Chapter 2
Forest and Land Degradation in the Asia-Pacific Region

> If it should happen that the forests of the mountains are exhausted, and that of the forests of the piedmont only scattered remnants remain, or that they have disappeared, and that the thickets and marshes have come to the last days of their existence, the forces of the people will be weakened, the farmlands where the cereals and hemp grow will be uncultivated, and they will lack resources. The superior man should be concerned about this problem in a spirit of altruistic urgency, and without relaxation. How could it ever delight him?
>
> Duke Mu of Shan, a minister in the court of the Zhou high king, China, 524 BC.
>
> Elvin (2001, p. 17)

> The snapshot of the history of forest management in the Asia-Pacific over the last three decades is one of steady destruction. Scorched earth is increasingly the final picture.
>
> Dauvergne (2001, p. 27)

Introduction

The first chapter described how large amounts of deforestation and degradation have occurred in tropical forests across the Asia-Pacific region and how this is threatening biodiversity, while still leaving many people poor. This discussion covered the problem from a global and regional perspective but did not explore the reasons why these changes are occurring. Why should societies destroy their forests for what are sometimes only modest benefits? And why should different countries repeat the mistakes made previously by others? Is there no capacity to learn from neighbours or from history? This chapter considers the processes underlying deforestation and degradation in a little more detail. If we can understand why degradation has occurred, we might be in a better position to prevent it and to overcome it where it has already occurred.

It is important to realize that forests ecosystems are always being affected by naturally occurring disturbances such as windstorms, fires or landslips. Most ecosystems become adapted to these disturbance regimes and are able to recover. However, recovery is far more difficult when the nature of the historical disturbance regime changes. That is, if there is a change in the intensity, frequency, or

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extent of the disturbance to which the ecosystem is adapted. In such cases, the ecosystem must adapt and there are likely to be modifications to its composition and structure. Over time, the system may eventually recover its original condition. But severe disturbances can push the system over a threshold from which recovery is impossible. The new steady-state condition with new species and structural attributes may be more economically attractive, as in the case of an agricultural landscape, or it may be economically unattractive and represent a form of 'degradation'.

This chapter begins by reviewing different types of natural and human-mediated disturbances and the effects these can have on tropical forests. Deforestation has occurred as human populations have increased and have needed more land to produce food crops. In some cases, the transition from forest to cropland has been successful, while in others it has not. The chapter reviews the long history of this process in China and Japan, which have had contrasting responses to deforestation and degradation. It then examines a series of more recent case studies from across the Asia-Pacific region to explore why degradation is occurring now in order to understand what might be needed to overcome it in the future.

Natural Disturbances

Although tropical forests often appear ancient and relatively homogenous, most are made up of a mosaic of different successional stages and are recovering after a variety of naturally occurring disturbances (Chazdon 2003). Some of these disturbances occur quite frequently but are usually small in scale. Single tree falls are a common example. Other disturbances occur less frequently but cover much larger areas. Tropical storms are an example of such larger-scale disturbances. These storms regularly damage forests in many Pacific Islands, northern Australia, Philippines and coastal areas surrounding the South China Sea (Mueller-Dombois and Fosberg 1998). Their frequency varies; in the Southwest Pacific they can occur around 15 times per year but up to 25 times per year in the northwest Pacific (Scatena et al. 2005). Storm frequency in the north-west Pacific is greater in La Niña years (Kelly et al. 2001). In discussing frequency it is also necessary to specify storm intensity. Ash (1992) suggests cyclones with gusts up to 150 km/h occur across Fiji once every 5–10 years while those with gusts of up to 200 km/h occur every 30–50 years. These frequencies are clearly much shorter than the lifetimes of most forest trees.

Trees vary in their ability to tolerate strong winds. Most shallow-rooted species are easily blown over but some trees such as *Agathis* spp. are more resistant (Ash 1992; Mueller-Dombois and Fosberg 1998; Scatena et al. 2005). Keppel et al. (2010) suggest trees with higher wood densities and smaller leaves are most resistant. Many cyclones and other severe storms are accompanied by multiple landslides.

Nunn (1990) describes one storm in Fiji that triggered 620 separate landslips in a single catchment. The resulting soil loss from that storm exceeded the total soil loss from the site in the previous year. The effects of storms on forests can be long-lasting and the impact of one large storm that occurred in Sarawak in 1880 and which blew over forest covering hundreds of square kilometres has remained visible for more than 100 years (Whitmore 1984). In areas where storms are frequent so-called 'storm' forests develop in which vines dominate canopies and shroud tree regrowth (Webb 1958).

Fires are another disturbance that can affect even larger areas. This might seem surprising in wet tropical forests. However, droughts periodically occur (related to ENSO events in at least some parts of the region) and fires can burn during these periods (Knapen 1997). In more seasonal environments, fires can affect the boundaries between rainforest communities and more open forests and savannas as well as affecting the structure of the open forests (Bowman 2000; Rundel and Boonpragob 1995). In frequently burned areas, rainforests are restricted to wetter gullies or riverine areas. Historical evidence of the drought and fire history in the humid lowland rainforests of Papua New Guinea gathered by Johns (1989) demonstrates that a significant number of quite large fires have occurred over the last 100 years, including in places now occupied by dense rainforests. Fire records are often poor because the events are rarely documented, but dating of charcoal found in rainforest soils suggest they may have been much more common than is often suspected (Goldammer and Seibert 1989; Haberle et al. 2001; Hopkins et al. 1996; Whitmore 1984). Fire hazards increase in logged-over forests because of additional fuel in the form of logging debris (Siegert et al. 2001; Woods 1989). The hazard is also likely to increase as farmers move up logging roads and clear these areas for cropping.

Other natural disturbances that have an impact on forests include landslips, volcanic gas emissions and ash showers. These differ in frequency and scale but are especially common in seismically active areas such as Papua New Guinea and Indonesia. Finally, changing river alignments are common occurrences for many large, sediment-laden tropical rivers flowing across flatter lowland terrain. The significance of this in maintaining lowland forests in relatively early succesional stages can be appreciated by observing the extensive areas of braided streams, oxbows and shingle formations across the region. Similar changes have been observed in Amazonia (Salo et al. 1986). It goes without saying that some of these disturbances are very site specific (e.g. ash showers are only found around volcanoes). And, of course, places with overlapping hazards are more likely to have more frequently disturbed vegetation.

Any assessment about the rate at which forests are able to recover after such disturbances depends on how this is measured. Some ecosystem attributes such as tree heights may recover within decades, while others such as species richness may take centuries to return to their pre-disturbance condition (Chazdon 2003). Whether recovery does actually occur depends on the timing of subsequent disturbances. White (1975) suggested the frequency of naturally occurring disturbances in Papua

New Guinea is such that there are probably few old primary forests in the lowlands of that country. This view is supported by survey data showing that many lowland forests are dominated by long-lived secondary species and that truly ‘primary’ forest species able to regenerate and growth in shade are rare (White 1975; Johns 1989). The same may be true in other forests across the region (Brookfield 1997).

Human Uses of Forests

Hunting and Gathering

The hunting of wildlife for bushmeat and the gathering of plant foods is widely practiced in forests throughout the region (De Beer and McDermott 1989; Wollenberg and Ingles 1998). However, very few people living in rain forests are able to subsist by relying entirely on such activities despite the biological diversity present within these forests. The problem is that food resources are sparsely distributed and most plant species are present in low population densities rather than being clumped. In non-seasonal climates, these plants only flower and fruit irregularly, so they represent an unreliable food source. In seasonal climates, they are more likely to have a short-lived reproductive period, meaning that food supplies from these sources are episodic. Wildlife biomass may also be limited (Kikkawa and Dwyer 1992). These problems aside, the key difficulty is that while there might be fruit and nuts, there are relatively few naturally occurring energy-rich food resources such as carbohydrates present in most tropical forests.

This has led some to argue that it is simply not possible to live as hunter-gatherers in these forests and people who seem to do so are actually relying on trade with nearby shifting cultivators or sedentary farmers to obtain their carbohydrates (Bailey et al. 1989; Headland 1987). This suggestion prompted a rather vigorous debate among anthropologists, with Dwyer and Minnegal (1991) arguing there are some small groups who may be able to obtain sufficient carbohydrate from naturally occurring yams and from sago palms. Nonetheless, it seems few people living in rainforest areas rely entirely on hunting and gathering for their livelihoods. The situation is different in woodlands and savannas outside rainforests and Australian aborigines have successfully practiced hunting and gathering without resorting to agriculture. They do so by using fire to manipulate their environment and migrating to take advantage of seasonal changes in food resources (Bowman 2000).

But even if hunting and gathering largely provides a supplementary food source for many agriculturalists, it is, nonetheless, a very common activity. In addition to food, many people gather resources that are used domestically for medicines, fuel and building materials. Some of these are also traded and this trade in non-timber-forest-products (NTFPs) has a long history. Records describing trade between Laos, Cambodia, Vietnam and China go back over 2,000 years (Donovan 2003) while Dunn (1975) describes trade between Malaya, China and

Arabs as far back as the fifth century. The material traded includes animals and animal products as well as resins, nuts, rattans, specialty woods (e.g. camphor, sandalwood) and medicinal plants. Many of these still remain commercially attractive and trade in some has intensified as a consequence of new technologies (guns, motor boats) and improved road access (Dunn 1975). There is ample evidence that much of this hunting and gathering has been unsustainable and the populations of many species have shrunk or disappeared as a consequence (Donovan 2003; Sodhi and Brook 2006).

At a time when change is widespread, there is often a tendency to look back and regard traditional forest users as living in balance with their environments such that their rate of resource use matched the rate at which resources became available. Many traditional forest dwellers did, in fact, regulate hunting or gathering and often devised access or usage rules to decide who could use certain resources as well as when and how this could be done. These rules were not created for 'conservation' reasons. Instead, their real purpose was to benefit the group or clan rather than the wider community. Only rarely were traditional rules developed to conserve the *specie*s itself. If the ratio of land to people became unfavourable thereby increasing the risk of degradation, resources were redistributed by bending these rules or by forcing other people out of the area. Religious and magical rituals were also used to protect certain species or patches of forest. However, the beneficiaries of such practices were primarily the humans involved rather than the biota (because maintaining protection and the rituals leads to social or physical protection of the humans who established the protective regimes). This is not to argue that some traditional activities did not have environmental benefits. Rather, it points to the fact that any such benefits were secondary to the primary aims of these forest users. Bulmer (1982, p. 63) argues that:

> …traditional Papua New Guinea societies scored more points for adaption, innovation and development of new resources than they did for conservation. There is little evidence that Papua New Guineans were or are very different from the majority of humanity who have not been greatly concerned with the long-term conservation of their natural environment. What they were and still are concerned with, very directly and very profoundly, are the present and immediately foreseeable yields of their crops and catches and the amount of time, effort and care required to produce them. To these traditional primary concerns for yields, we must now add concerns for cash. Who can challenge the rationality of this view, given the current state of the world's economy, the rate of inflation, and the fluctuating prices of virtually every commodity.

Shifting Cultivation

Shifting agriculture or swidden agriculture has been commonly practiced across the region. It usually involves clearing a small patch of forest (often around 1 ha or less), burning the debris, planting a variety of food crops and then harvesting these over the next 1 or 2 years as they mature. In the tropical lowlands, up to 20 or 30 crop species can be used in a single garden; although one or two staple food crops usually predominate. Smaller numbers of plants might be used in upland regions.

The crops used by shifting cultivators vary across the region. Rice is the main crop in Asia, while root crops such as sweet potato (*Ipomoea batatas*), yams (*Dioscorea* spp.) or taro (*Colocasia esculenta*) are the main crops in the Pacific region. A large number of other plant species able to supply food, fiber and medicines are used in both areas. Rather than replanting these crops after harvesting, the site is abandoned and the gardeners move elsewhere to repeat the process. The abandoned site is quickly recolonised by forest trees which exclude weeds and restore soil fertility. Gardeners clearing the forest may deliberately leave fruit or nut trees or any larger trees that are difficult to fell. The presence of these, together with coppice from old stumps, helps accelerate the subsequent successional processes during the fallow period. Normally these sites were usually left under fallow for 15–20 years before being used again. By this time a secondary forest was well established. Most farmers preferred to re-use secondary forests on former garden sites since the smaller trees were easier to fell than undisturbed forests having larger trees. These basic patterns have been described by Freeman (1955), Clarke (1971), Geddes (1976), Kunstadter et al. (1978), Rappaport (1968) and Cairns (2007).

Not surprisingly, there are a large number of variations on this basic pattern. For example, burning may not be done in areas with heavy rainfall and Schiefflin (1975) describes a site in Papua New Guinea with a rainfall of over 5,000 mm where crops are sown prior to felling the trees. Some of the crop plants were subsequently damaged during clearing, but most survived. This form of shifting cultivation was not used because of a lack of dry weather to burn but rather to prevent the degradation and erosion of exposed bare soils and to prevent nutrient leaching losses. And farmers may not always prefer to use secondary regrowth forests; Freeman (1955) describes a form of shifting cultivation practiced by the Iban of Sarawak where new gardens were created in intact primary forest rather than secondary forest. These farmers might be thought of as ‘forest pioneers’ rather than ‘rotational’ shifting cultivators. This version appears to reflect the fact that the Iban were moving into essentially ‘virgin land’ and saw the forest as an expendable resource. Rather than settling in one place, they were moving rapidly to claim as much land as possible and could move 80–160 km in a single generation and not return.

The shifting agriculture system has several considerable advantages. Provided the sequence is maintained and fallow periods do not fall below 10 years, the system is sustainable and the crop plants do not need fertilizers, weedicides or pesticides. Nutrients are conserved on the site and weeds are excluded by shade. There is also an inbuilt form of insurance: if one crop species fails there are others still available. It is also highly efficient in terms of labour costs with the energetic value of the food output exceeding the energetic input cost (i.e. labour) by perhaps 15 or 20:1 (Rappaport 1971).

As population densities have increased and fallow periods have shortened, changes have occurred in the way shifting cultivation has been practiced (Cairns 2007; Clarke and Thaman 1993). Some of these involve the use of introduced shrubs or herbs to improve soil productivity, while others involve the introduction of additional trees that are able to provide various timber and non-timber products in the fallow stage. One of these systems, described as dispersed tree fallows, uses scattered plantings of woody legumes such as *Leucaena leucocephala*, *Sesbania* spp., *Falcataria moluccana* (known previously by a large number of synonyms including *Paraserianthese falcataria and Albizia falcata*), or *Erythrina* spp. Other versions of this system incorporate non-leguminous nitrogen-fixing species such as *Alnus nepalensis* and *Casurina oligdon*. Another type of tree-based fallow involves the well-known taungya system where crops are grown with trees for a few years until the tree canopies close. Crops are replanted when the trees are felled and are grown with the trees until canopy closure occurs again. A large variety of native and exotic tree species are also used in such systems. Finally, some fallows have been enriched to form essentially permanent agroforestry plantings. These latter systems will be discussed in more detail in Chapter 5.

Despite being potentially sustainable, shifting cultivation can lead to landscape degradation. This can happen in several ways. The most common is when populations increase and land becomes limiting (or where customary lands are taken over by the state leaving farmers with less lands available for the fallow cycle). Under these circumstances, the length of the fallow period shortens and the capacity of trees to re-establish and rejuvenate the site declines. Recolonisation by forest species is also more difficult as the overall area under cultivation enlarges and the dispersal distance for seeds from undisturbed natural forests increases. There is a risk that weeds, especially grasses, will persist once the length of fallow decreases to below 10 years. This, together with a lack of soil nutrient restoration, then makes the site difficult to use (Fig. 2.1).

A second trigger for degradation following shifting cultivation occurs when the duration of cropping lengthens. This was the case with the form of shifting

Fig. 2.1 Shifting agriculture progressing onto on steep slopes in northern Thailand

cultivation practised by the Hmong (or Miao) people in the hill areas of northern Thailand (Geddes 1976). They grew food crops and opium poppies in successive crops on the same piece of land for as long as 10 years depending on the rate at which productivity declined. Because of this, the sites become so degraded that a much longer fallow, perhaps up to 50 years, is probably needed before forests can be re-established (Geddes 1976). This system reflected the high cash value of opium at the time and the fact that people did not stay in the one location but moved significant distances once a particular site was abandoned. In that sense, they did not have to live with the adverse consequences of their system.

The permanent establishment of grasses usually marks the end of shifting cultivation and results in a complete turnover and replacement of species. The ecosystem can be said to have crossed a threshold and reached a new state-condition. This conversion is usually most likely in strongly seasonal climates that are more subject to wildfires that prevent natural forest regrowth. It may be still possible to continue farming in these grasslands and complex systems of tillage, composting and mounding are used in the highlands of Papua New Guinea to improve fertility and to deal with frosts. In these cases, grass fallows of 4–17 years are used (Vasey 1981; Waddell 1972). However, grasslands in lowlands across the region are usually much less productive and require draught animals for cultivation (Potter 1997). Conroy (1960) argues that the conversion of forest to grassland is much less common when annual rainfalls exceed 2,500 mm because, under these circumstances, the dry seasons are usually short and the fire frequency is then reduced.

Some shifting cultivators' plant trees within the shifting cultivation cycle but most of these are fruit trees or species providing something of particular subsistence value. The topic of such agroforests will be discussed further in Chapter 5. Few shifting cultivators have planted trees to simply restore the forest. When Papua New Guineans living in the large grassland valleys of the country's highlands were asked about other forest tree species they replied that these had been planted by ancestors and it was not their task to try to replace them (Meggitt 1960).

Sedentary Agriculture

Sedentary agriculture was first practised in Asia in the alluvial floodplains and only later spread into the hill areas where shifting cultivation was still practiced. The cause of the transition from shifting cultivation to sedentary agriculture has been the subject of considerable interest. Boserup (1993) argues that the change is primarily driven by increasing population densities in situations when people cannot expand their territories or migrate. Under these circumstances, fallows must shorten as populations increase. This means labour must be used to restore soil fertility. The key metric of efficiency shifts from the food produced per person or man-day of effort to the amount of production per hectare.

There is considerable empirical evidence supporting this view that population density is one of the key drivers of change though it clearly not the only one (Geertz 1963; Rasul and Thapa 2003; Stone 2001). In recent years, the decline in shifting cultivation has accelerated across the region, especially in lowland areas, and the role of some of these other factors may have strengthened. For example, road networks, market access and the provision of agricultural advice have all prompted the growing of new cash crops. Likewise, deliberate government policies aimed at changing land tenure arrangements and reducing the areas under fallow have also played a role in fostering more sedentary forms of agriculture (e.g. Midgely et al. 2007; Roder et al. 1995).

The conversion of forest to agricultural land is often quite wasteful with more forest being cleared than is actually needed at the time. This can be witnessed today in the clearings being carried out to establish oil palm. Fires associated with these clearings have sometimes become wildfires that burned through large areas of Borneo in the latter years of the twentieth century. But the same was true in the mid-nineteenth century, well before the tropical deforestation crisis was widely recognised. For example, the naturalist Henry Forbes lamented:

> As in Java the original forest is rapidly disappearing; each year sees immense tracts felled for rice fields, more than is actually neccessary, and also much wanton destruction by wilful fires.
>
> (Forbes 1885, p. 132)

Like their counterparts who practice shifting cultivation, sedentary farmers should not be seen as simply traditionalists who are stuck in a technological rut (though see Box 2.1). Instead, most are better described as people who are constantly experimenting, learning and modifying the production technologies to adapt to the unfolding circumstances in which they live (Kennedy and Clarke 2004). But, at the same time, there has been a trend towards simplification with more crops being grown in monocultures and a tendency for the number of varieties of each species to be lost and replaced by a smaller number of high-yielding cultivars (Clarke and Thaman 1993). Sometimes this combination of intensification with simplification has led to problems caused by diseases or declining soil fertility (see, for example, Henley 2005; Matson et al. 1997; Nibbering 1999). A common response in such cases is to change crops. In Papua New Guinea, sweet potato (*Ipomoea batatas*) appears to have been introduced some 400 years ago and was able to increase agricultural productivity when yields of traditional crops like yams and taro were declining (Allen et al. 1995). In Asia, cassava (*Manihot esculenta*) is often used at sites where fertility has declined following cropping with other species.

Sedentary farming sometimes fails entirely. Farmers growing cash crops are subject to market fluctuations and those who are entirely dependent on a single dominant crop can find themselves exposed when markets change. For example, Geertz (1963) describes how a collapse in international coffee prices in the 1930s caused the abandonment of coffee growing over large areas of southern Sumatra (needless to say, there have been many coffee ‘booms’ since then as well). Failures can occur and sites may be abandoned for a variety of other reasons as well,

Box 2.1 Errors in rice planting dates lead to food shortages

Inappropriate technologies can lead to sub-optimal or declining levels of productivity, especially when population numbers are increasing. Veldkamp (1979) describes how a government official once visited a village in Sumatra where the rice crop had failed several times. He noticed that a large post had been erected in the village with the Islamic Calendar on it. This calendar is lunar and not astral so that a few days are always 'lost' each year. Because the rice had been sown for many years on a certain Islamic date, the planting date had gradually shifted to an agronomically unfavourable time. The official's problem was how to persuade people to change without giving offence. He managed to get out of the predicament by finding a few old men and asking how they had known when to sow in the less enlightened days before this most excellent calendar had been introduced. After some hesitation, they started to chant a song which went something like 'at sundown point to the star and when the bracelet falls it is the time'. He asked them to point out this star and when the ivory bracelet fell to their elbows measured the angle. Subsequent information from the Bandung Observatory confirmed that the star had reached the correct position at the most appropriate date for rice sowing. And so, by cautiously suggesting that *adat* or traditional law should be followed again, he earned the name Tuan Padi (Mr. Rice). The incident shows how top-down prescriptions and conformity, in this case induced by religion, can have unexpected consequences.

including the use of inappropriate sites, warfare, short-term climate change or the arrival of new diseases. Some detrimental activities may initially produce an increase in farm income before increasing levels of degradation eventually leads to a productivity decline. Some landholders may consciously adopt this practice, secure in the knowledge they can move elsewhere when this becomes necessary. But others may have no fall-back position and use inappropriate practices because they have no other choice. In such cases degradation eventually leads to a decline in their standard of living. Evidence of abandoned former agricultural sites can be seen across the region. In the Pacific, this can sometimes be seen where old irrigation channels that once sustained extensive taro gardens are now enveloped in mature forest containing large trees (Hviding and Bayliss-Smith 2000). In other places, former intensively managed agricultural areas have reverted to grasslands.

A particular form of sedentary agriculture that forms a bridge between shifting agriculture and sedentary agriculture is agroforestry. A very large variety of agroforestry systems have been developed across the region. Some of these are simple home gardens involving small patches of trees intercropped with other species, but others are very extensive and species-rich agroforests that have been developed over long periods of time and which sometimes cover very large areas (Clarke and Thaman 1993; Kennedy and Clarke 2004; Michon 2005). These will be discussed further in Chapter 5.

Logging

Traditional forest dwellers made use of certain timber trees and there are records in Laos from as early as AD 200 of timber species such as eaglewood (*Aquilaria crassna*), ebony (*Diospyros* sp.), sappanwood (*Caesalpinia sappan*) and sandalwood (*Santalum* sp.) being traded with China, Cambodia and Vietnam (Donovan 2003). Much of this early log harvesting was opportunistic and unsustainable although it is likely that many of the people doing it had a good deal of knowledge about the basic biology of these species. Nonetheless it was probably only in the late 1800s and early twentieth century that sufficient was known about the silviculture of most tropical forest species to allow the development of the first management prescriptions.

If logging is to be commercially sustainable, managers must have a good understanding of the tree density and timber volumes of the preferred species, where these trees are located and how fast they are growing. In species-rich tropical forests, this information may take considerable time to assemble. Not all species are equally valuable in the timber market and the proportion of commercial species in a forest can vary with location. Statistically valid surveys are difficult to carry out in landscapes where roads may be sparse and the terrain is challenging. Measures of growth rates are especially difficult. Canopy trees exposed to light usually grow faster than trees in sub-canopy positions. But most trees grow faster after logging if the canopy is opened up around them to let in more light. Actual growth rates can only be assessed from successive measurements on the same tree. The usual way in which growth data is collected is to establish permanent plots and periodically remeasure these (Vanclay 1994). This is more easily said than done. E. Nir (personal communication 2003) described how Papua New Guinea foresters were able to ride motorbikes along former logging roads to establish permanent plots in recently logged forest. It is expensive to maintain these types of roads and, 5 years later when it was time to remeasure the plots, the roads were overgrown and they had to walk in. It took them a week to reach and then remeasure just one plot. Because of the difficulty of getting these basic volume and growth data, most logging across the region has been opportunistic and done without knowing the capacity of forests to provide a future timber yield.

Irrespective of future timber yields, logging should be done in such a way that regeneration is promoted. Several silvicultural systems have been developed that facilitate this objective although there a variety of variations and refinements to each of these (Baur 1964; Lamprecht 1993; Whitmore 1984). One involves harvesting all the trees in a stand at the same time to allow seedlings on the forest floor to grow in the improved light conditions present after logging. Such systems are referred to as Monocyclic or Uniform systems because there is a single logging cycle during the lifetime of the trees. A second harvest is possible after these seedlings grow up and reach a merchantable size, possibly after 80 years.

Another system, known as a Polycyclic system, depends on the fact that many forests contain a range of tree sizes including young saplings growing in sub-canopy positions and older trees that dominate the canopy. This system sets a cutting size limit and only takes commercially attractive trees with a diameter greater than this limit leaving behind the smaller (and mostly younger) trees to grow through and be harvested in the next cutting cycle. Growth of the remaining trees is usually enhanced after logging because harvesting opens up the canopy and reduces between-tree competition. A second harvest takes place once sufficient trees have grown in size and exceed the cutting threshold. This cutting cycle may take 30 years. This means there can be several logging episodes or cycles in the lifetime of a tree.

These two systems are not interchangeable but depend on the silvicultural characteristics of the trees in a forest. There are also a number of conditions that must be met if either of these systems is to work (Table 2.1). A variety of refinements have been developed to cater for situations where this is not possible (Baur 1964; Burgess 1991; Lamprecht 1993; Whitmore 1984).

Perhaps it is not surprising, given earlier comments about the difficulties in getting basic tree growth data, that there is often a good deal of difference between what should be done and what is actually practised. Logging is usually carried out by companies who hold a government concession to carry out logging in a particular area of land. The design of logging operations is rarely carried out by government or company foresters and is more commonly done at the whim of bulldozer operators who decide which path to take to reach a log. Damage to seedling pools and residual saplings and trees is common, while extensive soil disturbance and stream sedimentation is widespread. Further damage to vulnerable regeneration is caused if a second logging operation is carried out again before the forest has had a chance to recover. These are not problems that need further silvicultural research since there is ample evidence that such damage can be readily avoided using known prescriptions (Forshed et al. 2006; Sist et al. 2003). Instead, they require supervision to ensure these prescriptions are followed (Fig. 2.2).

The upshot is that the International Tropical Timbers Organisation found that only a very small proportion of the world's tropical forests were being managed sustainable (ITTO 2006). In the Asia-Pacific region, only 11.6% of the permanent forest estate in ITTO member countries was considered to be sustainably managed.

Table 2.1 Preconditions for using monocyclic or polycyclic silvicultural systems

System	Necessary pre-conditions	Failure if:
Monocyclic	An evenly distributed dormant seedling pool of commercially preferred species is present on the forest floor at the time of logging.	Seedling density is too low. Seedlings are destroyed by logging operation. Seedlings are swamped by weed growth.
Poly cyclic	Appropriate diameter limit set. An adequate number of trees of the commercially preferred species remain undamaged after logging. These residual trees are able to grow quickly.	Diameter limit is set too low. Too many residual trees are damaged by logging. Successive logging operations occur too frequent to allow regrowth. Tree growth is too slow leading to very long felling cycles.

Fig. 2.2 Poor forest regrowth in Sabah after intensive logging and fire (Photo: Robert Ong)

Table 2.2 Ways in which various forest uses can lead to degradation

Activity	Degradation and land abandonment likely if:
Hunting and gathering	Harvesting rates are too high driven by dense human populations and/or strong market demand for NTFPs.
Shifting cultivation	Fallow period shortens to less than 10 years and fertility declines, grasses encroach and recurrent fires occur.
Sedentary agriculture	Soil erosion leads to soil fertility declines, weeds encroach or if market prices decline abruptly.
Logging	If too many residual trees are damaged during felling (polycyclic system) or if seedlings of commercially preferred species fail to regenerate (monocyclic system). Degradation also occurs if successive logging occurs before recovery is complete (i.e. within <30 years).

Over most forests logging is of the cut-out-and-get-out variety, with the consequence being that any future harvests will now be far into the future. That is, the commercial value of many forests (not to mention their biodiversity values) has been unnecessarily reduced after the first logging cycle. Given time, many of these forests may eventually recover, but the roads left by logging can sometimes open up areas for agriculture and lead to the removal of forests on all but the steepest terrain.

In summary, all of these activities are potentially sustainable but most can also cause forest and land degradation (Table 2.2). Lands are degraded if shifting cultivation fallow period drops below 10 years or, in sedentary agriculture, when farming is extended on to marginal sites. Forests are unlikely to be significantly damaged by low-level harvesting, but many are now being over-exploited because of the unregulated use of intensive mechanised logging techniques which leaves them in a degraded condition.

Environmental Determinants of Deforestation

The likelihood that a particular site will be deforested or degraded depends on the types of land use activities being practiced. But this prompts several questions: are some sites more prone to deforestation than others? And, do certain environmental conditions predispose some sites to more deforestation than others? It is possible to explore these questions by examining the extent of deforestation occurring in islands scattered across the Pacific following their settlement by humans. Some islands were settled by migrants from the west more than 3,000 years ago, while others were colonised as recently as 1,000 years ago. It is a common observation that, across the Pacific, significant deforestation, erosion and biodiversity loss appears to have followed human settlement (Anderson 2002; Kennett et al. 2006). This means the colonisation of the Pacific can be seen as a gigantic natural experiment in which to explore the circumstances under which changes occur.

The scale of forest loss on many Pacific islands seems to have been disproportionately high compared with the agricultural demands of settlers. This may have been due to fires used to clear agricultural lands escaping and burning more forest than was intended, especially in some of the drier areas. Forests can recover after clearing but not if repeatedly burned and fires appear to have transformed many forests into degraded savannas and fern-grasslands (Clarke and Thaman 1993). At the time Europeans arrived, some islands still had large areas of forests (e.g. Samoa, Bismark Archipelago), but others had been completely deforested (e.g. Easter, Necker and Nihao islands). Forest loss has led to severe erosion on many islands and this has sometimes been followed by declines in human populations (Clarke and Thaman 1993). In extreme cases, islands appear to have been abandoned some years after settlement largely because of the degradation that occurred.

Some of these differences may have been caused by cultural differences between the various colonists. But might some have been driven by environmental factors? This was investigated by Rolett and Diamond (2004) who studied pre-European conditions at 81 sites on 69 Pacific islands. They explored the relationship between their estimate of the amount of deforestation that had occurred and a variety of environmental and geographic factors. In addition, they also examined the relationship between the amounts of reforestation (including replanting with exotic tree species) that had occurred and these same environmental variables. These variables included: (i) rainfall and temperature (as indicated by latitude), because these are primary determinants of plant growth; (ii) island age and volcanic ash fallout, because these are indicative of soil fertility (younger islands have less heavily weathered soils while regrowth is likely to be more rapid on fertile soils although these are also more favoured by farmers) and (iii) elevation, area and isolation, because these could have multiple effects.

Table 2.3 Environmental factors acting as significant predictors of deforestation or reforestation on Pacific islands (Rolett and Diamond 2004)

Factors increasing the likelihood of deforestation	Factors decreasing the likelihood of reforestation
Lower rainfall	
Higher latitude	Higher latitude
Older islands	
Distant from zone of aerial tephra	Distant from zone of aerial tephra
Low islands	Low islands
Small islands	Small islands
More isolated islands	More isolated islands

The results are shown in Table 2.3 and are much as might be expected. Deforestation was found to be more likely where growing conditions are less favourable and where soil fertility is likely to be poorer (i.e. more deforestation occurred on drier and cooler islands with less fertile soils). By contrast, islands with higher elevation were likely to have more forest because of orographic rains and because steeper terrain is less attractive to farmers. Deforestation was also more likely on smaller islands because these probably have a lower diversity of habitats and relatively fewer coastal resources. More isolated islands are likely to be more deforested because the human populations have fewer opportunities to obtain alternate resources by trading or to escape by emigrating. The extent of reforestation was affected by many of the same variables. Overall, the analysis suggested permanent deforestation was more likely where environmental stresses were greater.

While these findings make sense and are intuitively satisfying, they are not necessarily the most important causes of deforestation. Societies differ in their organisation, political institutions and forms of governance, as well as in their attitudes to environmental conservation. Over time, such difference can have profound effects on the rates of deforestation (and reforestation).

The Socio-Economic Context – a Short History of Deforestation in China and Japan

China and Japan are outside the main geographic scope of this book but the unique written records describing their long environmental histories provide some insights into how societal factors can influence deforestation and degradation.

China

When Europeans visited China in the nineteenth century, they found it bare and degraded with most of the natural forests destroyed. Because of this they described the Chinese as being ‘destructive’ or ‘ruthless’ and having an innate hatred of trees. In fact, the situation was far more complex than this and there have been periods of forest protection as well as periods of forest destruction (Menzies 1996). China has a long written history concerning forests and the effects of deforestation. One of the first texts on silviculture appeared in the Han period around AD 200 entitled 'On planting trees, storing fruit and caring for silkworms' (*Chung Shu Tsang Kuo Hsiang Tshan*) (Menzies 1996). Others followed. In AD 530, the agricultural text *Chhi Min Yao Shu* appeared with descriptions of techniques for breaking seed dormancy, striking cuttings and transplanting established trees from an early age. There was also knowledge about the effects of tree density on tree size and growth (Menzies 1996). Subsequent texts from the medieval period describe the silviculture of particular tree species and complex silvicultural systems where trees were inter-planted with food or perennials (Menzies 1996). These various books clearly reflect a significant and widespread knowledge about forests and tree growing that pre-date all comparable European texts.

There are few records from these early periods discussing the extent of deforestation or land degradation, although official concerns about diminishing natural resources appear from as early as the fifth century BC (Elvin 2004). Forests were nominally under the control of the Emperor and commoners were officially only allowed access under prescribed conditions. However, centralised control was difficult. In AD 500:

> The prefect of Yangzhou … reported to the Emperor 'Though the prohibitions regarding the mountains and lakes have been established since times past, the common people have become accustomed to ignoring them, each one of them following in this the example of others. They completely burn off the vegetation on the mountains, build dams across rivers, and act so as to keep all the advantages for their families… It should be reaffirmed that the old laws that defined what was beneficial and what harmful are still in Force.'
>
> (Elvin 2004, p. 55)

The Emperor demurred, saying that the prohibitions were rigorous but severe and so they should be eased so as to be in keeping with the spirit of the times. Besides, if the lands were taken back it would provoke anger and resentment. He went on to prescribe maximum land holdings for people. But attitudes and policies changed over time and other emperors had different views. Thus the Emperor Hsuan Tsung AD 800 was more 'conservation minded' and sought to maintain temple and mausoleum gardens and protect forests for watershed protection reasons (Schafer 1962). In an edict issued to protect the slopes of a mountain near his capital city from fuelwood cutters he declared:

> …from now and thereafter let the gathering of fuel be taboo there!
> Consider that a sealed precinct!
> Consider our will in this!
>
> (Schafer 1962, p. 295)

There are a number of early records describing attempts to reforest cleared lands. One of the earliest accounts describes the officially sponsored plantations established along Great Wall in 221 BC to hinder military invasions (Menzies 1996). Other early records describe how degraded shrublands were reforested using commercially attractive species.

> …the old country town was in the mountains. In the twentieth year of Khai Yuan (732AD) it was moved out of the mountains. Dense thickets and brush grew where the former town had been, where animals and poisonous snakes had their lairs. This had been troubling the

> townspeople for a long time so in the eight year of Yuan Ho (813AD) the District Magistrate Han Chen ordered that the grass and trees be burned over and the area planted to pine and cunninghamia
>
> (Menzies 1996, p. 577).

In other locations, reforestation was achieved through natural regeneration and this was done after the Ming capital moved to Peking in the early fifteenth century. In this case, a ban was imposed on recutting local forests and this was maintained long enough for reforestation to take place and overcome damage caused by the previous dynasty (Menzies 1996).

For most Chinese the medieval forests must have seemed inexhaustible. On the other hand, there were references as early as in the eleventh century to deforestation and local wood shortages caused by land clearing for farmland and timber harvesting for fuel and for building materials (Elvin 2004). Some reforestation was carried out on a small scale to supply local needs and there were state incentives to plant fruit trees or mulberry trees for silkworms but there were none for large-scale reforestation, such as, for example, of watersheds.

Forest losses accelerated in the seventeenth century largely as a result of population pressure. The population in AD 1000 was around 100 million but reached 200 million by the eighteenth century and 400 million by 1850. By the late nineteenth century most of the temperate forests had disappeared. Murphey (1983, p. 116) quotes:

> All boys in the village big enough to walk and carry a basket are sent out over the hillsides to gather grass, twigs and any kind of herbage that can be used as fodder or fuel. Each boy carries an iron grubbing hook, and thus equipped he clambers up the slopes working away at his task with cheerful energy. Through the industry of this army of human locusts the mountains are denuded of herbage and even roots are often grubbed up.

Despite activities such as these small pockets of forest persisted. Some of these were protected by geomancy while others were in hillier or more remote regions. These remnants were not enough to protect larger animals such as elephants which had disappeared from most of China by the early 1800s (Elvin 2004), but many wildlife species did persist. For example, Wilson (1986) describes an 'extra-ordinary wealth of species exists notwithstanding the fact that every available bit of land is under cultivation' in Hupeh and Szechuan provinces of western China in 1899. He also commented on the good 'sport' (i.e. hunting) still to be had in this area. Forests remained in the tropical south for a little longer than the remainder of the country. This may have been because the area was viewed as being a terrible place and a 'benighted land of exile where pestilential vapours and malaria constantly threatened the health of immigrants' (Menzies 1996). It was only after the beginning of the nineteenth century that substantial deforestation appears to have occurred in the south but, once started, it was soon completed.

Throughout China, the deforestation that occurred was primarily carried out to create food-producing agricultural land. Cash cropping was of minor importance (except for tea) and, by the nineteenth century, most of the timber taken from the forests then remaining was used for fuel or local building purposes rather than for sale or export. Once forests had been cleared peasants often burned the hillsides since the lands could not be used and the resulting wood ash might wash down the slopes onto fields and act as fertilizers. The fires may have also discouraged bandits and predatory wild animals (Murphey 1983). Although this seems wasteful, Murphey (1983) argues that the average farmer could not survive on the low yields likely from farming steeper slopes and that tree crops or grazing animals could only be marginal side-lines to which most farmers could give little time. Most non-agricultural land was eventually privatised, commonly by the rich and powerful (Elvin 2001). Some communities did have communally-owned woodlots, but most were small and these were far from universal. Many such woodlots were destroyed by marauding armies in the final years of the nineteenth century and in the early years of the twentieth century.

The picture that emerges from this 2000-year history is of the seemingly inevitable deforestation of China. It occurred despite a rich silvicultural knowledge base, an understanding of the functional and protective role of forests and a strong political apparatus that had built a unified state. There was also a philosophical tradition that emphasised a reverential attitude to nature and which stressed man's lesser status (Murphey 1983). This tradition required men to adjust to and respect nature and to not despoil it; nature was seen as a source of virtue, wisdom and internal peace and to be contemplated rather than dominated.

Given all these circumstances, why was deforestation so complete? Apart from the relentless demographic pressures, there appear to have been at least two reasons. One concerns the limited ability of the successive governments to use existing knowledge and impose their policies.

> All of the psychological conditions to produce sound policy for the protection of nature were present in T'ang times. But though enlightened monarchs issued edicts, conformable to the best morality of their times these were ignored by their successors. In short, there was no embodiment of these advanced ideas in constitutional form. And so they were ultimately ineffective.
>
> (Schafer 1962, p. 30)

The second was that the philosophical views about nature were limited to a very small proportion of the population who had either the means or status enabling them to be free of manual labour. Most peasants had neither and had to use nature and its resources for their own purposes in a continuous struggle to feed themselves and survive. The ever-increasing population of peasant farmers needed new lands, fuel and building materials and forests were the natural source of these. Over several thousand years, they were able to continue to find new forest lands to expand into and clear until, suddenly, there were no more.

> If we had to create a swift characterization of this Chinese style in the last centuries of the empire it would be in terms of a dynamic but relatively poor society that was constantly driven by population expansion to attempt to master nature in new environments, and which often achieved this in a skilful manner, marked by a patient tenacity but which in the long run more often than not damaged or even destroyed these environments. And yet, overall, a larger and larger population was supported. This can be seen, according to ones perspective, as either a disaster or a triumph.
>
> (Elvin 2001, p. 29)

There are some obvious parallels here between this history and the present-day situation in parts of the Asia-Pacific region; not only is there still an inability to use existing knowledge to manage forest resources but there is also a disconnect between the views of small farmers attempting to wrest a living from their own small patch of land and those whose circumstances mean they can afford to be concerned about global conservation issues.

Japan

The environmental history of Japan is quite different. Like China, Japan went through an extended period of forest exploitation with little concern about the extent of harvesting, or of the capacity of the residual forests to regenerate. But, unlike China, feedback from the problems induced by deforestation were eventually recognised and acted upon (Totman 1989). The geography of Japan imposes substantial limits on agriculture. There is a comparatively small area of alluvial soils and a large area of earthquake-prone mountain areas. The boundaries between the two are more clearly defined than in China and when agriculture was pushed beyond its limits, the result was expressed as severe ecological damage and human hardship.

In the twelfth century, Japan entered a period of unstable decentralised rule after a period of stability under an imperial court. This period of civil war lasted for several hundred years. But, during this time, the population grew substantially (nearly doubling from 7 million in 1200 to 12 million in 1600) and increased use was made of the forests outside the agricultural areas. They were used to collect fuel, fodder and as green manure to fertilise paddy fields. They were also exploited by the local elite for buildings such as temples and fortresses.

In late sixteenth century, a military dictatorship re-imposed order on the country. Overall control was in the hands of the Shogun, but there was a hierarchical but decentralized form of administration with local power being in the hands of daimyo or feudal lords (Totman 1983). Forests were controlled by the Shogun as well as the daimyo, but much of the forest land around villages was assigned communally to villagers. Peace resulted in a massive surge in the rate of forest exploitation by villagers and the noble elite. Towns, temples and fortress buildings were all constructed of timber. Many of these buildings were periodically burned, giving rise to a cycle of construction, loss and replacement, which accelerated the demand for timber even further. As forests were degraded and cleared there was widespread erosion, flooding and damage to downstream cropland. Disputes over rights to particular forests increased.

Eventually there was a turnabout or what Totman (1989) refers to as a 'negative regimen'. This took place in the period between 1630 and 1720. Constraints were imposed on access to forests and the tools that could be used to fell trees. There were also limits on wheeled vehicles that could be used to transport logs and timber. The intent was to take the pressure off forests and allow natural regeneration. But even these changes were not enough and, eventually, a period of tree planting began. Reforestation became increasingly widespread from the late eighteen century, especially in market-oriented areas near towns. This involved sophisticated and sometimes novel silvicultural techniques. Reforestation had both a protective and a production objective, although the type of planting carried out depended on who was doing it. The daimyo or lords tended to favour conifers able to produce large logs suitable for building purposes such as *Cryptomeria* and *Pinus*. Villagers tended to plant hardwoods such as *Quercus* for fuelwood or species such as chestnuts (*Castanea*) for emergency food. The changes were not cost-free and they tended to discriminate against lower status people by denying them access to lands they would have otherwise used.

The interesting question, of course, is why did these changes occur? Totman (1989) argues that a number of factors appear to have been involved. Firstly, the changes were a practical response to a problem from which they could not escape. Since Japan is an archipelago of islands, people could not move elsewhere, which is the usual response by people who have destroyed their resources. In addition, Japan adopted the policy of minimizing external contacts and so precluded the receipt of ideas from abroad. People took it for granted that they would have to solve their own problems.

Secondly, the changes were encouraged by a number of institutional arrangements that defined rights and regulated forest usage by both villagers and lords. These included the fact that households were recognised as the building blocks of society and the social status and location of households was hereditary. It was assumed that one's heirs would inherit the household estate and that the results of one's labours would benefit these heirs. In addition, the control of forests was placed in the hands of those with a vested interest and with the resources to pursue long-term forest regeneration. Parts of forests around villages were allocated to households to manage with strict conditions on their use. Forests in more distant locations were managed by imposing systems to prevent over-cutting and facilitate regeneration. There were also various forms of forest leasing and joint ventures between households and daimyo to encourage sustained management. All of these arrangements gave the community a reason to exercise responsible stewardship and were crucial to the natural and artificial reforestation that subsequently occurred (Totman 1983, 1989). As Williams (2006, p. 310) observed about the Japanese experience:

> …it was a unique social and environmental situation in which a disciplined and literate society sorted out its priorities, people of all classes knew that resources were limited and they simply had to make do with what they had

These necessarily short accounts show the Japanese experience stands in stark contrast to that of China. Over the long history of China, there was much inconsistency between successive dynasties and constraints on forest usage in one period could be replaced by policies offering incentives for land clearance and resettlement in another. In Japan, forest degradation was accompanied by recognition of the relationship between environmental problems and the uncontrolled use of forests. This recognition was accompanied by a rising consciousness of the need for conservation. A stable system of government and supportive institutional settings enabled forest regeneration to take place. This difference between the two countries in institutional settings, legal consistency and in the opportunities for those living in degraded lands to move elsewhere, appear to have contributed to their different environmental histories.

Deforestation and Degradation in the Asia-Pacific Region

Unlike China or Japan, most of the rest of Southeast Asia was comparatively untroubled by increasing population pressures until the late 1800s, with the exception of a few places like Java, the Khmer kingdom and some of the more fertile river deltas where substantial deforestation also occurred. As noted earlier, NTFPs were the primary resource harvested from forests and timber harvesting was generally restricted to a few key species (e.g. teak). This began to change during the nineteenth century as logging increased and states asserted ownership over forest resources. By 1880, many states had begun to establish Forestry Departments to regulate logging operations in order to obtain a greater share of the timber revenues. These forestry agencies also sought to define logging concession areas and the rates at which logging would be permitted.

But the need for more agricultural land also increased. Between 1880 and 1980, the population in Southeast Asia rose from 57 million to 356 million, a sixfold increase. The pattern of decline in overall forest cover and the matching rise in cultivated lands are shown in Table 2.4 which is based on a comprehensive study by Richards and Flint (1994). Statistics on forest cover are notoriously difficult to assemble and some of their data are imperfect or incomplete (a fact acknowledged by these authors). However, their study probably represents the best broad overview of changes in forest cover during an important 100 year period in Southeast Asian history.

Table 2.4 shows that total forest cover declined from 365.7 million hectares in 1880 to 274.2 million hectares in 1980, a loss of 91.5 million hectares of forest or 25% of the total forest cover (including forests/woodlands as well forested wetlands and ‘interrupted woodlands’ which they defined as forested lands with less than 40% canopy cover). The loss of largely intact forests (i.e. excluding interrupted woodlands and wetlands) was 83 million hectares or 32% of the area of this type present in 1880. The annual rate of loss increased sharply after 1950 rising from 0.81 million hectares each year to 1.3 million hectares per year. Much of this change was due to an increasing area of agricultural land. This rose from 16 million hectares to 78 million hectares over the same period. Most of this was used for annual crops such as rice but 17.9 million of the total (29%) was in permanent crops such as rubber plantations.

Table 2.4 Changes in cover (million hectares) of forest, cultivated lands and degraded lands[a] in Southeast Asia between 1880 and 1980 (Richards and Flint 1994)

	1880	1920	1950	1980
Forest				
Total[b]	365.7	337.5	313.3	274.2
Intact[c]	255.3	236.0	210.1	171.9
Annual loss		0.705	0.806	1.303
Non-forest				
Cultivated	16.1	34.0	45.7	78.0
Grasses	57.1	67.5	79.4	84.0
Population density[d]	0.13	0.23	0.39	0.79

[a] Includes grasslands, shrublands and barrens
[b] Includes forest/woodlands, interrupted woodlands and forested wetlands
[c] Forest/woodlands only
[d] (Persons/ha)

The Rise in Abandoned Former Agricultural Lands

An important finding from Richards and Flint's analysis was that only 68% of the cleared forest land was used for agriculture and, over time, the remaining 32% was presumably added to the categories they classify as grasslands, shrublands and barren grounds. Some of these lands may have been used for purposes such as grazing, but some many constitute 'degraded lands' and have suffered topsoil erosion, weed invasion and be subject to recurrent fires. These areas increased by nearly 27 million hectares over the period, to reach 84 million hectares by 1980. This degraded land represented 19% of the total land area and was equivalent to nearly half the area of remaining intact forest.

This pattern has continued and Houghton (2001) suggested that between 1980 and 1985, 59% of all cleared land is subsequently abandoned and becomes degraded land (although this estimate was for tropical Asia as a whole and not just Southeast Asia). Other estimates of the areas of shrub, brush, pasture, waste and 'other' land categories (some of which may be secondary vegetation) now present in Southeast Asia were described in Chapter 1. Fox and Vogler (2001) estimate these degraded areas range from 26% to 49% of all cleared lands. Such assessments are sensitive to differences in the definitions of forest cover and measurement methodologies used in various countries Nonetheless, they point to the creation of very large areas of under-utilised and 'degraded' land in a relatively short period. Many of these areas continue to be used for grazing or gathering thatching materials, or other purposes (Potter 1996). Nonetheless, they represent a change to a category of agricultural land with undeniably lower levels of productivity.

Populations and Deforestation

These changes occurred as population grew and more land was needed to raise food. However, the nature of the relationship between population and deforestation has been controversial (Carr et al. 2005; Geist and Lambin 2002; Kummer 1992; Kummer and Turner 1994; Mather and Needle 2000; Uusivuori et al. 2002). On the one hand, many have seen population growth in Malthusian terms so that it is self evident that larger numbers of people need more land on which to grow food. And over the long sweep of human history, it is clear that rising populations have been accompanied by decreases in forest cover. This pattern is exemplified by the history of land use in China. But not all deforestation is carried out for subsistence agriculture and the simple statement that population and forest cover are linked is not particularly useful in furthering an understanding of the processes involved when deforestation occurs, particularly at a regional or local scale. Sometimes, the present forest cover reflects changes that took place many years earlier and are not at all indicative of the present relationship.

Changes can also occur over time in the nature of the relationship so that forest cover increases at the same time as populations rise. This happened in Japan and Gilmour and Fisher (1991) and Lindblade et al. (1998) give some more recent examples from Nepal and Kenya respectively. Kummer (1992) also points out that there is considerable ambiguity in the terms ‘population’ and ‘deforestation’. What measure of population is most relevant – the total population, the population density, density per unit of arable land, percent increase in population, absolute increase in population or amount of in-migration? Likewise, is it the present forest cover, the deforestation rate or the increased area of arable land that is most relevant?

In the majority of cases, the most useful terms are probably population density and deforestation (i.e. the rate of net forest loss). A high population density is likely to cause more deforestation than a low density but an area with a low population density (and low overall population) could still have rapid deforestation if a steady stream of immigrants kept arriving to match the forward movement of the deforestation zone. Although many early studies were based on pooled data sets involving many countries, most now recognise that it is usually more profitable to explore these relationships as changes over time within a particular national or local context.

Richards and Flint (1994) did such a study using the data set referred to above and this is shown in Fig. 2.3 Their data has been supplemented using recent updates of 1980 cover estimates for Philippines, Thailand and Vietnam and post-1980 forest cover estimates for all countries (FAO 2007). The results show that, across the region, the area of forest land has decreased over time with increasing population density.

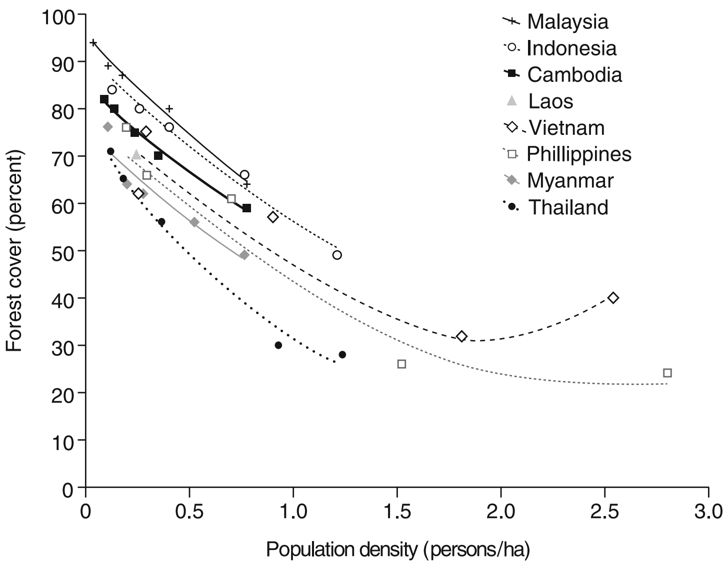

Fig. 2.3 Population density (persons/ha) and estimates of forest cover (including plantations) based on Richards and Flint (1994) and supplemented by 2005 data from FAO (2007). Updated information has been used to change the original 1980 estimates for Philippines (Kummer and Turner 1994), Thailand (Hurst 1990, Poffenberger 1990, Feeny 1988) and Vietnam (de Jong et al. 2006)

The general trends are similar but there are clear between-country differences in the relationship. For example, at a population density of around one person per hectare the forest cover in Thailand is around 30% but nearly 60% in Indonesia. These differences suggest the rate of deforestation is affected by factors other than just population density. Such factors might include the productivity of the farming systems (a function of soils, climate, technology etc.), the proportion of the national landscape suitable for agriculture, land tenure systems (landless people might be more inclined to migrate to find new land) or government policies affecting the extent to which cash crops or plantation estates are established. The Vietnam data also shows that at some point forest cover can begin to increase once more, despite the fact that population density continues to increase (Vietnam probably reached its lowest forest cover of perhaps 26% in the late 1980s when the population density was around two persons per hectare although the evidence is anecdotal). The process by which net deforestation changes to an increasing overall forest cover will be discussed further below.

Causes of Deforestation

A number of studies have explored the cause of deforestation and concluded there are usually a variety of factors responsible. Most studies have distinguished between (i) direct or proximate drivers such as agricultural expansion, logging, infrastructure development, fire or war and (ii) indirect or underlying drivers such as demographic changes, economic factors, government policies and cultural factors (Chomitz 2007; Geist and Lambin 2002; Kummer and Turner 1994; Nguyen and Gilmour 2000). The critical role of agriculture was reviewed by Kaimowitz and Angelsen (1998). They found forests are likely to be cleared for agriculture when the lands are accessible and when soil fertility is high. Deforestation was also more common when agricultural and timber prices were high, when there were opportunities for long distance trade, when there was a shortage of off-farm employment and when rural wages were low. They also found many forests are cleared when they are seen as being open-access resources. In such situations, clearing is a means by which a person can obtain property. All of this makes perfect sense. What is less obvious is why so much of this cleared land is subsequently abandoned? And why has so much forest been so badly degraded that it is unlikely to be productive for the foreseeable future?

Seven Forest and Land Degradation Case Studies

Seven case studies have been gathered to explore how forest and land degradation has occurred in different parts of the Asia-Pacific region and to tease apart the factors responsible. Three of these case studies describe how forests supposedly managed to sustain a local timber industry and protect watersheds and biodiversity have been degraded or deforested (Sarawak, Philippines, Thailand). Two other case studies involve situations where governments were deliberately seeking to clear forests to promote agriculture (North Queensland, Indonesia) or national development (Papua New Guinea) and where the programs ultimately failed. The final case study describes the degradation of forests supposedly managed as a common property resource (Samoa).

Case Study 1 – Intensive logging, Sarawak, Malaysia

Sarawak, together with Sabah, joined with the states of Peninsular Malaya to form Malaysia in 1963. As part of the negotiations, it was agreed that the states would retain control of land and forest resources while the new federal government would have responsibility for oil and gas reserves. Since then, Sarawak's forestry policies have differed sharply from those of the other states of Peninsular Malaysian. It did not join the National Forestry Council (made up of relevant federal ministers and chief ministers of each state) which was established in 1971 to coordinate forest policies across the country. Instead, the state chose to be represented by observers. Neither did it adopt the Council's 1978 National Forest Policy that sought to establish a permanent forest estate across Malaysia, promote sound forestry management and foster a sustainable industry. Instead, it has pursued a pattern of intensive logging that has had little to do with sound management or sustainable practices (Dauvergne 2001).

The state was well-endowed with forests, although these were not as commercially attractive as those in Peninsular Malaysia or Sabah (Ross 2001). On the other hand, there was no strong pressure for agricultural clearing because the state's population density was comparatively low (in 1980 the population density in Sarawak was 10.6 persons per km^2 while Peninsular Malaysia had 86 persons per km^2). In any case, only 28% of the land area is suitable for agriculture (with half of this being regarded as 'marginal'). This suggests the state could have developed a permanent and sustainable forest industry without the agricultural pressures experienced by many other countries in the region. This was not to be. Large scale logging lagged behind that in Peninsular Malaysia but by the late 1970s it had become a major component of the state economy. In 1972, a team from FAO estimated sustainable production could be achieved with an annual allowable harvest of 4.4 million cubic meters per year. But, by the late 1970s, the logging rate was nearly double this level and in 1982 FAO advised the government to take 'urgent action' to avoid the possibility that sustained yield management and the development of forest industries might be compromised (Ross 2001).

As the scale and intensity of logging increased so too did protests from some indigenous forest-dwelling people and a number of NGOs. In response to this criticism, a mission from the International Tropical Timbers Organization (ITTO) was invited to assess logging operations in 1989. This mission concluded that the then annual logging rate of 18 million cubic metres was well beyond their estimate of the sustainable yield of around 4 million cubic metres per year. Note that this ITTO estimate was very similar to the previous FAO estimate provided 17 years earlier (Ross 2001). ITTO suggested the logging rate should be decreased and the government agreed to do so. However, 9 years later, it was still 13 million cubic metres.

The puzzle is why such destructive logging should be allowed in a state with a low population density and only limited agricultural opportunities? The answer is that the forest industry had been captured by a corrupt political elite who were unlikely to slow the pace of logging to simply avoid deforestation or degradation (Dauvergne 2001; Hurst 1990; Jomo et al. 2004; Ross 2001). Sadly, it was also clear that the state was not benefiting as much from the industry as it should have and the royalties or resource rents being charged to loggers were very low compared with other Malaysian states such as Sabah (Gillis 1988; Vincent 1997).

The long-term impact of these logging practices on Sarawak's forests is not known. If properly managed, forests like these are probably capable of generating a sustained yield of timber in perpetuity. And again, if properly managed, much of the biodiversity contained in these forests could be conserved. But there appears to be no information on the state of Sarawak's forests after logging or about their capacity to sustain a second cutting cycle. The condition of similar forests in the nearby state of Sabah gives some cause for concern. In that case a World Bank study found 20% were virtually deforested by poorly supervised logging and a further 50% were poorly or very poorly stocked with residual trees of commercial value leaving only 30% in reasonable condition (Jomo et al. 2004). It seems entirely likely that a similar degree of forest degradation has occurred in Sarawak as well. Some have claimed that shifting cultivation has been the primary cause of deforestation in Sarawak (Lau 1979) but others strongly contest this and argue that shifting cultivation this has not been nearly as damaging as claimed (Cramb 1993; Hurst 1990; Jomo et al. 2004). The weight of evidence suggests that Sarawak is simply another example of a boom-then-bust logging cycle where the forests were treated as a free-good.

The next stage is unclear. Since the 1990s there has been an acceleration of large scale oil palm plantations and agricultural development. Most of the early developments have occurred on land logged in the 1960s and 1970s. These have been excised from the Permanent Forest Estate and re-gazetted as agricultural land (Hansen 2005). Given that only about a quarter of the land in Sarawak is thought to be suitable for agriculture, there is presumably a limit to the extent to which such agricultural developments can be extended onto other heavily logged land. Provided migrants do not move along old logging roads into these areas, the forests may eventually recover although the composition and nature of these future secondary forests is difficult to predict.

Conclusion: forest degradation has occurred because of the failure to enforce regulations and because of corruption. The forests have been regarded as a free public good and, consequently, the silvicultural and environmental costs of poor logging practices have been ignored.

Case Study 2 – Unregulated logging, Philippines

By the end of the twentieth century, most of the primary forests in the Philippines had been destroyed and the Philippines had gone from being the world's largest producer of tropical timbers in 1975 to being a net timber importer in 1994. This was despite the fact it was one of the earliest countries to begin developing silvicultural management systems aimed at preventing this. Both the scale of deforestation and the rate at which it occurred exemplifies just how easily technical knowledge can be over-ridden by poor governance.

Most of the significant early deforestation in the Philippines was carried out to enable the development of commercial agricultural activities such as sugar (Roth 1983). Substantial fuelwood logging was also carried out in some locations to power the new sugar mills. Much of the newly cleared land remained permanently under agriculture except when clearing was carried out on steeper land. In 1863, a Bureau of Forestry was established to help manage forests and prevent inappropriate logging and clearing on steeper lands. An active group of professional foresters were recruited, especially after the turn of the century. Significantly increased logging began at this time and large amounts of timber began to be exported. Forests then covered around 70% of the country. Most of the early logs were species of Dipterocarpaceae and studies were commenced to develop ways of ensuring these regenerated so logging could be sustainable (Roth 1983). By the 1920s, the Philippines had become Asia's largest timber supplier, a position it would hold for the next 50 years.

The pace of logging increased after the 1950s. As Ross (2001) notes, the country was in an enviable position. Forests still covered over 50% of the country and managers had access to some of the most advanced harvesting practices in the world. The Bureau of Forestry also had a corps of well-trained staff to supervise the industry and manage the forests and was regarded as one of the least-corrupt of the government's institutions. But the situation changed as the windfall profits being gained by loggers soon attracted unscrupulous politicians and businessmen. Politicians were able to ensure logging concessions were awarded to friends or companies controlled by themselves. In return, loggers contributed to their political campaigns. The profitability of logging was so great that no attention was paid to the previously assessed annual allowable cut or to the notion of a sustainable harvest; it became simply a cut-out then get-out operation. In 1954 loggers removed 3.6 million cubic meters of timber (which was believed to be the maximum sustainable harvest) but by 1964 this had increased to 11.4 million cubic meters. Concerns were raised by Philippines foresters as well as World Bank and United Nations agencies but these were ignored. By 1987 forest cover had declined from 50% in the immediate post-war years to around 22% (Fig. 2.4) which must rate as one of the fastest episodes of deforestation in the tropics. By then there was no unlogged forest remaining except for small patches in inaccessible areas. In 1985 the Ministry of Natural Resources estimated that one third of the country was 'severely' eroded (Hurst 1990).

The financial benefits to the national economy of this whole episode were small. Kummer (1992) quotes one estimate that the state probably received only 12% of the revenues which had probably amounted to around US$1 billion. This means abnormal profits of around US$820 million was diverted to private interests. Most of these were friends of President Marcos who was in power between 1965 and 1986 (Dauvergne 2001).

A striking feature of Philippines society is in the way land is concentrated in the hands of a wealthy minority. In the late 1980s about 6% of landowners owned 50% of the land. This elite gradually acquired even more power and the proportion of

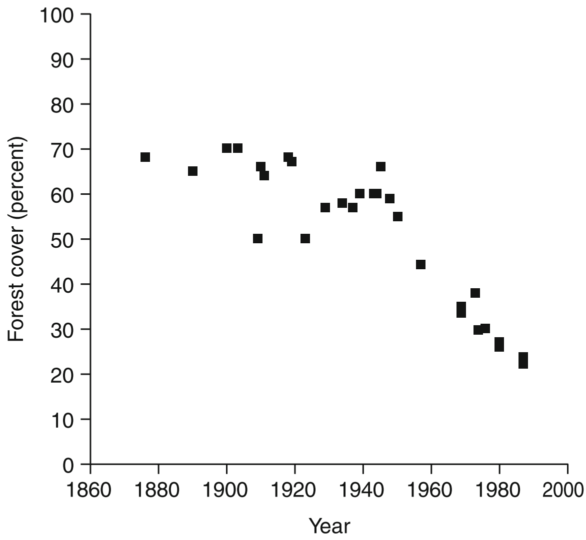

Fig. 2.4 Estimates of changes in forest cover over time in the Philippines based on data from Kummer (1992)

farmers having to rent from landlords rose from 37% in 1948 to 72% in the late 1980s (Leonen 1993). This situation led to large numbers of people moving out of lowland areas and into the uplands in search of farmland. Throughout this period the Philippines GNP grew but most indicators showed that people's income and standard of living actually declined. Large numbers of children remained malnourished and poverty worsened; by 1975 around 60% were living in poverty and this increased during the 1980s (Kummer 1992).

As noted earlier, logging does not necessarily lead to deforestation if it is managed correctly but this population movement meant few of the logged-over forests were able to regenerate. Kummer and Turner (1994) provide strong evidence that logging and agricultural deforestation went hand in hand in the Philippines. By the mid 1980s about 18 million people lived in the uplands and 77% of these were on land classed as public forest lands. This number had probably grown to 24 million by 1995. Large numbers of poor landless people used former logging roads to gain access to forest areas and quickly cleared the remaining vegetation to establish farms (Dawning et al. 1993). The highest rates of population growth were in areas with logging concessions. By the mid 1980s only 10% of land logged before 1955 was still occupied by forest (Kummer 1992; Kummer and Turner 1994).

At a superficial level it might seem that deforestation in the Philippines was simply caused by population pressure. However, Kummer (1992) argues that the primary cause of deforestation was not population pressure nor even misguided government policies. Instead it was caused by both wealth and poverty. A corrupt and 'predatory' economic and political elite deliberately manipulated government policies and regulations. These policies guaranteed a large land rent and those mismanaging the resource were not replaced or punished. Neither were illegal loggers stopped or penalised. On the contrary, there was large-scale collusion between government officials, military and loggers and a deliberate manipulation of statistical reporting system by agencies responsible for management to mislead the public and prevent the records being critically examined by outsiders. Farmers left landless by the inequitable distribution of land had no alternative but to use logged-over forest lands irrespective of its suitability for farming.

By 1987, a large area of degraded land described in forest survey statistics as 'other' had accumulated. This covered 10.9 million hectares (c.f. the 11.3 million hectares converted to farmland and the 6.7 million hectares remaining as forest). In other words, it represented 37% of all land. Most of this land was probably grasslands (Kummer and Turner 1994).

Conclusion: Forest and land degradation were caused by a failure to enforce regulations, low stumpage fees, corruption and a large landless rural population who saw the residual forest as being a free public good.

Case Study 3 – Spontaneous settlement in Uthai Thani Province, Thailand

The forests of Thailand, especially those in the north, were attractive to loggers from an early period because they contained commercially attractive species such as teak which has always fetched a high market price. During the nineteenth century loggers spilled over from what is now Myanmar to harvest teak for the booming local and international trade. By the late 1800s, Bock (1985) reported seeing 600 elephants employed at just one location in central plains of Thailand (Raheng, now called named Tak) bringing logs to the river where they were floated down the Chao Phraya river to Bangkok. The river banks were 'lined for a considerable distance with enormous piles of timber, awaiting a sufficient volume of water to carry them downstream'.

The first attempt to regulate this logging occurred in 1896 when a Forestry Department was established. Despite this, the rate of teak logging increased and may have reached a peak in 1907 before stabilising, although the rates which were mostly still higher than those achieved in the latter years of the nineteenth century (Feeny 1988). In the meantime, population increases created an increasing demand for agricultural cropland. It is difficult to get precise statistics on just how rapidly clearing took place in these early years. Feeny (1988) estimates the area under cultivation increased at an annual rate of 3% between 1906 and 1955 with most of the new cropland outside the Chao Phraya river delta being created by deforestation of state-owned forest land. The lowlands areas were mainly used, at least initially, for irrigated rice but shifting cultivation continued to be practiced in the northern uplands.

Faced with this rate of clearing, the Royal Forestry Department made a number of attempts to create a permanent forest estate. In the early 1950s the target was at 50% of the area of Thailand. However, continued agricultural clearing and illegal logging meant it had to be revised downwards and by 1971 it had dropped to 37% (Feeny 1988). Figure 2.5 shows the pattern of decline in forest cover over time.

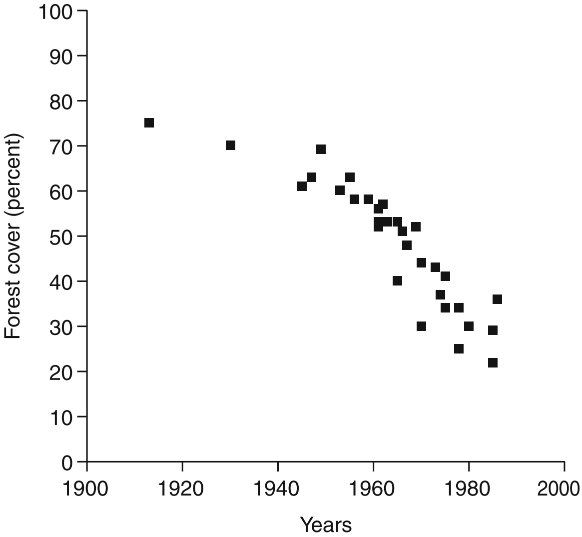

Fig. 2.5 Estimates of changes in forest cover in Thailand over time based on Feeny (1988) and Hurst (1990)

These statistics come from a variety of sources including some where 'forest' includes land that may have been heavily degraded. Nonetheless, the data show that the rate of forest loss increased sharply after 1950. Not all land cleared for agriculture continued to be used for this purpose and Feeny (1988) estimates that only 85% of the forest cleared between 1913 and 1975 was permanent converted to cropland. Most of the remaining 15% presumably reverted to shrublands and grasslands although it is possible some may have regenerated as forest.

Much of the new agricultural lands were cleared by farmers moving in along former logging roads. This meant that 'logged-over' but regenerating natural forest was quickly destroyed and the rate of deforestation then became equal to the rate of logging in the corresponding period (FAO 1981). But this also meant that few of these farmers had any title to the land they were farming. According to Hurst (1990), only 3.7 million hectares of the 24 million hectares under cultivation in 1981 were being farmed by owners with formal legal tenure that gave them secure access and usage rights.

These 'spontaneous' agricultural settlements were not simply the result of demographic pressure. Instead, the process was a rather more complex phenomenon reflecting a number of inter-related influences with the spontaneity modified by the timing of various policy settings. Perhaps the two most important factors were the awarding of timber concessions by the Royal Forestry Department to logging companies and the accelerated national road building program in the 1970s. Both created access into previously inaccessible forest areas.

Hirsch (1988) describes the process of spontaneous settlement that took place in the Lan Sak district of the Uthai Thani Province in central Thailand. This is probably representative of many other such deforestation episodes during this period. The dry dipterocarp and mixed deciduous forests in the area were originally used by shifting cultivators (mainly Karen people). However, in the 1950s, lowland Thai people moved in to tap resin from *Dipterocarpus* trees and to carry out hunting. In the early 1960s some small areas of rice were also being grown in lower lying areas. Access at this stage was difficult and the population remained small. Authority was maintained by local leaders who established rules relating to access to forest resources. In 1969 a logging concession was granted to the government-owned Thai Plywood Company and in 1973 a logging road was built. Although guidelines were in place to regulate logging practices, illegal loggers also moved in and caused severe damage to the forests remaining after the 'official' logging. New settlers also used the logging roads to move into the area encouraged by the then high prices for agricultural produce and by the relative fertility of the newly cleared lands. By 1980, large areas had been cleared and the population was growing rapidly. In 1975 it was 13,500 and the annual rate of increase was 30% (the population reaching 47,000 by 1987).

As more new settlers moved in, the number of land conflicts increased. Thirty people died in a single month in 1970. No legal title was available and land boundaries were not formally defined. Those asserting 'ownership' over a particular area had to enforce their claim against newcomers by personal authority. The area was still regarded as a forest reserve by the Royal Forestry Department but the Lands Department took a different view and demanded payment of a land tax from the settlers. This was often paid because settlers thought this might help them acquire legal tenure.

Over time, ecological changes caused changes in the forms of agriculture being practised. The species initially used by most settlers were low-input but high-yield crops like maize.

But the soil fertility gradually declined and, after the fourth year of cropping, fertilisers and ploughing were needed to maintain productivity. Few settlers had cattle to plough their fields and most were unable to afford the hire of a tractor. Because of this, maize was replaced by crops like mung beans and cotton but the former was too sensitive to occasional dry periods and cassava gradually became more prominent. Weeds such as *Imperata* grass and *Thysanolaena maxima* also began to be more troublesome.

Social changes occurred as well. Declining yields together with stagnant or falling crop prices meant increasing numbers of people acquired debts. Most of these were owed to influential villagers who simultaneously acted as money lenders, suppliers, tractor owners and middlemen. More of the smaller and poorer farmers were bought out by wealthier farmers.

In summary, spontaneous settlement at Lan Sak went through three stages. The first was when the forest and its NTFPs was more important than the timber it contained or the land on which it grew. At this stage the pressure on resources was low. The second stage occurred after logging commenced when the district was colonized by sedentary farmers and rapid population growth occurred. At this stage there was a breakdown of what had then become a managed common property resource. Competition for forest and land became intense. The third and final stage was a period of consolidation and degradation. By then, sedentary agriculture had completely replaced shifting cultivation but there was an increasing need for external inputs to sustain agricultural productivity.

Conclusion: deforestation in this region was caused by corrupt local officials unwilling to control illegal logging. In the scramble for land, poor people cleared areas that should have remained under forest cover. Some of this newly cleared land was quickly degraded because it was unsuitable for agriculture.

Case Study 4 – Planned agricultural settlements on the Atherton Tableland, Australia

When the first European settlers arrived in the wet tropics of north Queensland, the area was dominated by tropical rainforest. These first settlers were tin miners and timber cutters who moved into the Atherton tableland area, near Cairns in 1875. The stature of the forests was impressive suggesting the soils were productive so some settlers established farms in the area in the 1880s. More followed after 1907 when the government made land formally available to new farmers. Government policy at the time was to support agricultural development across the state. This was often done with little regard for economics or environmental realities. The official vision was of a rural community of yeoman farmers and this drove government policy for perhaps the next 60 years. The Atherton tablelands are 50 km from Cairns, the nearest port on the coast, and several thousand kilometres from the state capital, Brisbane. These long distances mean considerable care has to be taken to ensure farming is economically viable. Nonetheless, a large number of enthusiastic settlers moved in and cleared forest for farms. Large scale forest destruction was common because transport was difficult and much forest was simply burned where it fell (Frawley 1987). Maize growing was the dominant crop in the early years but dairying became more prominent as farmers and government researchers gradually learned – over a period of several decades – how to establish the best pasture species (Lamb et al. 2001). Land continued to be opened up for farmers by the government but, by the 1930s, government policies required roads be completed first so that any valuable timbers be extracted before land clearing could proceed. By the time of the Second World War most of the tablelands had been cleared though small patches of forest remnants scattered throughout the area. Forests on the hills and mountains remained as state forests or, later, as national parks.

A final allocation of land was made available for settlement after the war in the early 1950s. This was in an area known as Maalan and lay to the south of the dairy town of Milla Milla. These lands were around 1,000 m in elevation and covered by dense rainforest. The Forestry Department opposed the proposal because the area was occupied with some particular valuable timber stands and they were worried too much land was being cleared for agriculture. They complained:

> The logging and milling industry cannot be made permanent if it has to depend for existence on the desperate salvaging of logs (prior to clearing for agriculture) from the unique jungle forests of the North before their conversion to smoke and ashes.
>
> (Frawley 1987, p. 35)

However, the government believed the proposal was popular with the community and over-ruled the department. The Maalan block was made available in 1953.

Successful applicants received surveyed blocks of around 80 ha and were obliged to clear 10 ha each year and establish pasture or a crop in each of the first 3 years to fulfil purchase conditions. All clearing was done by hand using axes and crosscut saws. The Maalan area was often steep and had a high rainfall (annual rainfall was >2,500 mm with more than 150 rain days per year). Most settlers found it difficult to clear and even more difficult to establish pastures or crops. Conditions were too wet for the good burn that was needed to remove the felled trees and many of the soils were relatively infertile (compared with the rather better soils occupied by earlier settlers on the tablelands). Most farmers initially used the pasture grasses *Melinus minutiflora* (molasses grass) and *Panicum maximum* (Guinea grass). But frosts could kill *Melinas*. When, after a process of trial and error lasting several years, suitable crops or pasture species were eventually identified most farmers found the soil fertility had declined because of the heavy rainfall. Some found it difficult to continue and by 1960 five of the original 24 farms had changed hands. By 1970, a total of 13 had been sold. Frawley (1987, p. 1) quotes Otto Benecke, one of the original Maalan farmers as saying:

> To go down the Maalan, you need a fistful of dollars, a big heart, no brains, and a bloody big umbrella.

In the late 1960s, Gilmour and Reilly (1970) concluded there were up to 50,000 ha of degraded farmland in the southern Atherton tablelands (including the Maalan area) available for reforestation because agricultural productivity was so low. Most of the failed farms were in the higher rainfall areas with steep slopes and poorer soils. In the meantime, selective logging of the remaining forests continued without leading to deforestation. Indeed, Poore (1989); Vanclay (1993); Vanclay et al. (1991) regarded these operations, based as they were on a set of silvicultural prescriptions and a network of growth plots, as being an example of good and sustainable management. Logging ceased in 1988 when all the remaining Australian tropical rainforests were placed on the UNESCO World Heritage List and became part of the national protected area estate (Lamb et al. 2001).

Conclusion: political pressure led to land that should have remained under forest cover being made available to farmers. Agricultural systems able to use this land had not been developed and many farms failed.

Case Study 5 – The mega rice project, Central Kalimantan, Indonesia

During the Suharto era in Indonesia a number of very large agricultural resettlement schemes were carried out to help migrants from densely populated Java move and resettle in some of the outer Provinces of Indonesia. The so-called Mega-Rice project (or, more formally, the Peat Area Project) in Central Kalimantan was one of these. This scheme began in 1996 and aimed to convert 1 million hectares of wetlands and peat swamp forest into irrigated rice fields. It was seen as a way of helping Indonesia to become self-sufficient in rice.

The area chosen was covered by peat with the depth reaching up to 14 m in some locations (Page et al. 2009). The peat is represented by large 'domes' up to 50 km wide and rising several meters above river levels. Each dome is demarcated by rivers and forms its own hydrological unit. Deep peats are not good agricultural soils and are subject to subsidence and accelerated decomposition. Some can become acidified when they dry if the peat contains enough sulphidic compounds (Rieley and Page 2008).

Some selective logging was carried out in the area prior to the project commencing. The forests growing in these areas contained typical wetland communities including the valuable timber species ramin (*Gonystylus bancanus*) and meranti (*Shorea teysmanniana*, *S. platycarpa*, *S. uliginosa*). It is noteworthy that ramin has subsequently been listed as an endangered species under the CITES convention.

When the Mega-Rice project began a more intensive 'salvage logging' operation was carried out and then the remaining vegetation was cleared in order to cultivate rice. A series of drainage canals were constructed through the area. The total length of these was 4,600 km, with the largest being 25–30 m wide. The drainage canals were to remove water during the wet season and allow rice to be irrigated during the dry season. Following the start of the project around 50,000 people moved into the project area to take up land. Few if any of these people had experience in farming peatland areas and it was assumed they could transfer their knowledge of growing irrigated rice in Java to the peatlands.

Very little rice was ever produced because the drainage system led to over-drainage, which allowed the peat to dry out but failed to impound water for irrigation. Draining areas at edge of the peat dome also caused areas in the centre of the dome to dry out and become more susceptible to fire. The summer of 1997/1998 was an El Nino year and Borneo suffered from a series of large wildfires. Smoke from these fires blanketed Southeast Asia and resulted in a massive loss of greenhouse gases. One estimate suggests these represented 13–40% of global emissions from burning fossil fuels (Aldhous 2004). Around 80% of the Mega Rice Project area was damaged by these fires. The legacy was a treeless landscape with a network of malfunctioning canals and a huge peat deposit that was rapidly oxidizing. The project was closed in 1999, not long after President Suharto was forced to step down after the 1997 Asian financial crisis. The area has been since affected by further wildfires.

The failure would not have been surprising to the various specialists who had previously argued against the project going ahead. It appears no preliminary agricultural testing was carried out. The project also violated the government's own regulations which forbade clearing of lands with peat depths greater than 3 m and also required that an environmental impact assessment should be made before projects of this magnitude could proceed. An impact assessment was eventually carried out but not until 6 months after the project began (Boehm and Siegert 1999).

The former settlers were placed in a desperate situation and, not surprisingly, some fell back on logging to try to make a living. This was carried out in forests surrounding the area with funds being supplied by town businessmen. Others are now growing swidden rice and some have established rubber plantings. But the extent of degradation means that, over much of the area, forest restoration will be the best way of dealing with what has happened. Attempts are now being made to restore the forests by blocking the drainage canals at frequent intervals and exploring various ways of carrying out reforestation including using natural regrowth as well as planting (Page et al. 2009).

Conclusion: large-scale agricultural developments need careful planning. In this case an area totally unsuited for agriculture was cleared on the assumption that techniques developed elsewhere could be transferred and used. Even the government's own safeguards were ignored and there was a wilful disregard for the need to undertake preliminary field trials and experimentation.

Case Study 6 – Pulpwood logging in the Gogol Valley, Papua New Guinea

A large pulpwood logging operation commenced in the lowland rainforests of the Gogol Valley on the northern coast of Papua New Guinea in the early 1970s (Lamb 1990). This was established in the final years before independence when the country was being administered by Australia as a Trust Territory of the United Nations. The Administration was concerned that the soon-to-be independent country should be financially secure and the forests were seen as one national asset that might help this be achieved. But, at this time, the country's forests were not as attractive to loggers as those of nearby Indonesia, Philippines or Malaysia where fewer conditions were imposed. Eventually, an offer by a Japanese paper company to carry out pulpwood logging was reluctantly accepted. This proposal involved a clear-felling operation that removed all trees (except *Ficus* which could not be pulped) irrespective of size. The Administration purchased the rights to harvest timber from the traditional landowners and these were then passed on to the company.

The project took place within a very complex social setting. The proposed concession area covered 73,000 ha of forest in the Gogol Valley and an additional block in the valley of a nearby tributary, the Naru River. There were 3,000 people belonging to 330 land owning clans living in the area and, between them, these people spoke eight languages. All of these people practiced shifting cultivation and their isolation meant few were able to participate in the market economy or had access to government services such as schools or health clinics. At the time the project first began to be discussed, many of the able bodied men had already left their villages to seek work in towns and it appeared to the Administration that the social fabric in some communities was breaking down.

A considerable effort was needed to contact the land-owning clans and obtain their agreement to go ahead with the proposal. The social complexities meant lengthy negotiations were needed to define clan land boundaries, settle disputes over these and arrange a schedule of payments to individual clans as the land was progressively logged. Most village people had only an imperfect knowledge of events taking place beyond the village and few were aware of the coming political changes that independence would bring. This meant it was difficult to explain the advantages and disadvantages of logging or to discuss future land use options. Nobody, including the administration, had experienced logging of this intensity. Nonetheless, most people were willing to accept the proposal because of the perceived benefits it would bring. Of these, the most valued was road access to the outside world.

Both the colonial administration and its critics at the time were concerned about the post-logging land use. Since the administration had not purchased the land but only the rights to harvest timber, it had no control over what would be done after logging was completed. A number of alternative scenarios were proposed that allowed for different combinations of plantation reforestation (to permit a continuation of the timber industry) as well as rice growing, pastures for cattle and other land uses. After considerable debate, a plan was eventually adopted that included most of these land uses. The administration favoured reforestation with fast-growing pulpwood species but for this to be viable it had to arrange a land lease for 20,000 ha from the various landowners. This proved impossible to achieve and only 10,000 ha could be acquired for planting. Nor did the rice or the cattle industries develop. In each case, the reason was largely because of the reluctance of landowners to commit to new land uses about which they had little experience. It is a large step to change overnight from a simple shifting cultivator to a sedentary farmer growing cash crops. And, compared with coffee, trees were not a crop in which anyone had any confidence. Many also thought the logging operation was more damaging than they had expected and felt they had been ‘tricked’ by the administration into allowing it. This being the case, they were reluctant to take additional advice from the administration on what they should do next.

These issues meant key government agencies were unable to follow through with advice on how to make better use of the newly cleared lands. The options were limited. The nearest town, Madang, is small and was already well-supplied with fruit and vegetable. Some coffee could be grown for export but this would have to be the lower quality robusta variety because of the lowland climate. But, in any case, the ecological, agricultural and social changes underway were simply too great for people to make quick decisions. As a result, most landowners continued to practice shifting cultivation and most of the clear-felled forest land was simply abandoned. Fortunately, natural regeneration was rapid. After 10 years, regrowth had formed a closed canopy and trees were 20 m tall while the average tree species richness in 0.12 ha plots was 50–60 tree species (Saulei and Lamb 1991). This diversity was comparable with that in unlogged forests although, unsurprisingly, there were rather more secondary forest species represented in the regrowth. This suggested recovery was well underway but was still incomplete. The logging plan ensured a number of small forest reserves were left unlogged near villages to protect drinking water supplies and maintain the supply of various NTFPs. However, the advent of shotguns and the new road network appear to have led to the disappearance of many larger wildlife species.

The road network left behind after logging prompted many of the original households to shift so they could be closer to transport and this is likely to increase the risk of shorter fallows and more grasslands along these zones. Unlike parts of Asia, no immigrants from outside the area have used these roads to colonise the site since it was well known that all land was formally owned. The new landscape is now a patchwork of regrowth forest, post-farming fallow and some grasslands. Meanwhile, the commencement of several other large national development projects elsewhere in the country and the commencement of a system of provincial government meant the project began to receive much less government attention. This meant opportunities for modifying management practices and learning from the accumulating experiences declined.

Conclusion: despite an attempt to devise future land uses after logging, the government was unable to implement this because of the complex social circumstances prevailing at the time. Over time, it may have been possible to devise better use of land cleared by logging but political circumstances led to extension services and government support being withdrawn before this could happen.

Case Study 7 – Changed land systems, Western Samoa

Substantial deforestation has occurred in Western Samoa in the last 50 years and forest cover has declined from 74% in the 1950s to 40% by 1990. Population growth, logging and commercial agriculture have all played a role in this decline but were not the primary causes. Nor was corruption by political elites. Rather, the change appears to have been more a consequence of changes in customary land tenure (Paulson 1994; Ward 2002). Prior to 1960, most rural people originally lived in coastal villages because water was easier to get from coastal springs and because there were few interior roads. This meant it was easier to carry agricultural products (copra, cocoa) to market by boat than by overland transport.

A strong social system controlled how land was used. People belonged to an extended family or *aiga* (which could contain several households) with these being under the authority of a chief or *matai*. The chief controlled land allocation and use. They also mobilised the workforce and managed the distribution of produce from gardens.

The old systems began to change when the country achieved independence in 1962. Only *matai* were given the right to vote in the new legislature and, for largely political reasons, this prompted an increase in the number of *matai* titles. At about the same time, a new road network began to be developed across the inland areas and chainsaws became increasingly available. Piped water also followed the roads. Together, these changes prompted people to move inland and led to an increase in forest clearing. Under traditional practice, an *aiga* clearing land and using it in some way allowed the family to attain rights to this land although these rights were formally vested in the *matai*. Adjoining *matai* acknowledged the claim as long as the land continued to be used. The new roads enabled changes since these provided access to lands not already claimed by the tradition *matai*. Many new *matai* and some individual families began to clear this new land for themselves. They saw themselves achieving economic and social security through having personal control over their own land rather than through a system of traditional reciprocity and service. The changes were also facilitated by opportunities for new, non-traditional cash crops and by the fact that larger numbers of people had begun working away from the village for wages or a salary. This meant a ‘new’ tenure system rapidly developed in parallel with the existing ‘old’ system as people sought to establish landholdings they could pass on to their children under ‘new’ tenure rules. As time has gone by, large areas of land with tree crops (e.g. coconuts, cocoa) grown under the original tenurial arrangements are being abandoned because nobody is interested in investing time or effort in these communal lands.

The government is seemingly powerless to prevent these changes and conserve forests. This is because all land is supposedly under the control of the *matai.* Even though individual land holdings are widely evident they are not publicly acknowledged because most people still prefer to espouse the merits of traditional practice. Until this impasse between the two tenure systems is resolved, deforestation looks set to continue.

Conclusion: degradation has been caused by changing patterns of land tenure, by inappropriate policy settings and by a reluctance to acknowledge changing land use practices.

Lessons Emerging from These Case Studies About the Causes of Forest and Land Degradation

Logging does not necessarily lead to either forest degradation or deforestation. And neither does deforestation necessarily lead to land degradation. But these several case studies show how easily these transitions can occur, especially on the agricultural frontier. There are also some striking parallels with Chinese experiences.

Blaikie (1989) suggested the reasons why degradation occurs can be found at one or more points along a 'chain of explanation'. At the beginning of the chain are factors associated with site conditions such as soil fertility or climate. As previously noted, Rolett and Diamond (2004) concluded some Pacific islands are more prone to degradation than others simply because of their particular biophysical attributes. Among the case studies described above, the environmental conditions at some of the sites being cleared on the Atherton Tablelands in Australia (Case Study 4) and at the Mega-rice project in Indonesia (Case Study 5) were also such as to make them difficult to convert to productive agricultural lands. Under these conditions, some form of degradation was almost inevitable.

The next step in Blaikie's chain concerns the specific land use practices used and the resources available to managers at particular sites. These might be inappropriate practices caused by a lack of knowledge, or by restrictions imposed by poverty, or they might be the result of a wilful failure to use existing knowledge. The former might occur when a migrant farmer begins at a new site where they have little knowledge about the best species to grow or the local constraints on crop production. Such farmers might have a limited capacity to experiment or purchase resources such as fertilisers. The case of the immigrant farmers in the Thailand (Case Study 3) is an example. The poorly managed logging operations in Sarawak and the Philippines (Case Studies 1 and 2) are examples of where existing and well-established silvicultural knowledge and codes of practice were disregarded causing severe damage to the forest resources and biodiversity values.

The third stage in the chain concerns the nature of agrarian society. By this, Blaikie (1989) is referring to issues such as land tenure and the distribution of land between wealthy and poor landholders as well as population densities and local terms of trade (difference in prices received when selling goods and those paid when buying goods). Land tenure is especially important because those without some degree of certainty that they will benefit from investing for the long-term are less likely to engage in sustainable land use practices. The role of land tenure is illustrated by the dramatic changes in farming in Samoa when tenurial arrangements changed (Case Study 7).

Finally, there are several factors distant from the field that, nonetheless, have a major impact on how land users behave and on the likelihood that degradation will occur. One of these is the role of the state. The role of the state is substantial because it establishes the policies and institutions that determine how forest utilisation and land use planning shall be carried out. It also maintains the bodies responsible for administering these policies. If this framework is poorly conceived or is undermined by politics or corruption, such that laws are not enforced, then forest and land degradation is more likely. Most of the case studies outlined above point to some form of policy or administrative failure. In some cases planning or policies were simply inappropriate (Case Studies 3, 4 and 5) or faulty (Case Study 6). In others, government agencies did not respond quickly enough to feedback showing the original policies were not working or they simply ignored the feedback completely. The final factor in Blaikie's causal chain concerns international economic events. He was largely concerned with issues such as foreign debt, but other international factors such as a strong international market for timber will inevitably tempt some to ignore laws or local codes of practice. This seems to have been one of the factors underpinning the events taking place in both Sarawak and the Philippines (Case Studies 1 and 2). Similarly, strong agricultural export markets may lead to marginal lands being cleared that should have remained under forest. Subsequent fluctuations in these prices can have dramatic effects on rural economies and the abilities of land users to avoid degradation.

The chain of explanation is a useful conceptual approach, but forest and land degradation are usually not the result of single causal factors. More commonly there is often a mixture of causes from various points along the chain and often interactions between these various points. For example, inappropriate government policies can cause a cascade of changes that impact on rural societies, overturn local land use practices and ultimately affect the capacity of farmers to be able to survive on their farms. Nonetheless, several key drivers of degradation emerge from these case studies and from other reports (e.g. Barbier 1997; Blaikie and Brookfield 1987; Colombijn 1997). These have been separated into those largely concerned with forest degradation and those mostly concerned with land degradation though there is some overlap between both groups.

Underlying Drivers of Forest Degradation

1. *External costs are transferred*: if the beneficiaries of poor logging are able to transfer the external costs (e.g. erosion, river sedimentation, hydrological changes, biodiversity losses) to others, there is less reason for them to adopt more prudent and conservational management practices. Poor logging practices are less likely where this is prevented and there is a market for ecological services.

2. *Regulations are not enforced*: enough is already known to enable logging to be carried out in most forests with only limited environmental damage. But logging prescriptions, Codes of Practice and even the idea of a Permanent Forest Estate are all ineffective if governments are unable or unwilling to enforce them. Confusion allows considerable scope for people to 'interpret' regulations or laws to suit themselves.
3. *Corruption*: corrupt politicians or public officials seeking personal wealth from forest logging can disrupt or dismantle institutions meant to regulate forest management and maintain forest values. Corruption also means the financial resources of states and their capacity to deal with any subsequent degradation is reduced. Corruption leads to a lack of trust in public systems of governance and a reluctance to invest for the longer-term.
4. *Low stumpage and taxes*: if the fees charged on timber from forest concessions are too low, there may be little incentive to carry out careful logging. In addition, low financial returns may encourage governments to convert forests to other land uses that yield higher returns.

Underlying Drivers of Land Degradation

5. *Land users lack tenure*: Farmers without land are likely to move into and clear recently logged forest including marginal land more prone to degradation. Many of those lacking tenure will subsequently move to a new site once productivity declines rather than invest in improving productivity. Those practicing shifting cultivations are usually forced to use much shorter fallow periods when they lose access to their customary lands thereby increasing the risk of degradation.
6. *Inappropriate technologies and lack of knowledge*: farming often needs specialised knowledge; techniques developed for some situations may not work in others, especially where unfamiliar crops are being used or where soils are less fertile. Degradation may occur because a farmer uses inappropriate species or management systems. It can take time and expertise to develop appropriate methods and most migrant smallholders lack both of these.
7. *Poverty*: many people living in or about forested landscapes are poor. They may have a limited capacity to sustain the productivity of marginal soils which they find themselves using (e.g. by using fertilisers). As was the case with land tenure, poor farmers may find it easier (and cheaper) to abandon a site once productivity begins to decline and begin again elsewhere.
8. *Forests are often viewed as being 'endless'*: an apparently inexhaustible forest area can encourage the view that it is easy to move and clear more forest if degradation occurs. This attitude can be common in so-called frontier situations at the interface between forests and the expanding agricultural sector. It is less likely if some form of monitoring is carried out so that the actual state of forest and land resources are known. The perception is one that may be held by both individual farmers as well as by governments.

9. *Uncertain markets*: changes in commodity prices or labour costs can make previously successful farms uneconomic. This may prompt changes in ownership or cause sites to be over-exploited and degraded before being finally abandoned. The problem is likely to be most acute where lands are only marginally suitable for agriculture.
10. *Inappropriate land use policies*: not all lands are suitable for agriculture and agricultural settlements are sometimes promoted or permitted to develop on lands that should be left under forest cover (e.g. poor soils, steep hill slopes, difficult climate, deep peatlands or sites distant from markets). This often occurs when landless farmers use logging roads to move into recently logged forests and during the land rushes that often develop in these situations.

In short, degradation can arise from attempts to maximise the short-term benefits from using forests or land, irrespective of the consequences. It can also occur when managers have neither the capacity nor the resources to invest in practices that will maintain productivity. Climatic changes and changes in market prices can both trigger degradation at marginal sites. But perceptions also matter and land can be abandoned as wasteland – irrespective of its condition – if farmers believe they will be better off moving and starting again in another location. Population density is sometimes seen as a cause of land degradation and it may be so where farmers have insecure tenure. But it was not a principle cause of degradation in any of these case studies.

Thresholds and Forest Transitions

Much degradation occurs quickly and before government bureaucracies are aware that it has happened, or of the scale at which it is occurring. But at what point do they become concerned enough about deforestation and accumulating areas of wastelands to reverse these trends and undergo what Rudel et al. (2005) refer to as the ‘forest transition’? The historical evidence is that some societies such as China have been unable to prevent almost complete deforestation while others such as Japan have been able take action at a much earlier stage when significant amounts of natural forest still remain. The turnabout occurs when increases in the area of new forests, either natural regrowth or plantations, outweigh losses of natural forest such that the overall forest cover begins to increase. Several explanations have been offered to explain this change. One is that the reversal is largely driven by changes associated with economic development. Some deforestation is required to enable this development but, at a certain point, the wealth acquired allows reforestation to occur. This transition has been likened to an environmental Kuznet’s curve with the relationship between forest cover and economic development resembling a U shape. Bhattaria and Hammig (2004) found empirical evidence supporting this view but concluded that the nature of the relationship was also influenced by governance and the quality of governmental institutions and not just wealth.

Rudel et al. (2005) approached the problem in a slightly different way and suggested there are two potential triggers. One they labelled the 'economic development pathway'. This occurs when the growth of employment in towns and cities is sufficient to draw people away from the countryside, leading to farmland being abandoned. Under these circumstances, any reforestation is unplanned and largely takes place because of natural regrowth rather than because of any deliberate government reforestation policy (in fact it reflects the absence of any such policy). Perhaps the best tropical example of this actually occurring is in Puerto Rico where regrowth has flourished as large numbers of people have left the land (Aide et al. 1995). Something similar may be beginning to happen in parts of Peninsular Malaysia where Jomo et al. (2004) describe the development of a pool of 'idle land' now reaching 890,000 ha or 22% of the land cultivated by smallholders. Many of these farms have become increasingly small and it seems some owners or tenants have left them to seek more remunerative opportunities in urban areas.

The other trigger they termed the 'forest scarcity pathway'. In this case, an increasing shortage of natural forests eventually drives up the local prices of forest products and prompts reforestation. Under these circumstances, landowners find it profitable to plant trees for their own use or for commercial reasons. A striking example of this occurring was provided by Holmgren et al. (1994) who described how Kenyan farmers began planting trees on farms and created a timber resource that became greater than that in natural forests. Contrary to expectations, there was a positive relationship between population density and planted woody biomass. Similar findings have been reported from India (Foster and Rosenzweig 2003). An example from the Philippines is described in Box 2.2. In each case, forest resources were suddenly in short supply and farmers found it financially rewarding to adopt timber trees as a new cash crop.

There is little doubt that reforestation for commercial gain does take place when market conditions are attractive, but governments have a crucial role to play in establishing a supportive policy framework and providing the technical assistance needed to overcome degradation. Many governments have sought to foster reforestation to improve economic outcomes but also to overcome erosion, improve watershed conditions, prevent floods and conserve biodiversity resources. Some governments have simply promoted reforestation but allowed deforestation to continue while other have tried to prevent further deforestation and also foster reforestation. Examples of such government driven reforestation programs in Asia are those in Japan (Totman 1983) and more recently in China and India (Mather 2007) and Korea (Tak et al. 2007). The Korean example is dramatic with more than 2 million hectares, or around 30% of the landscape, being reforested since the 1950s, bringing the total forest cover to 63% of the land area (Tak et al. 2007). This suggests the two models identified by Rudel et al. (2005) are insufficient to describe all transitions.

The only country in Southeast Asia that has undergone the forest transition is Vietnam (see Fig. 2.3). There is some uncertainty about just how far deforestation progressed before change occurred. Some suggest forest cover may have fallen to as little as 15–17% (De Koninck 1999), although a cover of 24–26% in the early 1980s appears to be more widely accepted (De Jong et al. 2006; Meyfroidt and Lambin 2008; Nguyen and Gilmour 2000). Whatever the precise figure, forest

Box 2.2 The forest transition at a local level in Northern Luzon, Philippines

The dipterocarp forests in the mountain areas of northern Luzon have been heavily logged and most of the area is now without a commercially attractive timber resource. Workers attracted to the area during the height of the logging boom have either left the area or taken up farming on former logging concession areas. Some have also carry out illegal logging in the remaining forests but favour the local *Pterocarpus indicus* rather than the dipterocarp species taken by the original logging companies. This timber is used by local furniture makers and now commands a much higher price than the local dipterocarps (that were previously used for plywood). The new supplies of this timber have led to a doubling in the number of furniture factories. Not surprisingly, this is causing a gradual depletion of the *Pterocarpus* resource. In the meantime, a number of former loggers have begun planting trees on their own land in addition to crops like maize, rice and bananas. Seki (2003) describes this as ‘spontaneous’ reforestation because it has occurred without significant government assistance. The reason for this reforestation is the changing economic and ecological conditions surrounding the ex-logging workers. A survey found most of those interviewed planted trees (mostly *Gmelina arborea*) because they believed it would be profitable for them or because they saw the need for a new natural resource to replace that destroyed by logging. Tree planting has became more profitable as the natural forest shrunk and became confined to less accessible areas where the costs of transporting logs is increasingly high. Under these circumstances, local sawmills have found *Gmelina* an acceptable alternative. Growing *Gmelina* is also attractive to growers for other reasons other than there being a ready market; seed is easily obtainable, the species is resistant to fire and harvesting can be carried out after only 8 years. Seki (2003) considers the success of this reforestation phenomenon is unrelated to the government’s community-based forest management strategy. The latter is more interested in large-scale tree plantation programs managed by cooperatives but this has sometimes led to land disputes. While cooperatives may be appropriate for managing residual secondary forests, they are much less attractive to former logging workers who prefer managing their own farms rather than being employed as plantation workers.

cover had increased to 40% by 2005 (FAO 2007). The early stages of this turnaround occurred when Vietnam was a centrally planned economy and reforestation was carried out under the direction of the state. But the process changed after 1989 when Vietnam began transforming itself into a market economy. Households were granted long-term access and rights to use land and assistance was given to households to protect existing forests and replant new production and protection forests (De Jong et al. 2006; Do and Le 2003; Nguyen and Gilmour 2000). This alone may not have been enough to encourage reforestation (Sikor 2001) but the government has also promoted the idea through policy and legislative changes and funded a series of national reforestation programs. The most recent of these programs aims to reforest an additional five million of land (MARD 2001). It should be noted that Vietnam's attempts to reduce deforestation and increase the national forest cover have been assisted by the importation of large volumes of illegally logged timber from neighbouring countries (Meyfroidt and Lambin 2009).

This transition does not immediately fit either the simple 'environmental Kuznet's curve' of Bhattaria and Hammig (2004), or the 'economic development pathway' of Rudel et al. (2005). On the other hand, there is some evidence that elements of the 'forest scarcity pathway' were at work. Based on a regression model of landscape changes, Meyfroidt and Lambin (2008) suggest changes in land tenure arrangements have allowed the intensification of agriculture in valleys and leaving land available for reforestation on upper hillslopes. In areas with road access it has been profitable for farmers to reforest these slopes because of a market for forest products. They refer to this as being a 'smallholder agricultural intensification pathway'. Markets and road access have been undeniably important but there is little doubt that the evolving national policy framework in Vietnam has also been instrumental in dealing with some of the problems described in the case studies and facilitating the turn-about (De Jong et al. 2006).

Conclusions

This chapter provides additional evidence concerning the extent of forest degradation and loss in the region. Traditional agricultural practices have damaged forests in the past but recovery has usually occurred because the scale of the damage was limited. More recently, the rate and scale of clearing has accelerated. Some of the cleared land has been successfully used for agriculture but other areas have been used only briefly and then abandoned in a degraded state. It is not easy to determine the proportion of land affected in this way because of the difficulty of defining and mapping degraded lands, but estimates range from 26% to 49% of all cleared land.

Some lands may be more prone to degradation than others because of their biophysical attributes but forest and land degradation has often been caused by a wilful disregard for regulations and of well-established practices designed to prevent degradation from occurring. It is often a sign of poor governance with the distribution of costs and benefits being grossly inequitable and with neither ecological nor economic information being used in decision-making. In some cases, poor farmers have been the agents as well as the victims of land degradation because they did not have the knowledge to manage their land or were unable to afford the investments needed to make their land productive. The economic costs of degradation are generally invisible in national accounts but the effects are usually profound, especially for the poorer members of society, since they are the ones most dependent on the natural resource base.

At a national scale, there appear to be at least three pathways by which reforestation might occur. One of these is the 'economic development pathway' that develops when agricultural land is abandoned as people move to urban areas. A second is the 'forest scarcity pathway' where reforestation is triggered by a shortage of forest goods or services. The third pathway is where governments initiate and facilitate reforestation. In each of these cases, reforestation will be assisted if the policy and institutional failures that led to degradation can be overcome. But new land use policies and silvicultural techniques will also be needed that match the economic and ecological circumstances now present in these degraded lands. These will need to address the needs of smallholders as well as large industrial plantation owners. They should also ensure the new forests are capable of producing a wide range of ecosystem services, including biodiversity conservation, as well as just timber.

The decline in forest cover and the increase in areas of degraded land raises two important questions. One is how to conserve the biodiversity still remaining in tropical landscapes? Is the present reliance on protected areas sufficient or are other approaches also needed? The second question is what can be done to hasten the forest transition in order to improve the livelihood of people now living in these deforested and degraded areas? Might some forms of reforestation be beneficial or must further deforestation occur if their living standards are to increase? Both these issues will be discussed in the next chapter.

References

Aide TM, Zimmermann JK, Herrera L, Rosario M, Serrano M (1995) Forest recovery in abandoned tropical pastures in Puerto Rico. For Ecol Manage 77:77–86

Aldhous P (2004) Borneo is burning. Nature 432:144–146

Allen BJ, Bourke M, Hide RL (1995) The sustainability of Papua New Guinea agricultural systems: the conceptual background. Global Environmental Change 5:297–312

Anderson A (2002) Faunal collapse, landscape change and settlement history in remote Oceania. World Archaeol 33:375–390

Ash J (1992) Vegetation ecology of Fiji: past, present, and future perspectives. Pac Sci 46:111–127

Bailey RC, Head G, Jenike M, Owen B, Rechtman R, Zechenter E (1989) Hunting and gathering in tropical rain forest: Is it possible? Am Anthropol 91:59–82

Barbier E (1997) The economic determinants of land degradation in developing countries. Philosphical Transactions of the Royal Society of London B 352:891–899

Baur GN (1964) The Ecological Basis of Rainforest Management. Forestry Commission of New South Wales, Sydney

Bhattarai M, Hammig M (2004) Governance, economic policy and the environmental Kuznets curve for natural tropical forests. Environment and Development Economics 9:367–382

Blaikie P (1989) Explantation and policy in land degradation and rehabilitation for developing countries. Land Degrad Rehabil 1:23–37

Blaikie P, Brookfield H (1987) Land Degradation and Society. Methuen, London

Bock C (1985) Temples and elephants: the narrative of a journey of exploration through Upper Siam and Lao. White Orchid Press, Bangkok (originally published by Sampson Low, Marston, Searle, and Rivington. London, 1884)

Boehm H, Siegert F (1999) Remote sensing verification by aerial surveys and ground truth campaigns 1997 and 1998 in Central Kalimantan, Indonesia – peat swamp forest, Mega-Rice Project and fires. Workshop on Tropical Forest and Remote Sensing The Center for Remote Sensing, Imaging and Processing, National University of Singapore, 5 March 1999

Boserup E (1993) The Conditions of Agricultural Growth: the Economics of Agrarian Change under Population Pressure. Earthscan, London

Bowman DMJ (2000) Australian rainforests: Islands of Green in a Land of Fire. Cambridge University Press, Cambridge
Brookfield H (1997) Landscape history: land degradation in the Indonesian region. In: Boomgaard P, Colombijn F, Henley D (eds) Paper Landscapes: Explorations in the Environmental History of Indonesia. KITLV Press, Leiden, pp 27–59
Bulmer RNH (1982) Traditional conservation practices in Papua New Guinea. In: Morauta L, Pernetta J, Heaney W (eds) Traditional conservation in Papua New Guinea: implications for today. Institute of Applied Social and Economic Research; Monograph 16, Port Moresby, pp 59–777
Burgess P (1991) Natural rainforest management. In: Collins M, Sayer JA, Whitmore TC (eds) The Conservation Atlas of Tropical Forests: Asia and the Pacific. MacMillan Press, London, pp 43–50
Cairns M (ed) (2007) Voices from the Forest. Resources for the Future, Washington
Carr DL, Suter L, Barbieri A (2005) Population dynamics and tropical deforestation: State of the debate and conceptual challenges. Popul Environ 27:89–113
Chazdon RL (2003) Tropical forest recovery: legacies of human impact and natural disturbances. Perspectives in Plant Ecology, Evolution and Systematics 6:51–57
Chomitz K (2007) At Loggerheads? Agricultural Expansion, Poverty Reduction and Environment in the Tropical Forest. World Bank, Washington
Clarke WC (1971) Place and People: an Ecology of a New Guinean Community. Australian National University Press, Canberra
Clarke WC, Thaman R (1993) Agroforestry in the Pacific Islands: Systems for Sustainability. United Nations University Press, Tokyo, New York, Paris
Colombijn F (1997) The ecological sustainability of frontier societies in eastern Sumatra. In: Boomgaard P, Colombijn F, Henley D (eds) Paper Landscapes: Explorations in the Environmental History of Indonesia. KITLV Press, Leiden, pp 309–340
Conroy W (1960) The evolution of the agricultural environment in Papua and New Guinea. Symposium on the impact of man on humid tropics vegetation; Goroka Territory of Papua and New Guinea. Administration of the Territory of Papua and New Guinea and UNESCO Science Cooperation Office for South East Asia, pp 94–97
Cramb R (1993) Shifting cultivation and sustainable agriculture in East Malaysia: a longitudinal case study. Agric Syst 42:209–226
Dauvergne P (2001) Loggers and Degradation in the Asia-Pacific: Corporations and Environmental Management. Cambridge University Press, Cambridge
Dawning SL, Iverson LR, Brown S (1993) Rates and patterns of deforestation in the Philippines: application of geographic information system analysis. For Ecol Manage 57:1–16
De Beer J, McDermott M (1989) The Economic Value of Non-timber Forest Products in Southeast Asia. Netherlands Committee for IUCN, Amsterdam
De Jong W, Sam DD, Hung TV (2006) Forest Rehabilitation in Vietnam: history, realities and future. Center for International Forestry Research, Bogor
De Koninck R (1999) Deforestation in Vietnam. International Development Research Center, Ottawa
Do DS, Le QT (2003) Forest policy trends in Vietnam. In: Inoue M, Isozaki H (eds) People and Forest - Policy and Local reality in Southeast Asia, the Russian Far East and Japan. Kluwer Academic Publishers, Dordrecht
Donovan D (2003) Trading in the forest: Lessons from Lao history. In: Lye T-P, De Jong W, Abe K (eds) The Political Ecology of Tropical Forests in Southeast Asia: Historical Perspectives. Kyoto University Press, Kyoto, pp 72–106
Dunn FL (1975) Rainforest collectors and traders: a study of resource utilisation in modern and ancient Malaysia. Monograph No. 5. Malaysian Branch of the Royal Asiatic Society, Kuala Lumpur
Dwyer P, Minnegal M (1991) Hunting in lowland tropical rainforest; towards a model of non-agricultural subsistence. Hum Ecol 19:187–212
Elvin M (2001) Three thousand years of unsustainable growth: China's environment from archiac times to the present. East Asian History 6:7–46
Elvin M (2004) The Retreat of the Elephants: An Environmental History of China. Yale University Press, New Haven and London

FAO (1981) Tropical Resources Asessment Project: Forest Resources of Tropical Asia. Food and Agriculture Organization of the United Nations and the United Nations Environment Programme, Rome

FAO (2007) State of the World's Forests 2007. Food and Agriculture Organisation of the United Nations, Rome

Feeny D (1988) Agricultural expansion and forest depletion in Thailand 1900 – 1975. In: Richards JF, Tucker RP (eds) World deforestation in the twentieth century. Duke University Press, Durham, pp 112–143

Forbes HO (1885) A Naturalist's Wandering in the Eastern Archipelago: a Narrative of Travel and Exploration from 1878 to 1883. Sampson Low, London

Forshed O, Udarbe T, Karlsson A, Falck J (2006) Initial impact of supervised logging and pre-logging climber cutting compared with conventional logging in a dipterocarp rainforest in Sabah, Malaysia. For Ecol Manage 221:233–240

Foster AD, Rosenzweig MR (2003) Economic growth and the rise of forests. Quarterly Journal of Economics 118:601–637

Fox J, Vogler J (2001) Land-use and land-cover change in montane mainland southeast Asia. Environ Manage 36:394–403

Frawley K (1987) The Maalan Group Settlement North Queensland: A Historical Geography. Department of Geography and Oceanography, University College, University of New South Wales, Australian Defence Force Academy, Canberra

Freeman JD (1955) Iban Agriculture: A report on the Shifting Cultivation of Hill Rice by the Iban of Sarawak. H.M. Stationery Office, London

Geddes WR (1976) Migrants of the Mountains: the cultural ecology of the Blue Miao (Hmong Njua) of Thailand. Clarendon Press, Oxford

Geertz C (1963) Agricultural Involution:the Process of Ecological Change in Indonesia. University of California Press, Berkley

Geist HJ, Lambin EF (2002) Proximate causes and underlying driving forces of tropical deforestation. Biotropica 52:143–150

Gillis M (1988) Malaysia: public policies and the tropical forest. In: Repetto R, Gillis M (eds) Public Policies and the Misuse of Forest Resources. Cambridge University Press, New York, pp 115–164

Gilmour DA, Fisher RJ (1991) Villagers, Forests and Foresters. Sahayogi Press, Kathmandu

Gilmour DA, Reilley JJ (1970) Productivity survey of the Atherton Tableland and suggested land use changes. Journal of the Australian Institute of Agricultural Science 36:259–272

Goldammer JG, Seibert B (1989) Natural rainforest fires in eastern Borneo during the Pleistocene and Holocene. Naturewissenschaften 76:518–520

Haberle SG, Hope GS, van der Kaars S (2001) Biomass burning in Indonesia and Papua New Guinea: natural and human induced fire events in the fossil record. Palaeogeogr Palaeoclimatol Palaeoecol 171:259–268

Hansen TS (2005) Spatio-temporal aspects of land use and land cover changes in the Niah catchment, Sarawak, Malaysia. Singapore Journal of Tropical Geography 26:170–190

Headland TN (1987) The wild yam question: How well could independent hunter-gatherers live in a tropical rain forest ecosystem? Hum Ecol 15:463–491

Henley D (2005) Agrarian change and diversity in the light of Brookfield, Boserup and Malthus: historical illustrations from Sulawesi, Indonesia. Asia Pacific Viewpoint 46:153–172

Hirsch P (1988) Spontaneous land settlement and deforestation in Thailand. In: Dargavel J, Dixon K, Semple N (eds) Changing Tropical Forests: Historical Perspectives on Today's Challenges in Asia, Australasia and Oceania. Center for Resource and Environmental Studies, Australian National University, Canberra, pp 359–376

Holmgren P, Masakha EJ, Sjoholm H (1994) Not all African land is being degraded - a recent survey of trees on farms in Kenya reveals increasing forest resources. Ambio 23:390–395

Hopkins MS, Head J, Ash JE, Hewett RK, Graham AW (1996) Evidence of a Holocene and continuing recent expansion of lowland rain forest in humid, tropical North Queensland. J Biogeogr 23:737–745

Houghton R (2001) Agriculture. In: Woodwell GM (ed) Forests in a Full World. Yale University Press, New Haven and London, pp 35–50

Hurst P (1990) Rainforest Politics: Ecological Destruction in South-East Asia. Zed Books, London

Hviding E, Bayliss-Smith T (2000) Islands of Rainforest: Agroforestry, Logging and Eco-tourism in Solomon Islands. Ashgate, Aldershot

ITTO (2006) Status of Tropical Forest Management 2005. International Tropical Timbers Organisation; Technical Series no 24, Yokohama

Johns RJ (1989) The influence of drought on tropical rainforest vegetation in Papua New Guinea. Mt Res Dev 9:248–251

Jomo KS, Chang YT, Khoo KJ (2004) Deforesting Malaysia: The Political Economy and Social Ecology of Agricultural Expansion and Commercial Logging. Zed Books in Association with United Nations Research Institute for Social Development, London and New York

Kaimowitz D, Angelsen A (1998) Economic Models of Tropical Deforestation: A Review. Center for International Forestry Research, Bogor

Kelly PM, Hoang MM, Tran VL (2001) Responding to El Niño and La Niña: averting tropical cyclone impacts. In: Adgers WN, Kelly PM, Ninh NH (eds) Living with environmental change: social vulnerability, adaptions and resilience in vietnam. Routledge, London, pp 155–181

Kennedy J, Clarke WC (2004) Cultivated landscapes of the Southwest Pacific. Resource Management in Asia-Pacific Working Paper No 50, Resource Management in Asia-Pacific Program; Research School of Pacific and Asian Studies; The Australian National University, Canberra

Kennett D, Anderson A, Winterhalder B (2006) The ideal free distribution, food production and the colonization of Oceania. In: Kennett D, Winterhalder B (eds) Behavioural Ecology and the Transition to Agriculture. University of California Press, Berkeley, Los Angeles, London, pp 265–288

Keppel G, Buckley Y, Possingham H (2010) Drivers of lowland rainforest community assembly, species diversity and forest structure in islands in the tropical South Pacific. J Ecol 98:87–95

Kikkawa J, Dwyer P (1992) Use of scattered resources in rainforests of the humid tropical lowlands. Biotropica 24:293–308

Knapen H (1997) Epidemics, droughts and other uncertainties in Southeast Borneo during the eighteenth and nineteeth century. In: Boomgaard P, Colombijn F, Henley D (eds) Paper Landscapes: Explorations in the Environmental History of Indonesia. KITLV Press, Leiden, pp 121–154

Kummer DM (1992) Deforestation in the Postwar Philippines. University of Chicago Press, Chicago

Kummer DM, Turner BL (1994) The human causes of deforestation in Southeast Asia. Bioscience 44:323–328

Kunstader P, Chapman EC, Sabhasri S (1978) Farmers in the Forest: Economic Development and Marginal Agriculture in northern Thailand. East-West Center and University Press of Hawaii, Honolulu

Lamb D (1990) Exploiting the Tropical Rainforest: An Account of Pulpwood Logging in Papua New Guinea. UNESCO and The Parthenon Publishing Group, Paris and Carnforth

Lamb D, Keenan R, Gould K (2001) Historical background to plantation development in the tropics: a North Queensland case study. In: Harrison SR, Herbohn J (eds) Sustainable farm Forestry in the Tropics: Social and Economic Analysis and Policy. Edward Elgar, Cheltenham, pp 21–34

Lamprecht H (1993) Silviculture in the tropical natural forest. In: Pancel LR (ed) Tropical Forest Handbook. Springer-Verlag, Berlin, pp 728–810

Lau BT (1979) The effect of shifting cultivation on sustained yield management for Sarawak national forests. Malaysian Forester 42:418–422

Leonen M (1993) Philippines: dwindling frontiers and agrarian reform. In: Colchester M, Lohman L (eds) The Struggle for Land and the Fate of the Forests. Zed Books, London, pp 264–290

Lindblade K, Carswell G, Tumuhairwe JK (1998) Mitigating the relationship between population and land degradation: landuse change and farm management in southwest. Uganda Ambio 27:565–571

MARD (2001) Five Million Hectare Reforestation Program Partnership: Synthesis Report. International Cooperation Department, Ministry of Agriculture and Rural Development, Hanoi

Mather AS (2007) Recent Asian forest transitions in relation to forest-transition theory. International Forestry Review 9:491–502
Mather AS, Needle CL (2000) The relationship of population and forest trends. Geogr J 166:2–13
Matson P, Parton WJ, Power AG, Swift MJ (1997) Agricultural intensification and ecosystem properties. Science 277:504–509
Meggitt MJ (1960). In discussion, p.137. Symposium on the impact of man on humid tropics vegetation. Goroka, Territory of Papua and New Guinea. Administration of the Territory of Papua and New Guinea and UNESCO Science Cooperation Office for South East Asia, Papua and New Guinea
Menzies NK (1996) Forestry. In: Needham J (ed) Science and Civilisation in China. Cambridge University Press, Cambridge
Meyfroid P, Lambin EF (2008) The causes of reforestation in Vietnam. Land Use Policy 25:182–197
Meyfroid P, Lambin EF (2009) Forest transition in Vietnam and displacement of deforestation abroad. Proc Nat Acad Sci 106:16139–16144
Michon G (2005) Domesticating Forests: How Farmers Manage Forest Resources. Institut de Recherchepour le Developpement, Center for International Forestry Research, World Agroforestry Center, Paris, Bogor
Midgely S, Blyth M, Mountlamai K, Midgely D, Brown A (2007) Towards Improving Profitability of Teak in Integrated Smallholder Farming Systems in Northern Laos. Australian Center for International Agricultural Research, Canberra
Mueller-Dombois D, Fosberg FR (1998) Vegetation of the Pacific. Springer-Verlag, New York
Murphey R (1983) Deforestation in modern China. In: Tucker RF, Richards JF (eds) Global Deforestation and the Nineteenth-Century World Economy. Duke Press Policy Studies, Durham, pp 111–129
Nguyen VS, Gilmour DG (2000) Forest rehabilitation policy and practice in Vietnam. In: Anon (ed) Forest rehabilitation policy and practice in Vietnam: Proceedings of a National Workshop, Hoa Binh. International Union for Conservation of Nature, Hanoi, pp 4–34
Nibbering JW (1999) Tree planting on deforested farmlands, Sewu Hills, Java, Indonesia: impact of economic and institutional changes. Agroforest Syst 46:65–82
Nunn PD (1990) Recent environmental changes on Pacific Islands. Geogr J 156:125–140
Page S, Hoscilo A, Wösten H, Jauhiainen J, Silvius M, Rieley J, Ritzema H, Tansey K, Graham L, Vasander H, Limin S (2009) Restoration ecology of lowland tropical peatlands in Southeast Asia: current knowledge and future research directions. Ecosystems 12:888–905
Paulson DD (1994) Understanding tropical deforestation: the case of western Samoa. Environ Conserv 21:326–332
Poffenberger M (1990) Keepers of the Forest: Land Management Alternatives in Southeast Asia. Kumarian Press, Connecticut
Poore D (1989) Queensland, Australia: an approach to successful sustainable management. In: Poore D, Burgess P, Palmer J, Rietbergen S, Synnott T (eds) No Timber Without Trees: Sustainability in the Tropical Forest. Earthscan, London, pp 28–39
Potter LM (1996) The dynamics of Imperata: historical overview and current farmer perspectives, with special reference to South Kalimantan, Indonesia. Agroforest Syst 36:31–51
Potter LM (1997) The dynamics of Imperata: historical overview and current farmer perspectives, with special reference to South Kalimantan, Indonesia. Agroforest Syst 36:31–51
Rappaport RA (1968) Pigs for the Ancestors: Ritual in the Ecology of a New Guinea People. Yale University Press, New Haven
Rappaport RA (1971) The flow of energy in an agricultural society. Sci Am 225:117–132
Rasul G, Thapa GB (2003) Shifting cultivation in the mountains of South and Southeast Asia: regional patterns and factors influencing change. Land Degrad Dev 14:495–508
Richards JF, Flint J (1994) A century of land-use change in south and southeast Asia. In: Dale VH (ed) Effects of Land Use Changes on Atmospheric CO2 Concentrations: South and Southeast Asia as a Case Study. Springer Verlag, New York, Berlin, pp 15–66

Rieley J, Page S (2008) The science of Tropical Peatlands and the Central Kalimantan Peatland development Area. Master Plan for the Rehabilitation and Rehabilitation of the Ex-Mega Rice Project Area in Central Kalimantan. Euroconsult, Mott MacDonald and Deltares; Delft Hydraulics
Roder W, Keoboualapha B, Manivanh V (1995) Teak (*Tectona grandis*), fruit trees and other perennials used by hill farmers of northern Laos. Agroforest Syst 29:47–60
Rolett B, Diamond J (2004) Environmental predictors of pre-European deforestation on Pacific Islands. Nature 431:443–446
Ross ML (2001) Timber booms and institutional breakdown in Southeast Asia. Cambridge University Press, Cambridge
Roth DM (1983) Philippines forests and forestry: 1565-1920. In: Tucker RP, Richards JF (eds) Global deforestation and the Nineteenth-Century World Economy. Duke Press Policy Studies, Durham, pp 30–49
Rudel TK, Coomes OT, Moran E, Achard F, Angelsen A, Xu JC, Lambin E (2005) Forest transitions: towards a global understanding of land use change. Global Environmental Change-Human and Policy Dimensions 15:23–31
Rundel PW, Boonpragob K (1995) Dry forest ecosystems of Thailand. In: Bullock SK, Mooney HA, Medina E (eds) Seasonally Dry Forests. Cambridge University Press, Cambridge
Salo J, Kalliola R, Häkkinen I, Makinen Y, Niemala P, Puhakka M, Coley K (1986) River dynamics and the diversity of the Amazon forest. Nature 322:254–258
Saulei S, Lamb D (1991) Regeneration following pulpwood loggingin lowland rainforest in Papua New Guinea. In: Gomez-Pompa A, Whitmore T, Hadley M (eds) Rain Forest Regeneration and Management. UNESCO and The Parthenon Publishing Group, Paris, pp 313–322
Scatena FN, Planos-Gutierrez EO, Schellekens J (2005) Natural disturbances and the hydrology of humid tropical forests. In: Bonell M, Bruijnzeel LA (eds) Forests, Water and People in the Humid Tropics. Cambridge University Press and UNESCO, Cambridge, pp 489–512
Schafer E (1962) The conservation of nature under the T'ang dynasty. Journal of the Economic and Social History of the Orient 5:279–308
Schiefflin EL (1975) Felling the trees on top of the crop: European contact and the subsistence ecology of the Great Papuan Plateau. Oceania 46:25–39
Seki Y (2003) Adaptability of community based forest management for ex-logging workers in the Philippines. In: Inoue M, Isozaki H (eds) People and Forest - Policy and Local Reality in Southeath Asia, the Russian Far East, and Japan. Kluwer Academic Publishers, Dordrecht, pp 287–298
Siegert F, Ruecker G, Hinrichs A, Hoffmann AA (2001) Increased damage from fires in logged forests during droughts caused by El Nino. Nature 414:437–440
Sikor T (2001) The allocation of forestry land in Vietnam: did it cause the expansion of forests in the northwest? Forest Policy and Economics 2:1–11
Sist P, Fimbel R, Sheil D, Nasi R, Chevallier MH (2003) Towards sustainable management of mixed dipterocarp forests of South-east Asia: moving beyond minimum diameter cutting limits. Environ Conserv 30:364–374
Sodhi NS, Brook BW (2006) Southeast Asian birds in peril. The Auk 123:275–277
Stone GD (2001) Theory of the square chicken: advances in agricultural intensification theory. Asia Pacific Viewpoint 42:163–180
Tak K, Chun Y, Wood PM (2007) The South Korean forest dilemma. International Forestry Review 9:548–557
Totman C (1983) The forests of Tokugawa Japan: a catastrophe that was avoided. Transactions of the Asiatic Society of Japan 18:1–15
Totman C (1989) The Green Archiplelago: Forestry In Pre-industrial Japan. University of California Press, Berkley
Uusivuori J, Lehto E, Palo M (2002) Population, income and ecological conditions as determinants of forest area variation in the tropics. Global Environmental Change 12:313–323
Vanclay JK (1993) Tropical rainforest logging in North Queensland: Was it sustainable? Annals of Forestry 1:54–60
Vanclay JK (1994) Modelling Forest Growth and Yield: Applications to Mixed Tropical Forest. CAB International, Wallingford

Vanclay JK, Rudder EJ, Dale G, Blake GA (1991) Sustainable harvesting of tropical rainforests: reply to Keto, Scott, Olsen. J Environ Manage 33:379–394

Vasey D (1981) Agricultural systems in Papua New Guines: adapting to the humid tropics. In: Denoon D, Snowden C (eds) A History of Agriculture in Papua New Guinea: a Time to Plant and a Time to Uproot. Institute of Papua New Guinea Studies, Port Moresby

Veldkamp JF (1979) Obituary of Charles Monod de Froideville. Flora Malesiana Bulletin 197 32:3180–3183

Vincent J (1997) Resource depletion and economic sustainability in Malaysia. Environmental Research and Economics 2:1937

Waddell E (1972) The Mound Builders: Agricultural Practices, Environment, and Society in the Central Highlands of New Guinea. University of Washington Press, Seattle

Ward RG (2002) Deforestation in Western Samoa. Pacific Viewpoint 36:73–93

Webb LJ (1958) Cyclones as an ecological factor in lowland tropical rain-forests, North Queensland. Aust J Bot 6:220–228

White KJ (1975) The Effect of Natural Phenomenon on the Forest Environment. Presidential Address to the Papua New Guinea Scientific Society, Port Moresby

Whitmore TC (1984) Tropical Rain Forests of the Far East. Clarendon Press, Oxford

Williams M (2006) Deforesting the Earth: From Prehistory to Global Crisis. University of Chicago Press, Chicago, IL

Wilson EH (1986) A naturalist in Western China. Cadogan Books, London (first published 1913 as A Naturalist in Western China with Vasculum, Camera and Gun: being an account of eleven years travel, exploration, and observation in the more remote parts of the flowery kingdom). Methuen & Co., London

Wollenberg E, Ingles A (1998) Incomes from the forest. Center for International Forestry Research and the International Union for the Conservation of Nature, Bogor

Woods P (1989) Effects of logging, drought, and fire on structure and composition of tropical forests in Sabah, Malaysia. Biotropica 21:290–298

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