Introduction 1

1.1 Harvest Operations in Context

Forests cover 25% of the Earth's surface and 60% of the world's forests are within the tropics. More than one billion people depend on tropical forests for some part of their livelihood. Forests provide the opportunity to directly contribute to the well being of many and through economic development, and supporting industries, the well-being of many more. At the United Nations Conference on Environment and Development (UNCED) in 1992, the international community accepted the concept of sustainable development as a framework for future development. Sustainable development embodies a reduction of poverty, unemployment, and inequality.

Forest management is a deliberate and guided intervention to manipulate the complex biotic and human components of forests in order to satisfy the needs of particular beneficiaries. Forest operations consist of all technical and administrative processes to develop technical structures and facilities, to harvest timber, to prepare sites for regeneration, and to maintain and improve quality of stands and habitats. The concept of sustainability in forestry implies the total welfare effects of forest management should never decrease. Harvesting and extraction for sustainable timber production is not to be confused with logging associated with land conversion activities such as conversion to permanent or temporary agriculture, pasture land, or domesticated trees.

Harvesting is an essential activity in forest management. It involves all operations from tree felling to delivering logs at the mill, rail depot, or ship dock. If carefully planned and implemented, benefits, which were anticipated at the time of the forest investment, are possible. Poor planning and/or poor implementation of forest plans can be costly, result in environmental degradation as well as excessive wood waste, poor utilization of the available resource, and injury to personnel. Harvesting activities must consider, and can influence, stand treatment regimes, and must be consistent with terrain characteristics. Sound forest operations require a thorough understanding of these factors.

Historically, harvesting of tropical forests has been in natural forests, but this picture is rapidly changing. Plantations are a rapidly growing source of world wood, and the tropics are no exception. Today, forest plantations ring the globe, from Southeast Asia, to India, to Africa, and tropical Latin America. Most of these plantations are being grown for timber production.

This book presents the fundamentals of harvest operations both in natural forests and in planted forests. Our focus is on operations in wet tropical forests, but we provide information that can also be applied to dry tropical forests. The book is designed to be a handbook for the forest engineer and a textbook for those interesting in learning about tropical harvest operations. The fundamentals of road operations in natural and planted forests in the tropics are presented in a companion volume.

1.2 Overview of the Tropics

The tropics are bounded roughly to the north of the equator by the Tropic of Cancer and to the south of the equator by the Tropic of Capricorn. Although the tropics are often portrayed as an area that has remained unchanged for a long time, i.e., not subject to glacial activity and large climate swings, that does not mean that they are homogeneous. Differences can be described by elevation, topography, temperature, mean annual rainfall, seasonal rainfall, and soils. The tropics can be divided into the warm tropics and cold tropics, wet tropics and dry tropics. There are three major tropical regions, America, Asia, and Africa (Fig. 1.1) Some generalizations can be made between regions and within regions. Southeast Asia is much more mountainous than Africa or South America and has many young, eroding landscapes. It also has substantial areas of volcanic rock and soils. In Africa and South America, recent volcanic rock and soils are much less common.

Considering within-region variation, slightly more than 50% of tropical America, for example, has a mean annual precipitation of 1,600–3,200 mm/year and less than 5% receives more than 3,200 mm/year and less than 5% receives under 400 mm/year. Similarly, the majority of tropical America has pronounced seasonal rainfall, with most of the seasonal rainfall coming in summer, but some eastern coastal areas have the pronounced seasonal rainfall coming in winter. Other areas have rainfall well distributed throughout the year. One can generalize that tropical America is flat. Eighty-two percent is less than 8% slope, and 4% is greater than 30% slope. And one could generalize that tropical America is well drained, but about 25% of the flat terrain would be classified as poorly drained.

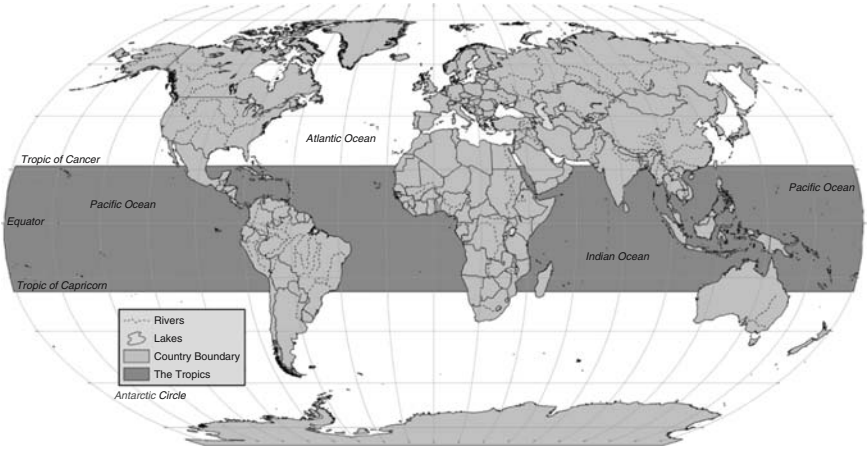

Fig. 1.1. Tropics of the world

Much international interest focuses on that part of the tropics that supports tropical rainforests (Fig. 1.2). Tropical America has about 50% of that total, with the remainder concentrated in Southeast Asia and Africa (Table 1.1) Tropical rainforests are found in places that have no dry months or only a few dry months. Tropical evergreen rainforest occurs in places with no dry season, and tropical semievergreen rainforest forms where there is a dry season. Tropical evergreen rainforests differ from semievergreen rainforests in that semievergreen rainforests have some species that are deciduous. In general, the western Amazon rainforests are evergreen, and the eastern Amazon rainforests are semievergreen. Southeast Asian rainforest is almost entirely evergreen and African rainforest is almost entirely semievergreen.

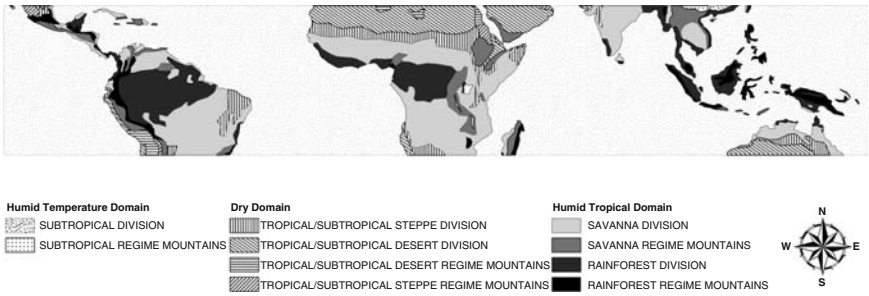

Fig. 1.2. Bailey's ecosystem classification of the tropics

Table 1.1. Distribution of tropical rainforest

Region	Rainforest area (million hectares)	Percentage of total	Primary location
South America	400	48	Amazon, Orinoco basins
Southeast Asia	250	30	Malesia, Asian subcontinent to India
Africa	180	22	Zaire basin to Gulf of Guinea

1.3 Factors Affecting Operations in Tropical Rainforests

There are some physical, biological, and social factors which, in combination, are unique to tropical forests:

- *Climate.* During much of the year the climate is often wet, hot, and humid, affecting choices of equipment, length of operating season, and labor productivity. Rapid wood deterioration after cutting may be a concern in some species.
- *Topography.* The topography is mostly flat, but mountainous regions exist in some areas. In many instances in the tropics, the terrain is hilly, consisting mainly of short hills. Water transport often plays a more important role for access and transport than in temperate areas.
- *Soils.* Wet soils provide poor traction for skidding and hauling. Sound rock is often not available, particularly in South America and Africa. Road surfacing may be expensive or scarce, affecting season of operation, road cost, and skidding distances.
- *Species.* In natural forest, up to 100 or more species can be found per hectare with widely differing tree sizes. Nearly all are hardwoods. Harvestable volumes of commercial species may be sparse, perhaps only several trees per hectare. An exception is the dipterocarp forest of Southeast Asia. Many of the trees have intermingled crowns connected by vines or lianas, and often supporting large hidden dead branches. At the base of many species are large flutes or buttresses.
- *Location.* Many tropical forests are in remote, undeveloped areas. Special attention must be given to choice of the level of mechanization and establishment of infrastructure for equipment maintenance, parts, and fuel supply.

- *Labor.* In some areas, a large unemployed or underemployed pool of unskilled labor may be available. Social policy as well as cost factors may affect the choice of harvesting systems.
- *Disease.* Tropical forests are home to parasites and require special planning to provide safe housing for forest workers. In particular, much of the tropics is affected by malaria, at least during certain periods of the year. In Africa, bilharzia eye disease from stagnant water is very frequent.

1.4 Successful Harvest Operations

Harvest operations to be successful must be:

- Technically feasible considering physical laws, engineering knowledge, and environmental relationship of the forest
- Economically viable considering the costs and benefit of short-range and long-range consequences
- Environmentally sound considering impacts on the natural and social environment, and efficient use of natural resources, including renewable materials, nonrenewable materials, water, energy, and space
- Institutionally feasible considering the laws and regulations governing operations, landowner objectives, and social values

1.5 Codes of Harvesting Practices

Considerable progress has been made in recent years in the introduction of environmentally sound forest harvesting practices in many parts of the tropics. A number of tropical countries have developed harvesting codes of practice. The International Labor Office (ILO) and Food and Agriculture Organization of the United Nations (FAO) have been active supporters.

One of the earliest national harvesting codes of practice in the tropics was adopted by Fiji in 1990 with the help of ILO. In 1996, FAO released its *Model Code of Harvesting Practice* (Dykstra 1996) which as of 2006 has been used as the template for at least 30 countries in the tropics. Several regional codes have been developed or are in development. Examples include the regional *Code of Practice for Forest Harvesting in Asia-Pacific* published by FAO in 1999 (FAO 1999) and endorsed by the Association of Southeast Asian Nations

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