestry

Close to nature forestry is a theory and practice that takes the forest as an ecosystem and manages it as such. It is based on reduced human intervention that should be directed to accelerate the processes that nature would do by itself more slowly. (Turckheim, et al., 2005). When restoring an ecosystem to its natural state, an important strategy is to mimic nature. Close to nature forestry is a sustainable forestry, but the reverse does not apply. These are some of the distinctions between both systems.

- Sustainable forestry tries to preserve forests for the future, close to nature forestry aims to improve them.
- Sustainable forestry seeks a balance between competing interests; close to nature forestry integrates mutually interacting interests.
- Sustainable forestry aims to restrain forestry practice in order to preserve ecological values, close to nature forestry uses ecological principles to promote forestry results.

One of the basic objects of the National Forest Policy 1988 is conserving the natural heritage of the country by preserving the remaining natural forests with the vast variety of flora and fauna, which represent the remarkable biological diversity and genetic resources of the country

Environmental Information System (ENVIS) Centre, Kerla states that the forest of Kerala is mainly classified into 5 major categories. The coverage of the plantations forestry is to the extent of 13.5 percent of the total area. There are considerable variations in forest type, the predominant three broad types being tropical moist deciduous forests from the plains to 750 MSL, tropical wet evergreen forests in the mountain ranges of ghats and tropical semi evergreen forests between these two types. These three types together cover most of the natural forest area. According to the FSI reports 2009, the coverage of the plantations forestry is to the extent of 29.97 percent of the total area.

The oldest teak plantation of India was raised in Nilambur of Kerala State during 1840s. About 20,000 ha area was brought under teak until 1960. Although regular plantation activity started during the second five year plan, greater momentum was achieved after 1980s. During 1980 to 1985, a total of 1,17,630 ha of area was under plantations of different species and this was increased to 3,10,830 ha in 1985-1990. Later on, the trend reversed and there was decline in plantation area to 85,300 ha in 1990-95 and to 1,03,750 ha in 1995-2000. Presently only the existing areas under plantations are managed and no more natural forest area is converted into plantation. The trend in reduction in establishment of plantation and current strategy of non-conversion of natural forests into plantation is a positive indication toward sustaining the status of the natural ecosystem which in turn also improves the

indigenous biodiversity of the State. These types of initiatives and practices will help India in moving *toward an ecosystem approach to forest management, applying principles of "Close to Nature Forestry."*

Continuous cover forestry

Continuous cover forestry is another ecosystem approach to forest management where efforts are made to develop mixed species, uneven-aged, and multiple story forestry structures that is more ecologically stable and resilient compared to even-aged monoculture. A structure containing native species will help to cope better with climate change-associated stresses and will be more adaptable. Under this approach, sustainable harvesting are used based on a selection system to maintain continuous forest cover.

16.15 Restoration Types and Objectives

The two types of management interventions for restoring degraded ecosystems are as follows (Lamb and Gilmour, 2003):

1. **Biodiversity-focused intervention**
    a. Passive restoration
    b. Enrichment planting
    c. Direct seeding
    d. Scattered tree planting
    e. Close-spaced planting
    f. Intensive ecological reconstruction using dense planting of many species
    g. Intensive ecological reconstruction after mining
2. **Biodiversity- and productivity-focused intervention**
    a. Secondary forest management
    b. Enrichment planting
    c. Agroforestry
    d. Monoculture plantations using indigenous species
    e. Monoculture plantations and buffer strips
    f. Mosaics of species monoculture
    g. Mixed species plantations
    h. Encouragement of understory development

One should be clear about the objectives of rehabilitating degraded forests. These include:

- Production of timber
- Production of fuel wood
- Carbon sequestration
- Biodiversity conservation
- Development of pasture
- Protection of watershed
- Conservation of soil
- Habitat for wildlife
- Improving aesthetics

Once the objectives are clear, site conditions that can support a specific operation must be considered. For example, shallow soil may not support long rotation timber trees. Rocky outcrops with negligible soil layer may support only grass. An intervention must be directly related to restoration objectives and is subject to site conditions.

16.16 Restoration at the Landscape Level

Forest **landscape restoration** is a process that aims to regain ecological integrity and enhance human well-being in deforested or degraded forest landscapes. Some of the methods for forest landcape restoration are given below:

- Site level
- Reclamation
- Rehabilitation
- Replacement
- Restoration

Natural recovery without intervention

Some degraded sites are able to recover naturally, but many do not. The reasons for this include:

- Few original plants remain at the site;
- Change in biophysical environment (e.g., soil fertility); and
- Repeated disturbances that preclude successional development.

A landscape focus is suggested (over a focus on individual ecosystems), as it involves a mosaic of land uses (e.g., protected areas, wildlife corridors, tree plantations, agriculture, or agroforestry). Trade-offs may need to be made, such as the balance between maximizing carbon sequestration and productivity of commercial species, or enrichment of biodiversity. Landscape restoration is done for

multiple objectives. The ultimate aim is to restore ecological integrity for promoting resilient ecosystems and the ability to ultimately become self-sustaining. Resilient ecosystems are able to withstand disturbances and readapt while undergoing change to retain some functions, structure, and identity (Stanturf et al., 2015).

16.17 Restoration Strategy

- Identify the drivers of degradation such as overexploitation, heavy grazing, or invasive species.
- Stop abuse by eliminating or strictly reducing these drivers. This would include adding nutrients to depleted soil, adding new top soil, preventing fires, and controlling and eliminating invasive species.
- Protect the area from further degradation.
- If necessary reintroduce pioneer, keystone, and foundation species to help restore ecological processes (Tytler and Spoolman, 2009).
- Rehabilitate forests to be as close to natural forests as possible.
- Restore production system and enhance productivity of ecosystem goods and services that could be used on a sustainable basis for the benefit of society.
- Create multiple-age and multiple-species forests, which are more stable and resilient to climate change stress.
- Use native species.
- Regrow and manageproductive plantations as they are.
- Encourage biological diversity.
- Promote small, understory trees, shrub, and herb species.
- Plant nitrogen-fixing species of understory plants and shrubs to improve soil fertility.
- Replace exotic species by native species
- Replace coppice growth by seed origin growth
- Replace monoculture by mixed species
- Replace even-aged by uneven-aged stand

16.18 References and Additional Reading

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MODULE 6: FOREST GOVERNANCE

Since forests product such a variety of services, stakeholders are so many, and vested interest of such a long duration, that no discussion of forest management would be complete without a lecture on governance from a social science perspective.

Most forest lands in India are owned and managed by the State, either by national or state governments. Management tended to be by a top-down model. However, there is now national acknowledgement that increasingly private citizens are affected by the management of forest lands and should have a voice and agency in the management of the forest resource base. This is congruent with the understanding in EAFM of the importance of a multi-stakeholder, multi-disciplinary approach to forests management.

The lecture in this module covers how forest resource goveranance can be mainstreamed, specifically in India through Working Plans.

LECTURE 17: MAINSTREAMING FOREST GOVERNANCE

This lecture covers the following:

- Mainstreaming of forest governance
- Critical analysis framework of policy, legal, and institutional governance for working plans

17.1 Introduction

The paper is divided into two broad sections. The first section explores the concept of governance in a general context as well as the principles of good governance and challenges that impede the governance process. The second section focuses specifically on forest governance. The principles of good governance, identifying stakeholders, assessing governance, and challenges and building synergies for good governance in the forest sector are also discussed. The concluding section talks about inter-sectoral linkages in the forest sector.

17.2 Governance

The concept of governance is as old as human civilization. Governance can have a variety of meanings, depending on the context.

The World Bank defines governance as *"the traditions and institutions by which authority in a country is exercised."* Legality, legitimacy and participation are key attributes of the rules and processes associated with governance (World Bank, 2004).

It supports coherence, integrates policies, and strengthens the implementation of legislations and policies. It is the process of decision-making and the process used to implement decisions.

It is believed that the governments have the sovereign authority to develop rules governing problems in their own authority. However, governance is not the sole purview of the state, but rather emerges from the interactions of many actors, including the private sector and not-for-profit organizations.

Governance involves multiple actors, among which government is one of the key actors. These multiple actors articulate their interests, influence how decisions are made, who the decision-makers are, and what decisions are taken.

The need for governance exists anytime a group of people come together to accomplish an end. Though the literature proposes several definitions of governance, most rest on three dimensions: authority, decision-making, and accountability (Institute on Governance [IOG]).[1]

Governance is also a highly contextual concept. Governance can have several different meanings depending upon the context—be it political, geographical, social, economic, legal, or environmental. The process and practices that apply will vary

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[1] The Institute on Governance was founded in 1990. IOG's mission is advancing better governance in the public interest, which the Institute accomplishes by exploring, developing, and promoting the principles, standards, and practices which underlie good governance in the public sphere.

significantly given the environment where they are applied. When working in the field of governance, one operates in an area where one size does not fit all.

Governance in the public sector needs to take into account the legal and constitutional accountability and responsibilities. In the nongovernmental sector, representing stakeholder interests may be a deciding factor in the governance to be applied.

17.2.1 Good Governance and Bad Governance

Good governance is transparent, responsive, effective, and efficient, and follows the laws. It also allows equal participation of all stakeholders at all levels of decision-making (Sheng, n.d.). Good governance ensures that political, social, and economic targets are based on consensus; the poor and vulnerable in the society are represented in decision making and allocation of resources.

TABLE 17.1: THE UNITED NATIONS DEVELOPMENT PROGRAM (UNDP) MAJOR PRINCIPLES OF GOOD GOVERNANCE (UNDP, 1997)

Principles	The UNDP Principles and related UNDP text on which they are based
Legitimacy and Voice	**Participation—**all men and women should have a voice in decision-making, either directly or through legitimate intermediate institutions that represent their intention. Such broad participation is built on freedom of association and speech, as well as capacities to participate constructively. **Consensus orientation—**good governance mediates differing interests to reach a broad consensus on what is in the best interest of the group and, where possible, on policies and procedures.
Direction	**Strategic vision—**leaders and the public have a broad and long-term perspective on good governance and human development, along with a sense of what is needed for such development. There is also an understanding of the historical, cultural and social complexities in which that perspective is grounded.
Performance	**Responsiveness—**institutions and processes try to serve all stakeholders. **Effectiveness and efficiency—**processes and institutions produce results that meet needs while making the best use of resources.
Accountability	**Accountability—**decision-makers in government, the private sector and civil society organizations are accountable to the public, as well as to institutional stakeholders. This accountability differs depending on the organizations and whether the decision is internal or external. **Transparency—**transparency is built on the free flow of information. Processes, institutions and information are directly accessible to those concerned with them, and enough information is provided to understand and monitor them.
Fairness	**Equity—**all men and women have opportunities to improve or maintain their well- being. **Rule of Law—**legal frameworks should be fair and enforced impartially, particularly the laws on human rights.

These characteristics have come to be the mirror that reflects good governance, and they are widely seen as the key factors to ensure social, economic and national development.

Bad governance is associated with inequitable growth, social exclusion, and lack of trust in authorities. It is often regarded as one of the root causes of corruption within a system with no place for the rule of law. Bad governance is characterized by absence of participation and consensus orientation.

17.2.2 Challenges to Governance (OECD, 2009)

The major governance issues, which are important in the current global scenario, are identified as: evidence-based policymaking, integrity in the public sector, coordination of policies and programs across levels of government, and fiscal sustainability.

In dynamic environments, there is an imperative on governments to act. While resulting policies have clear immediate objectives, they may also have profound and long-lasting consequences. Tools such as regulatory impact analysis can help government's base policy decisions on evidence and assess their actual impacts and consequences. The expanded role of the government in the economy requires governments to be especially vigilant that the principles and practices of integrity are upheld. To improve the long-term sustainability of programs and policies, governments may use long-term fiscal projections more frequently and systematically.

17.3 Evolution of Governance Discourse in the Forest Sector

Ever since societies understood the adversities of human activities on the forests, assessing the best way to manage forests has been discussed at the global level. Over centuries, the nature of discourse has changed, but the issues relating to human activities and the state of the forests has always been at the core. It has been concluded that if the forest sector is to be sustainable, the forest management—apart from the forest managers—must involve the people who live in the forests as well the people who derive their livelihoods from the forests.

The increasing forest illegality, in terms of forests crimes and corruption, has led to the loss of public revenue and diminished the reputation of several forest agencies in the eyes of the public. In developing countries, illegal logging on public land causes estimated annual losses of US $10 billion in assets and revenue.[2]

The unpredictable business environment has also led to short-term profit maximization and discouraged socially and environmentally responsible long-term investments in the forest sector. In a study prepared for the Australian government, after deduction for consumer benefits, the combined net market costs (financial costs to legal producers) and nonmarket (environmental and social) costs globally were estimated at US $15 billion a year (Center for International Economics, 2010).[3] Poor

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[2] More than six times the total official development assistance dedicated to the sustainable management of forests (World Bank, 2006).

[3] These rough global estimates give an idea of the magnitude of the problem but mask country-specific variations (PROFOR, 2011a).

governance and corruption perpetuates illegal behavior that is notable in economic, equity and financial impacts to the stakeholders.

The forest sector saw many sustainable initiatives since the 1990s with the emergence of international initiatives such as UN Intergovernmental Panel on Forests (IPF) and the UN Forum for the Forests (UNFF). Private-sector schemes such as the Forest Stewardship Council (1993) and the Sustainable Forestry Initiative (SFI) were also established. These initiatives, to curtail forest illegality and promote sustainability, were thought to address the global concerns in the forestry sector.

A review by the World Bank's Operations Evaluation Department (OED) of the performance of the Bank's 1991 Forest Strategy (Lele et al., 2000) pointed out the failure to address governance issues as a serious gap in the Bank's work in forestry. The review recommended that the Bank help reduce illegal logging by actively promoting improved governance and enforcement of laws and regulations. As a result, the Bank placed forest governance and illegal logging high on the agenda in its 2002 Forest Strategy.

Forests ensure the sustainability of environmental services such as biodiversity conservation, carbon sequestration, and watershed protection.[4] If not managed properly in a sustainable manner, all these services are at risk. Thus, global efforts such as Reducing Deforestation and Forest Degradation program (REDD) emphasize the fundamental importance of good governance.

Governance reforms are a sensitive issue; hence the global dialogue is often complicated by the view that reform is a matter of national sovereignty. In this environment, the legality of global forest trade is seen as an issue in which consumer and producer countries could join forces to improve the law in the forest sector. Regional and sub-regional international political partnerships such as the ministerial conferences in Bali (2001) for Asia, Yaounde (2003) for Africa, and St. Petersburg (2005) for Europe and Central Asia, have created a regional momentum for governance reform and have led to tangible efforts (such as the Association of Southeast Asian Nations [ASEAN]) to promote field-level implementation.[5]

Several regional initiatives have emerged in which the governments of client and producer countries, the private sector, civil society, and international development partners are cooperating to improve forest governance. The European Union (EU) has been negotiating bilateral voluntary partnership agreements (VPAs) with

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[4] These environmental services cannot be commonly traded in the markets, as they are not directly consumable. However, they have been recognized to have most market potential for promoting sustainable forest management. (Katila and Puustjärvi, 2004).

[5] For recent initiatives to curtail illegal logging, see Brown et al. (n.d.a).

producer countries to establish national licensing schemes that will ensure the legality of exports to the EU markets. The EU is supporting Forest Law Enforcement, Governance and Trade (FLEGT)[6] and VPA-related capacity building in many countries and has become a major donor for country activities to promote good forest governance (European Commission, 2007).

However, most countries have complex legislation—laws may conflict, and illegality is not always easy to define. Thus, the countries need to begin with a process of agreeing on the definition of illegality to form the basis of monitoring the governance.

Individual consumer countries have issued national legislation aimed at curtailing imports of illegal timber. In the United States, INTERPOL's environmental crime program covers illegal wood products, and the World Customs Organization (WCO) and the United Nations Office on Drugs and Crime (UNODC) have specific, albeit small, programs covering illegal trade in wood and wildlife. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is specifically geared toward controlling trade in wildlife, but it also covers a few timber species.[7] The Food and Agricultural Organization (FAO) and the International Tropical Timber Organization (ITTO) have active programs to help member states curtail illegality and improve governance in the forest sector.

In developing countries, community rights and ownership of forests is a major governance issue. State ownership is a major issue of disagreement between indigenous and forest dependent communities and national governments in many countries, especially in Latin America.[8] In India, forests are governed under dual jurisdiction between federal and state governments and with different degrees of decentralization of management to communities (World Bank, 2006). Thus, the governance debate in the sector is not only about ensuring the legality of timber but also about the rights of communities to the resources and about benefit sharing among stakeholders.

Since the global environmental problems are complex, decision-makers are becoming increasingly dependent on scientific advice. Therefore, forestry scientists have a growing influence on the forest governance. Forestry science operates in a changing socio-political environment. This discipline acts a non-state actor that aims to insert its expertise in the political processes (Werland, 2009).

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[6] In 2003, the EU adopted an action plan on Forest Law Enforcement, Governance and Trade (FLEGT) to promote better forest governance and check illegal logging.

[7] From PROFOR 2011a.

[8] For example, in Liberia, land was recognized as the property of indigenous communities. However, it was increasingly considered state property from the 1950s. If communities wanted to own it, they had to buy it back (Wily, 2007).

Forestry science tends to build up on an exhaustive expertise on local forest management connecting the forest owners and administrators. Forestry science brings together local necessities and global demands in the context of governance. Thus, the discipline needs to be integrated with the governmental and non-governmental actors within the policy field.

Forests are used in many diverse ways, and overlapping and competing claims may be attached to them. Even good governance and legality do not always deliver sustainability. Thus, a variety of factors including forest governance, sustainable forest management, and role of expertise determines the development outcomes in forestry.

17.4 Forest Governance

The Forest Principles, adopted at the UN Conference on Environment and Development (UNCED) in 1992,[9] captured the understanding of sustainable management of forests (SMF). The aim of SMF is to maintain and enhance the economic, social, and environmental benefits of all types of forests for the benefit of present and future generations. However, in the last couple of years, the focus has shifted to forest issues as one dimension of the management of global and national public goods, and the theme of forest governance has come to the fore (Brown et al., n.d.b).

Management of forest resources requires an integrated ecosystem approach to protect valuable areas. The provisions under the Convention on Biological Diversity (CBD) have—or are expected to have—implications for forest management and conservation policies.[10]

The criteria that need to be considered in the assessment of SMF are (1) extent of forest resources; (2) forest biological diversity; (3) forest health and vitality; (4) productive functions of forest resources; (5) protective functions of forest resources; (6) socioeconomic functions of forests; and (7) legal, policy, and institutional framework (UN, 2008, Resolution 62/98). Investments in sustainable development yield better outcomes in a better governance environment.

Therefore, the main objective of forest governance is to ensure forest sustainability, together with fair decision-making and benefit distribution.

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[9] *Non-Legally Binding Authoritative Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of All Types of Forests*, a document produced at the Rio Earth Summit 1992. The summit essentially broadened the interest to incorporate concerns for biodiversity and forest environmental services as well as SMF (Brown et al., n.d.b).

[10] Since the majority of world's remaining terrestrial biodiversity is found in forests (UNEP, 1992).

Stern (2006) highlighted that forest conservation, afforestation, reforestation, and SMF can provide up to 25 percent of emission reductions needed to effectively combat climate change and that curbing deforestation has the potential to offer significant emission reductions fairly quickly in a highly cost-effective manner. REDD+ is a collaborative mechanism for providing financial rewards to countries that reduce carbon emissions caused by the loss and degradation of their forests.[11]

The research into forest governance issues is enduring. This is reflected, for example, by a large number of publications (Giessen, et al. 2009; Kleinschmit et al., 2009) on expertise in forest governance (Buttoud, 2012) and on economic mechanisms in forest governance (Hogl et al., 2012; Arts et al., 2012; Art and Visseren-Hamakers, 2012; Rametsteiner, 2009; Agrawal et al., 2008; Glück et al., 2005).

Forest governance research can be understood as social science inquiry into forest-related decisions, their implementation, and resulting effects within a given institutional setting. Since defining the terms, concepts, and methodological frameworks within forest governance research is not straightforward, the concept of forest governance is rather we mean flexible (Giessen and Buttoud, 2014).

Forest governance comprises (1) all formal and informal, public and private regulatory structures, institutions consisting of rules, norms, principles, decision procedures, concerning forests, their utilization, and their conservation; (2) the interactions between public and private actors therein; and (3) the effects of either on forests.[12]

“Forest governance” includes the norms, processes, instruments, people, and organizations that control how people interact with forests. This definition covers many things: traditional culture as well as modern bureaucracy, and private markets as well as public laws (Kishor and Rosenbaum, 2012).

Forest governance studies often focus on a particular level of analysis, ranging from global to international to national to regional and local. This focus requires developing and adapting definitions and concepts on global forest governance (Giessen, 2013a, b), international forest governance (Rayner et al., 2010), national forest governance (Krott, 2005), regional forest governance (Giessen, 2010), and local forest governance (Djogo and Syaf, 2004; Secco et al., 2014).

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[11] The UN-REDD Program is the United Nations collaborative initiative in developing countries. The program was launched in 2008 and build on the convening role and technical expertise of the Food and Agriculture Organization of the United Nations (FAO), UNDP, and UNEP.

[12] A wider definition fails to cover all the aspects of forest governance while maintaining scientific rigor (Giessen and Buttoud, 2014).

When developing the governance structure in the forest sector, focus should be on the following:

- Identifying stakeholders;
- Creating key positions, committees, groups, and structures;
- Outlining roles, responsibilities, and accountability; and
- Developing policies, bylaws, and ground rules.

In a nutshell, forest sector governance refers to the modus operandi officials and institutions (both formal and informal) use to acquire and exercise authority in the management of the resources sector to sustain and improve the welfare and quality of life for those dependent on the sector (ITTO and FAO, 2009).

17.4.1 REDD/REDD+ and Forest Governance

Since importance has been given to work on eradication of forest related crimes, large investments will be made in forests to mitigate climate change in coming years. These investments will depend on the way forests are governed in various countries.

With forest degradation and deforestation being the second important contributor, after fossil fuels, proposals and negotiations have been made under United Nations Framework Convention on Climate Change (UNFCCC) to include measures to reduce emissions from deforestation and forest degradation (REDD).[13]

REDD aims at reducing deforestation and forest degradation, promoting afforestation, reforestation and forest restoration, and sustainably managing existing forests.

Though REDD and REDD+ are not governance reforms, they are affected by forest governance. It either can alleviate the forest governance or be undermined by its all failures. However, forest governance alone cannot address the drivers of deforestation and degradation.

Forest law compliance and good governance assume even greater importance to take advantage of potential REDD mechanisms. REDD mechanisms are likely to be successful if they build on the interests of the local and indigenous communities.

The success and the effects of REDD on forest communities will depend on how incentives, benefits, rights, and political participation are distributed among, for

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[13] The UN-REDD program supports nationally led REDD+ processes and promotes the informed and meaningful involvement of all stakeholders, including the indigenous people and other forest-dependent communities, in national and international REDD+ implementation.

example, households, communities, districts, timber industries, and national and local government entities.

The UN-REDD program supports nationally led REDD+ processes and promotes the informed and meaningful involvement of all stakeholders, including indigenous people and other forest dependent communities.

17.4.2 REDD, Forest Governance, and Rural Livelihoods

About 1 to 1.6 billion people are directly dependent on the forests. These communities are usually among the poorest.

For REDD mechanisms to be successful, they need to build on the interests of these local and indigenous communities. The needs of local and indigenous communities should be addressed in actions to reduce emissions from deforestation and forest degradation in developing countries.

> *The project must generate net positive impacts on the social and economic wellbeing of communities and ensure that costs and benefits are equitably shared amongst community members and constituent groups during the project lifetime* (Standard CM1 in CCBA, 2008, 25).[14]

Although securing co-benefits, specifically about biodiversity conservation and poverty reduction, is a key challenge in REDD. If the REDD programs are to benefit forest communities, they will need to ensure the following:

- Incentives address relevant drivers of deforestation.
- Benefits are equitably distributed (social equity).
- Meaningful political participation of forest communities is linked to processes at the national and international levels.
- The rights of forest communities, particularly tenure, are recognized, secured, and strengthened (Angelsen, 2008b; Robledo et al., 2008; Griffiths, 2009).

The success of REDD and its effects on forest communities will depend on how incentives, benefits, rights and political participation are distributed among, for example, households, communities, districts, timber industries, and national and local government entities.

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[14] From CCB Standards, Available: https://s3.amazonaws.com/CCBA/Upload/ccb_standards_second_edition_december_2008+(1).pdf

Each country confronts an interplay of conflicting policy objectives, management and enforcement struggles over forest access, thus influencing land use decisions through global and national policy becomes a challenge.

Designing REDD schemes to benefit forest communities requires balancing complementary measures at various levels and sectors. To secure benefits for local people:

- The burden for forest management must be shared among all entities affecting deforestation and not disproportionately placed on forest communities;
- Nationally designed REDD programs must balance locally adapted and pro-poor measures with incentives that are linked to long-term development opportunities; and
- Benefits must be shared across levels and sectors to create safety nets and enhanced livelihood options for forest communities at multiple scales.

17.5 Major Stakeholders in the Forest

It is important to identify relevant stakeholders and encourage them to participate as gaps in knowledge, issues, or value representation emerge. The stakeholders may not necessarily live within the physical boundaries of the forests.

Here are some factors to consider when identifying stakeholders:

- **Influence**: goes beyond how much power a stakeholder can exercise to bring about change. It also includes the absence of influence. Consider the needs and interests of those who may be affected by decisions but have no power to influence those decisions.
- **Responsibility**: examine a potential stakeholder's responsibilities. These responsibilities may include regulatory responsibility for compliance with laws, policies and regulations; contractual or legal responsibility to other organizations; financial responsibility to donors or others that provide resources; and ethical or moral responsibility to those that are affected by, or that can affect, decision-making.

Representation: consider not only the different values and uses of the forest landscape, but the legitimacy of a representative and the number of interests represented. Legitimacy here refers to the extent to which a stakeholder truly represents its interests. The parties the stakeholder claims to represent should support the claim.

In general, three broad stakeholder groups have been identified to ensure good governance in the forest sector, namely

- **Government:** includes representatives from the judiciary system, ministries, forest agencies and related governmental departments;
- **Civil Society:** includes representatives of local and indigenous communities, social and environmental NGOs operating in the sector; and

- **Private sector:** includes representatives from companies, industries and trade associations that depend on forests.

17.6 What is Good Forest Governance?

Good forest governance is characterized by predictable, open, and informed policymaking based on transparent processes; a bureaucracy imbued with a professional ethos; an executive arm of government accountable for its actions; low levels of corruption; and a strong civil society participating in decisions related to the sector (Wageningen International, 2008).[15]

Good forest governance is attained by unique constraints and opportunities dictated by circumstances in individual countries, apart from the universal principles and concepts. Good governance has to do with process used to make the decisions. It involves actors and stakeholders beyond the government and the forest sector whose interests affect forest management (World Resources Institute, 2009).

Principles of Good Forest Governance:[16]

- **Transparency**: that the information about the forests and how it is governed should be reasonably available to all;
- **Participation**: that all interested people should have an opportunity to be heard or to influence government decisions that affect the forests;
- **Accountability**: that people and institutions should be accountable for their actions;
- **Direction**: all stakeholders should share a clear, articulated vision of the goals;
- **Coordination**: different actors/stakeholders should work together to achieve results;
- **Capacity**: can be measured in terms of financial, human, technological, and legal resources;
- **Effectiveness**: that the mechanisms of governance should achieve the ends they are intended to achieve;
- **Efficiency**: that governance should work with a minimum of waste; and
- **Fairness/equity**: that the benefits and burdens of the forest resource should descend down in a way generally viewed as just.

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[15] There are many definitions of governance; the publication *FLEGT beyond T,* by Wageningen International (2008), explores the meaning of governance in the forest law enforcement, governance and trade process.

[16] Extracted from Davis et al. (n.d.); Kishor and Rosenbaum (2012); and International Model Forest Network (2008).

Good forest governance is fundamental to achieving positive and sustained development outcomes such as efficiency of resource management, increased contribution to economic growth and to environmental services, and equitable distribution of benefits (Kishor and Rosenbaum, 2012).

Legality and good governance in the forest sector are essential for economic benefits, livelihoods, and environmental sustainability.

Although there are several definitions of forest governance, most of them overlap the above-mentioned points.

17.7 Assessing Forest Governance

Forest governance can be assessed as a scientific endeavor conducted within the scientific realm, or as a practical enterprise undertaken by actors in the field of forest conservation and utilization practices (Giessen and Buttoud, 2014).

Within the scientific realm, the researchers are guided by methodological frameworks, which they develop intersubjectively to advance scientific knowledge about real world phenomena.

The practice-oriented assessments of forest governance inherently imply value judgments within methodological frameworks. Various practice-oriented frameworks for assessing forest governance have been developed (Cowling et al., 2014; WRI et al., 2013).

17.7.1 Why Assess Forest Governance[17]?

Forest ecosystems are mega biodiversity spots, especially in tropics. Illegal use and crime, unclear tenure rights, disenfranchised stakeholders, and unskilled managers could hamper attempts to manage these resources purposefully. Furthermore, agricultural practices (such as slash and burn) and crops (such as white palm oil) also contribute toward land degradation.

In addition, the forest-dependent communities are usually caught in lifelong poverty cycles as their rights and interests are generally overlooked. Active stakeholders like people who live in and derive their livelihoods from the forests, rather than people making decisions, need to be heard.

Since management of things that can be measured is easier, measuring forest governance is a strong first step toward sustainable forest use and management. Measurement can raise awareness about the role of governance and motivate other stakeholders to argue for change, thus, laying the foundation for purposeful reforms.

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[17] Extracted from Cashore and Stone, 2012; and Kishor and Rosenbaum, 2012.

When people have strong, conflicting views on the forest use, good stewardship usually depends on good governance.

Understanding the strengths and weaknesses of forest governance can be useful to discover problems or to track the progress of reform. A broad guide serves to help discover problems and point toward options for addressing them. Subsequent targeted monitoring and assessment is useful to track reforms and improve implementation.

Measurement of forest governance is a cycle of policymaking decisions, their implementation, results, and subsequent monitoring and assessment.

17.8 When to Assess Forest Governance?

Measuring forest governance becomes important when the government has declared its intent to revise forest policies or legislation; when the government has recently committed to an international initiative such as a VPA or REDD+ that may require governance reforms; or when an international donor has announced its willingness to contribute toward new reform efforts[18] (Kishor and Rosenbaum, 2012).

17.8.1 How to Assess Forest Governance?

Improving forest governance requires a systematic approach to identifying the areas of weakness, devising and implementing appropriate responses, monitoring results, continuing adaptation, and learning to ensure progress.

Forest governance can be assessed following one of the practice oriented frameworks described below:

Framework for Assessing and Monitoring Forest Governance[19]

The World Bank, FAO, and the Swedish International Development Cooperation Agency (SIDA) organized an international symposium in Stockholm in September 2010. In the symposium, it was agreed that a core set of principles and criteria for assessing and monitoring forest governance should be developed to avoid duplication, especially in country-level applications. This common framework was considered able to foster synergies among forest governance initiatives and enhance efficiency.

It was envisioned that this framework should be generic enough for wide application, but also acquiescent to alterations meeting specific country application requirements.

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[18] REDD+ stands for Reducing Emissions from Deforestation and Forest Degradation, plus conservation, sustainable management of forests, and enhancement of forest carbon stocks.

[19] Extracted from PROFOR, 2011b.

FAO and the World Bank's Program on Forests (PROFOR) were called upon to convene a core group of experts and practitioners, including experts from potential user countries, to develop a common framework[20] for forest governance indicators.

It was considered important to identify what to assess, and propose a qualitative assessment framework that is systematic and replicable, to assess forest governance. The framework facilitates description, diagnosis, monitoring, assessment, and reporting on the state of governance in a country's forest sector.

The framework also identifies the areas of governance needing reform based on a broad and internationally developed framework for assessing forest governance. It also identifies governance priorities, encourage discussion of specific steps to be taken, and help build consensus for reform.

The framework is able to discover problems and point toward options for addressing them. Subsequent targeted monitoring and assessment are useful to track reforms and improve implementation of the forest governance.

The framework provides a means to analyze the interactions between institutions within and outside the forest sector that together create the conditions for governance of a country's forests and forest resources. It can assist governmental and non-governmental actors interested in improving the quality of forest governance in a particular country.

The framework builds on the understanding that the governance is both context and the product of interaction between a range of actors and stakeholders with diverse interests.

It draws on its pillars, components, and sub-components.

Pillar 1: Policy, legal, institutional, and regulatory frameworks: considers the long-term systems of policies, laws, rules, and regulations within the forest sector and in other sectors that impinge on forests.

Components under Pillar 1 are:

1.1. Forest-related policies and laws

1.2. Legal framework to support and protect land tenure, ownership, and use rights

1.3. Concordance of broader development policies with forest policies

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[20] The framework presented is a draft framework introduced at the Stockholm meeting and builds on the proposed core parameters for REDD+ governance monitoring. The draft framework was further developed by the group of experts between January and March 2011, in close coordination with the UN-REDD/Chatham House initiative for the development of draft guidance on how REDD+ governance safeguards could be monitored (PROFOR, 2011b).

1.4. Institutional frameworks

1.5. Financial incentives, economic instruments and benefit sharing

Components under Pillar 1 probe the existence and quality of forest policies, laws, and regulations; frameworks for protection of forest-related tenure and rights; and the functioning of key institutional frameworks.

Pillar 2: Planning and decision-making processes: considers the degree of transparency, accountability, and inclusiveness of key forest governance processes and institutions.

Components under Pillar 2 are:

2.1. Stakeholder participation

2.2. Transparency and accountability

2.3. Stakeholder capacity and action

Components under Pillar 2 examine the extent, characteristics, and quality of participation of a range of stakeholders in forest governance and the capacity of different stakeholder groups to engage in governance processes.

Pillar 3: Implementation, enforcement and compliance—examines the extent to which the policy, legal, institutional and regulatory frameworks are implemented.

Components under Pillar 3 are:

3.1. Administration of forest resources

3.2. Forest law enforcement

3.3. Administration of land tenure and property rights

3.4. Cooperation and coordination

3.5. Measures to address corruption

Components under Pillar 3 examine critical aspects of forest administration and law enforcement, measures that deal with corruption, and the administration of tenure and property rights.

17.8.2 The Governance of Forests Initiative (GFI) Indicator Framework[21]

The GFI indicator framework provides a clear model for identifying what to assess, and it proposes a qualitative assessment approach that is systematic and replicable.

[21] Extracted from WRI et al. 2013

In doing so, GFI aims to support ongoing efforts to strengthen forest governance around the world.

The GFI framework provides a comprehensive menu of indicators that can be used to diagnose and assess strengths and weaknesses in forest governance. The object of assessment for any indicator can be one of three different components of forest governance:

- **Actors**: the range of people and institutions that shape the decisions;
- **Rules**: the policies, laws and legislations that affect the forest; and
- **Practice**: the rules developed by actors to drive practices at an operational level.

The indicators are clustered according to six thematic areas, which reflect key forest-related issues of common interest and concern.

- **Forest Tenure:** forest ownership and use rights, tenure dispute resolution, state forest ownership, and concession allocation;
- **Land Use:** land use planning and implementation, sectoral land use, and forest classification;
- **Forest Management:** forest legal and policy framework, forest strategies and plans, forest monitoring, forest management practices, and forest law enforcement;
- **Forest Revenues:** forest charge administration, forest revenue distribution, benefit sharing, and budgeting;
- **Cross-cutting Institutions:** legislature, judiciary, executive agencies, private sector, and civil society; and
- **Crosscutting Issues:** public participation in decision-making, public access to information, financial transparency and accountability, and anticorruption measures.

The indicators can be taken as a complete package, or a subset of indicators can be selected. Furthermore, successful forest governance can be achieved by:

- Securing customary indigenous rights to local communities;
- Promoting broader cross-sectoral dialogue between trading countries to improve forest law compliance;
- Allowing poor marginalized groups to participate;
- Promoting transparent participatory processes, ensure greater equity; and
- Eliminating ambiguities in traditional and commercial resource use.

17.8.3 Challenges in Assessing Forest Governance

The major challenge in assessing forest governance is the ambiguous definition of the concept “forest governance,” which raises questions about what exactly should be assessed. Furthermore, if the government or powerful stakeholders resist reform, then measurement might not have much impact. Dealing with the relevant institutions and managing the data and information are a challenge.

Another major issue is the lack of forest law compliance—flawed policy and legal frameworks. Stakeholders including local communities, government bodies, and the private sector have limited rights and responsibilities restricting the ownership, use, and management of forests. Challenges in measuring forest governance impede efforts to strengthen it.

17.9 Challenges to Forest Governance

There are essentially two challenges to forest governance. The first one is the degradation of forests, through industrial or illegal logging, which negatively affects forest ecosystems. Second is the deforestation caused by other sectors that degrade forest landscapes, which ultimately impacts the forest ecosystems and disturbs the local livelihood. Many critical forest problems are cross-sectoral.

There is a need for international cooperation around forests to reverse the pressures because of deforestation and degradation and to find innovative solutions to address the issues. This cooperation be partly achieved by global biodiversity and forest policies, and partly by international trade laws. This combined cooperation, at both global and national level, can be attained by fostering synergy in the forest sector through inter-sectoral linkages.

17.10 Building Synergy in the Forest Sector

The forest policy reforms, which form the basis of good forest governance, tend to decentralize governance transferring the ownership and management responsibilities to local forest user organizations. In the last decade, such policy reforms have been rolled out on one-third of the forests in the developing countries.

Decentralization serves as a key mechanism to provide compliance incentives that enhances knowledge, develop stronger accountability and perceived legitimacy of forest rules. These incentives help the local communities to use forests sustainably. On the other hand, decentralization could also lead to resource capture by local elites without devolution of rights to local and marginalized communities.

The complex causes of forest problems, and the varied contexts in which they arise, require the application of the full range of available policy instruments. Thus, both formal international rules and other forms of authority and steering are potentially useful for achieving forest-related goals. An exclusive focus on one or the other overlooks the critical importance of developing a portfolio of mutually supportive policy instruments.

17.10.1 National Context

At the national level, usually the local elite and government officials influence the policy reforms. Often, women and marginalized groups are excluded from voicing their interests as a result of local customs or regional practices. Indigenous people are often not aware of their rights, which leads to social conflicts.

At the national level, perhaps the single most important governance issue is the need for transparent government decision-making. Poorly designed and implemented regulations may act as a burden to the poor in their attempts to escape poverty through accessing forest resources.

In addition the forest sector is often characterized as being heavily and inconsistently regulated with regulations that appear to favor powerful economic interests.

India has also made significant effort in involving the local community for management of forest through joint forest management (JFM) institutions since early 1990s. However, these JFM institutions need to be further strengthened by empowering the local communities with adequate power and responsibilities (Lele, 2011).

Multi-stakeholder dialogues (MSDs), involving all the stakeholders to influence forest reforms, can lead to a fairer and more sustainable forest use in such scenarios. IUCN's Strengthening Voice for Better Choices project is a brilliant example of projects based on MSDs in a practical context. The project ran from 2005 to 2009 in six countries across three continents. Its role, among others, was to support, facilitate, and convene MSDs (IUCN, 2009a).

Such multi-level stakeholder involvement can help understand different stakeholder's thoughts and interests to reach a common vision and shared strategy. They can provide the required collective governance spaces that will increase self-esteem and capacities of stakeholders to achieve common goals.

Furthermore, it is important to understand that MSDs cannot prevent conflicts altogether; however, they provide a framework for constructive discussions at all levels. This framework reduces the chances of a community breakdown. MSD-based governance initiatives should overcome equity challenges to increase the returns of local communities.

MSDs can promote leadership, adaptive management skills, confidence building, and transparency among stakeholders through training, funding and incentives. Though MSDs are expensive and time-consuming, they are capable of addressing social and economic needs in harmony with the environment.

17.10.2 Global Context

It is perhaps at the global level that the governance problems of forest management are greatest because the global benefits of forest services (such as climate and hydrology; climate change mitigation, biodiversity conservation; and watershed management) are increasingly recognized and valued.

Since the shifting of national and sub-national focus of the forestry sector to most exclusively global focus, bringing forests under the control of multilateral environmental agreements (MEAs) has proven particularly difficult. Synergy between global organizations, such as IUCN, WWF, ITTO and other conservation nongovernment organizations (NGOs), has helped promote responsible governance.

These organizations should understand that implementation of roles should be adopted in accordance with the circumstances of each country and process, including the needs and range of stakeholders and existing relations between them. The management and conservation of forest resources is a matter of informed societal choice for each country.

It is important that these organizations and their initiatives should

- Bridge different stakeholder groups as partners in the forest governance actions, empowering the stakeholders.
- Provide high quality advice for strong decision-making and implementation.
- Reach out and engage key constituencies in an ongoing bilateral fashion.
- Pilot early actions to test governance approaches identified in stakeholder deliberations.

Moreover, cross-country and cross-regional learning networks can facilitate learning exchanges between countries working on similar forest governance issues.

17.11 Inter-Sectoral Linkages in the Forest Sector

Improving international and national forest governance means acknowledging that many of the most serious forest challenges are highly cross-sectoral and require significant engagement with the agricultural, mining, energy, transportation, trade, climate change, and other sectors and their interests. Although international forest institutions and actors have long recognized this problem and have called repeatedly for it to be addressed, identifying and promoting effective inter-sectoral coordination and collaboration remain a largely un-met need (Glück et al., 2005).

In the last decade, the economic situation has significantly affected the forest sector globally, including forest management. The years of economic decline have had a negative impact on the activity of logging and processing companies, indirectly reducing the volume and quality of forest operations as well as the income and investment capacity.

The restitution of forest land and the privatization of wood harvesting, transport, and the processing sector probably have the greatest impact on development of the forest sector and their management. In addition, the poor capacity to enforce forest legislation and to raise forest owners” awareness of sustainable forest management results in environmental damage of private forests.

Public financing have a direct impact on development of the forest sector, as the regulatory, control, and extension functions of the state depend on the annual budget

allocation. For example, in Romania, the budget allocation for the forest sector has been relatively small in the last decade, which has had an effect on control and extension functions, as well as on the quality and commitment of public authority staff.

Unemployment have both negative and positive effects on forest management. In Romania, frequent illegal felling and overharvesting were recorded in some rural areas where the unemployment rate was high and the local communities were poor. Moreover, more labor for forest operations has been available in areas with high unemployment rates and has had a positive impact on forest management.

Agricultural policies and legislation have some important influences on forest sector development. Unsustainable agroforestry/agricultural practice leads to the reduction of the public forest area. Some agricultural policies and activities have negative effects on forests and forest management. Despite being forbidden by law, grazing represents by far the greatest problem.

Impacts of mining leading to deforestation has also been reported in several countries like Romania and Indonesia. Oil extraction has also influenced the forest sector, both by reducing the forest area and by increasing the risk of accidental pollution. The energy sector has had both positive and negative impacts on development of the forest sector. Expansion of the gas network in rural areas in recent decades has reduced the demand for fuel wood, which was traditionally used for heating and cooking. Though it has reduced pressure on the forest resources in forest-poor areas, the income for the fuel wood dependent communities has also declined.

Regional schemes such as the Mahatma Gandhi National Rural Employment Guarantee Act[22] and National Rural Livelihoods Mission [23] in India have been introduced to help the local communities in generating additional resources for sustainable forest management. Romania has developed a National Plan for Agriculture and Rural Development (NPARD), and significant EU support for NPARD implementation in the period 2002 to 2006 was available to Romania under the Special Accession Program for Agriculture and Rural Development.

Game management and hunting legislation also have an impact on forest management. In European countries, the central public authority for game management assigns game management rights to legally established hunting

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[22] [The Mahatma Gandhi National Rural Employment Guarantee Act (2005) aims to enhance the livelihood security of people in rural areas by guaranteeing hundred days of wage-employment. [Online] http://nrega.nic.in/rajaswa.pdf

[23] National Rural Livelihoods Mission; "To reduce poverty by enabling the poor households to access gainful self-employment and skilled wage employment opportunities, resulting in appreciable improvement in their livelihoods on a sustainable basis, through building strong grassroots institutions of the poor."

organizations. This provision has created some conflicts between hunting organizations and private agricultural and forest landowners.

In the period 1990-2000,[24] forests, environmental protection and water management have gained significant interest at the global level. Close cooperation has been developed between the forest and the water management sectors. However, the effect of water management on forests seems to be far lower than the effect of forest management on water quality and management. Special forest management practices are recommended to protect waters and watersheds.

Many forest ecosystems and wildlife species have been preserved as a result of the efforts of foresters. Forest organizations are usually been at the forefront in most of the processes, programs, and activities related to nature conservation, including the establishment of national parks. Although foresters and forest organizations have often made significant contributions to nature conservation, there have also been cases when their actions have had negative impacts—for example, the negative cumulative effects of harvesting on water quality, flora, and fauna.

Close linkages between tourism and forestry can also be demonstrated in several countries. In Romania, authority for tourism participated actively in development of the National Forest Policy and Strategy. The development of ecotourism has become a priority for both the forest sector and the Ministry of Tourism. While the presence of forest seems to have a positive impact on tourism, the latter has tended to have a negative impact on forests through, for example: clear-felling for the development and construction of hotels, restaurants, and skiing facilities; garbage left in the forest by tourists; illegal camping and picnicking; and forest fires caused by the negligence of tourists.

Development and modernization of the road infrastructure (public and forest roads) has both negative and positive impacts on forest sector development. Negative impacts result from forest clear-felling to make room for new public roads or motorways. On the other hand, development of the transport infrastructure has a positive impact on forest management, as it provides better access to forest resources for harvesting, tending, and maintenance operations.

17.12 References and Additional Reading

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