THE SECONDARY FOREST SITUATION IN SRI LANKA: A REVIEW

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PERERA, G. A. D. 2001. The secondary forest situation in Sri Lanka: a review. Most forests in Sri Lanka are secondary, are mostly confined to the dry and intermediate zones of the country, and arise out of swidden agriculture. The majority of secondary forests which regenerate after swidden farming in the dry parts of Sri Lanka are grown from vegetative parts, that is from remaining roots and stumps. Secondary forests provide numerous products of importance to local people. They also help to bridge seasonal gaps in livelihoods. Secondary forests of Sri Lanka are being disturbed or transformed by intensive cultivation, fire, the implementation of development projects, the establishment of plantations and by the construction of houses by the local people. Secondary forests in the dry parts of Sri Lanka could be managed as conservation areas for timber production or for multiple use. Regional climate, the ecology of secondary forests and anthropogenic pressures need to be considered when selecting suitable management options for a given site. Most of the secondary forests are heavily degraded and need to be rehabilitated. Intensification towards improved fallow systems or plantations is inhibited by poor site conditions, the threat of destruction by elephants, and insecure tenure.

Key words: Sri Lanka - secondary forests - swidden agriculture - dry zone - vegetative reproduction - degraded forests

PERERA, G. A. D. 2001. Situasi hutan sekunder di Sri Lanka: satu tinjauan. Kebanyakan hutan di Sri Lanka adalah sekunder, terhad di zon kering dan sederhana negara tersebut, dan wujud akibat pertanian ladang. Majoriti hutan sekunder yang pulih selepas pertanian ladang di bahagian kering Sri Lanka tumbuh daripada bahagian vegetatif, iaitu akar dan tunggul yang masih tinggal. Hutan sekunder menyediakan banyak hasil keluaran yang penting kepada penduduk tempatan. Ia juga membantu sebagai mata pencarian antara musim. Hutan sekunder di Sri Lanka telah rosak atau diubah akibat penanaman intensif, kebakaran, pelaksanaan projek pembangunan, penubuhan ladang dan juga pembinaan rumah oleh penduduk tempatan. Hutan sekunder di kawasan kering di Sri Lanka dapat diuruskan sebagai kawasan pemuliharaan untuk pengeluaran balak atau untuk pelbagai kegunaan. Iklim, ekologi hutan sekunder dan tekanan antropogen perlu dipertimbangkan apabila memilih pengurusan yang sesuai untuk tapak yang diberikan. Kebanyakan hutan sekunder berkeadaan teruk dan perlu dipulihkan. Pengintensifan ke arah memperbaik sistem tanah bekas ladang terhalang oleh keadaan tapak yang teruk, ancaman pemusnahan oleh gajah, serta pemegangan yang tidak pasti.

Introduction

Sri Lanka, a country situated in the Indian Ocean with a warm and tropical climate and a total land area of 6.6 million ha (Legg & Jewell 1995), has three different ecological zones (Figure 1). The distinction between zones depends mainly on the amount of rainfall they receive. The dry zone has an average annual rainfall of less than 1900 mm, the intermediate zone of about 1900–2540 mm, while the wet zone has an average annual rainfall of about 2540–5686 mm (Anonymous 1991). Closed natural forest covers 23.8% of the total island area (Legg & Jewell 1995), and most (85%) of it is situated in the dry zone (Perera 1994).

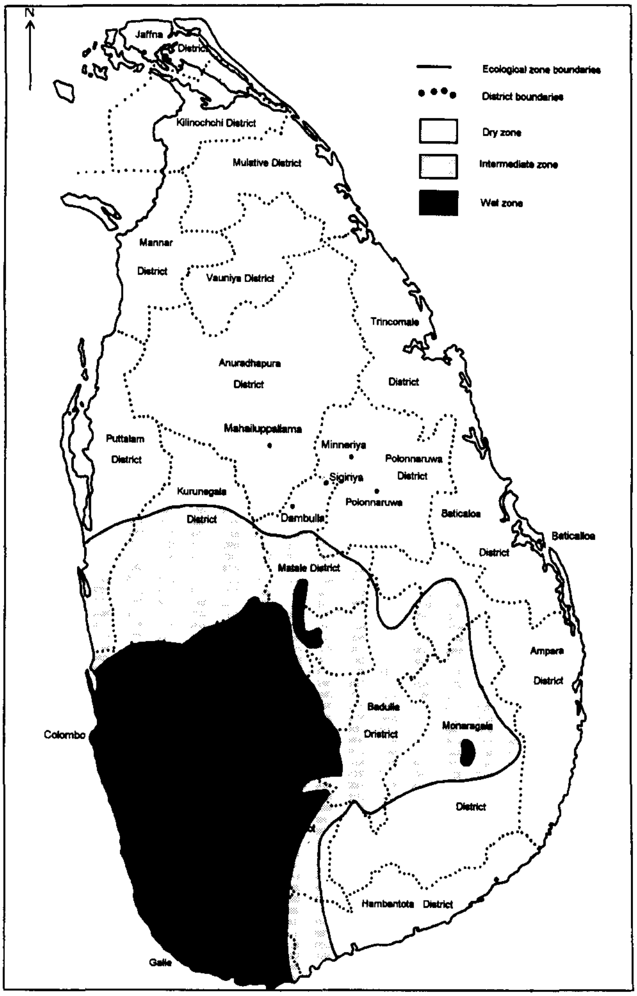

Figure 1 Major ecological zones and districts of Sri Lanka (Source: Survey Department 1988)

Sri Lanka contains a considerable amount of secondary forest. However, information on secondary forests is limited. A few researchers have studied the regeneration of forests after large-scale disturbance or described the ecology of secondary forests (e.g. Holmes 1954, 1956, 1957, de Rosayro 1961, Dittus 1977, Perera 1998). Secondary forests are defined here as "forests regenerating largely through natural processes after significant human disturbance of the original forest vegetation at a single point in time or over an extended period, and displaying a major difference in forest structure and/or canopy species composition with respect to nearby primary forests on similar sites" (Chokkalingam *et al.* 2000).

Most of the secondary forests are situated in the dry zone of Sri Lanka and arise from swidden agriculture (Liyanage 1996, personal observation). In areas where the rainfall is high and well distributed throughout the year, all the land previously used for swidden agriculture has already been converted to permanent agriculture or tree crops such as tea, rubber and coconut. There are also alternative job options and people do not have to rely on swidden farming. As a result, the wet zone of Sri Lanka has a negligible area of secondary forests (Table 1, Figure 1). In areas with high population density and intermediate rainfall, the length of the fallow period of swidden agriculture is between one and three years. Farmers in these areas may use chemical fertilisers to enhance their crop production.

Table 1 Extent of natural and sparse forests in different districts of Sri Lanka in 1992. (See also Figure 1)

District	Total area of district (ha)	Closed canopy natural forests (ha)	Sparse forests (ha)	% of sparse forests to the total forest cover
Ampara	450 031	124 908	41 760	25.1
Anuradhapura	722 178	180 083	116 693	39.3
Badulla	285 673	26 428	27 843	51.3
Baticaloa	263 983	36 493	16 325	30.9
Colombo	68 469	1832	36	1.9
Galle	161 256	19 089	1699	8.2
Gampaha	141 890	409	20	4.7
Hambantota	262 307	24 377	55 077	69.3
Jaffna	107 848	1081	298	21.6
Kalutara	164 391	20 310	1266	5.9
Kandy	192 808	27 241	5980	18.0
Kegalle	168 328	15 446	492	3.1
Kilinochchiya	132 499	32 686	6042	15.6
Kurunegala	489 787	9980	14 766	59.7
Mannar	200 148	113 445	11 762	9.4
Matale	206 050	74 809	9207	11.0
Matara	130 829	19 901	2076	9.4
Moneragala	576 763	182 601	52 569	22.4
Mulativu	260 946	154 332	17 987	10.4
Nuwara-Eliya	174 109	39 646	3273	7.6
Polonnaruwa	344 988	115 881	22 949	16.5
Puttalam	315 485	82 529	17 104	17.2
Ratnapura	327 034	62 357	4491	6.7
Trincomalee	267 991	113 812	17 629	13.4
Vavniyawa	200 835	103 182	16 504	13.8
TOTAL	6 616 627	1 582 858 (23.9% of the total land area)	463 848 (7% of the total land area)	22.7

(Source: Legg & Jewell 1995)

Farmers commonly practise swidden farming in the areas where the rainfall is low and seasonal, and there is much forest cover (Anonymous 1991). Also in this dry zone, there is rapid population increase (Survey Department 1988), lack of alternative job opportunities and inadequate facilities for sedentary agriculture. Most of the rural people in the dry parts of Sri Lanka continue to subsist below the poverty level (Navarathne 1985). Swidden fallow secondary forest regeneration and succession and the related restoration of soil fertility in these areas is slow, and farmers have to wait for at least 10–12 years for the next cultivation cycle. Swidden fallow secondary forests are defined here as "forests regenerating largely through natural processes in woody fallows of swidden agriculture for the purposes of restoring the land for cultivation again" (Chokkalingam *et al.* 2000). The status and condition of these secondary forests depends on intensity of cultivation, length of the fallow period, and intensity of fire, grazing as well as product extraction pressures. These secondary forests may contain some valuable timber species but the regeneration may need to be assisted and managed.

Intensive selective logging of Sri Lanka's natural forests has been taking place since colonial times. Although the government has prohibited logging since 1990, local people continue to practise illegal logging. In these logged-over areas, early and late seral species regenerate on patches, sometimes in combination with a few mature primary forest trees, forming post-extraction secondary forests. Post-extraction secondary forests are defined as "forests regenerating largely through natural processes after significant reduction in the original forest vegetation through tree extraction at a single point in time or over an extended period, and displaying a major difference in forest structure and/or canopy species composition with respect to nearby primary forests on similar sites" (Chokkalingam *et al.* 2000). Remote sensing techniques do not allow for accurate distinction between closed canopy post-extraction secondary forests and mature high forests.

The Forest Department of Sri Lanka considers secondary forests together with other types of open canopy forests and describes all these areas as "sparse forests". These sparse forests include the following subcategories:

(1) Swidden fallow secondary forests.
(2) Post-abandonment secondary forests following abandonment of permanent cultivation. Post-abandonment secondary forests are defined here as "forests regenerating largely through natural processes after total abandonment of alternative land use (plantations, agriculture, pasture, etc.) on formerly forested lands" (Chokkalingam *et al.* 2000).
(3) Post-extraction secondary forests.
(4) Young weed-ridden or fire-damaged plantations.
(5) A few natural scrub forests in very dry areas.

Satellite images showed that Sri Lanka has 463 847 ha of such sparse forests in 1992, amounting to 22.7% of the total area of natural forest (Legg & Jewell 1995). Remote sensing also does not allow for the distinction of different types of secondary forests based on underlying cause of origin. There are no statistics to show the extent of forest cover of each of the above subcategories. The Department of Wildlife Conservation protects 93 748 ha of the area under sparse forests, and the Forest Department protects 942 ha (Forestry Planning Unit 1995). Farmers still practise swidden farming in some of these protected areas as the institutions responsible for protection do not have adequate resources to stop the practice (personal observation).

This paper reviews the secondary forest situation in Sri Lanka and proposes options for managing this resource. The second section of the paper provides a historical perspective on secondary forests. The third section outlines current practices that give rise to secondary forests, their importance and the pressures they face. The last sections describe the ecology and management options for secondary forests.

Origin and management of secondary forests in Sri Lanka: a historical perspective

It is believed that in ancient Sri Lanka before the arrival of the Aryans in 585 B.C., farmers practised swidden agriculture (Anonymous 1991). The Aryans mainly engaged in sedentary agriculture using irrigation techniques and to a minor extent practised swidden farming in remote areas (Anonymous 1991, Nanayakkara 1996). At that time, most of the Sinhalese kingdoms occupied the northern dry zone of the country. The king of Sri Lanka exclusively owned the forest land (Tisseverasinghe 1956, Nanayakkara 1996).

The ancient hydraulic civilisation of the dry zone disappeared after the 12th century as a result of climatic change, malaria, invasions from south India and a famine (Paranavithana 1960, Anonymous 1991). The decline of irrigated agriculture caused demographic shifts from the dry zone to the wet zone. Forests grew back on many of the abandoned irrigated lands (de Rosayro 1961). It is believed that most of the present closed canopy mature forests in the dry zone of Sri Lanka are thus post-abandonment secondary forests regenerated on abandoned irrigated cultivation land. With the passing of time, the irrigation infrastructure decayed because of the lack of proper management and maintenance. Therefore, people who remained in the dry zone turned to swidden farming. Consequently, swidden fallow secondary forests were formed in the dry zone of Sri Lanka (Anonymous 1991).

In ancient times, only a few local people practised swidden farming and the demand for cultivation was not very high. Most of the time, farmers used mature secondary forest or primary forest patches for swidden agriculture and kept the land under long fallow periods (Gunawardena 1993). The long rotations helped maintain the ecological sustainability of the system.

During the British colonial period, the government considered those secondary forests, especially young swidden fallow secondary forests, to be degraded and poor quality forests. As of 1840, the Crown Land Encroachment Ordinance turned swidden agricultural land into crown property. The government took the decision to make them productive by planting timber or plantation crops (Tables 2 and 3). In the dry and intermediate zones it planted exotic timber species (e.g. teak,

Table 2 The extent of plantation forest land in Sri Lanka

Year	Total extent (ha)
1890	365
1952	10 522
1962	21 044
1992	125 000**

**estimated through satellite image analysis
Source: Nanayakkara 1996

Table 3 The extent of major plantation crops in Sri Lanka

Year	Total extent (ha)		
	Tea	Rubber	Coconut
1948	225 000	256 000	433 000
1952	231 000	266 000	433 000
1962	239 000	273 000	466 000
1972	242 000	230 000	416 000
1982	242 000	206 000	416 000[a]
1992	222 000	199 000	416 000[a]
1999	195 000	159 000	416 000[a]

[a]the accuracy of the data has not been confirmed.
Data supplied by the Central Bank, Colombo, Sri Lanka

Honduras mahogany, *Eucalyptus* species) as well as few indigenous tree species. The government also tried the Burmese taungya cultivation system on these fallow lands, especially to grow teak (Perera 1962, Nanayakkara 1996). In the wet zone entrepreneurs established tea, coffee, coconut and rubber plantations on secondary forest lands. Some of these plantations failed and were abandoned and evolved into post-abandonment secondary forests. However, very often, especially in the wet zone, failed plantations were replanted with tea or with exotic fast growing timber species such as *Pinus caribeae.*

After independence, the Forestry Department continued to establish teak plantations on "bare land" under the Co-operative Reforestation Scheme, especially in the dry and intermediate zones of the country. The local people were allowed to cultivate vegetables and cash crops in the plantations for the first three years while looking after young teak seedlings. However, "bare land" to a forester's eye was most probably a young swidden fallow secondary forest to local people. In 1981, the Forestry Department abandoned the Co-operative Reforestation Scheme because of continuous agitation by environmental groups (Nanayakkara 1996) and lack of support from local villagers.

At present there is increased interest from the government, academics and NGOs in forest conservation. Since 1990, the government has imposed a logging ban on timber from natural forests (Nanayakkara 1996). The new forest policy introduced in 1995 emphasises the protection of natural forests for biodiversity conservation and for the perpetuation of environmental benefits. The Sri Lanka Forestry Sector Master Plan (Forestry Planning Unit 1995) has identified six types of degraded lands and it emphasises the necessity of rehabilitating them. The degraded lands include all *patana* grasslands, abandoned and degraded tea estates that were handed over to the Forest Department, degraded rubber plantations, catchments and watersheds devoid of trees, sandy tracts on the coastline and highly degraded scrubland in the dry zone. This last land category may involve both young healthy swidden fallow secondary forests as well as secondary forests disturbed by repeated cultivation, fire or grazing. The perception of secondary forests as highly degraded, unproductive land has not changed and at present government agencies continue to establish new forest plantations on very young fallow forests with many indigenous species such as *Chloroxylon swietenia* (Satin wood), *Chukrassia tabularis* (Hulan Hik), *Azadirachta indica* (Kohomba) and *Berrya cordifolia* (Halmilla). In the wet zone, the private sector continues to cultivate tea, rubber and coconut (Table 3).

Table 3 shows that there is a slight reduction of the land area under tea, rubber and coconut plantations, a result of occupation as living space. Plantation owners have abandoned some tea plantations in the wet zone, especially on steep slopes, because of low soil fertility and resulting low productivity. These areas either remain as grasslands or become occupied by local people for the cultivation of spices (personal communication with the officers of the Central Bank, Sri Lanka). Thus, there has been no silvicultural or other type of management on secondary forest lands of Sri Lanka apart from swidden agriculture or conversion to other land use.

Formation, importance and causes of change of secondary forest

Swidden farming in the dry zone of Sri Lanka and secondary forest

Traditional swidden farmers in the dry zone of Sri Lanka clear a forest area of 8–10 ha in the main dry season (July or August). Usually, 10–12 families cultivate a single site. They allow the vegetation to dry and then burn it prior to the rains of August or September. Farmers sow seeds at the onset of the rains around September–October. The most important crops they grow are *Brassica juncia* (mustard), *Eleusine coracana* (elucine), maize and vegetables. Farmers will harvest their fields towards the end of the rainy season, around January, and then abandon the land for several years. Agricultural weeds (de Rosayro 1961) and the lack of water during the dry season are the major factors that limit continuous cultivation. Wild elephants and other grazing animals often visit abandoned swiddens. At present, in the rural dry zone of Sri Lanka, the fallow period is 12–15 years, but shorter in more densely populated areas.

In addition to swiddens, households independently grow mustard in 0.5–1 ha plots. Farmers also prepare the land for this crop by clearing and burning the vegetation, and they will abandon such lots after cultivating once. In addition to swidden land, most of the farmers have permanent cultivation fields near water reservoirs and streams. They live in separate permanent settlements and do not settle inside their swidden land.

To regulate swidden farming in Sri Lanka the District Government Agent used to issue cultivation permits. Since 1981, this agency has stopped handing out these permits (Ranasinghe 1996), but this has not stopped local people from continuing to practise swidden farming. The government does not collect official statistics on the area under swidden agriculture, while local people are reluctant to give information. The present extent of land occupied by swidden agriculture is therefore unknown.

The importance of secondary forests

Like any natural forest ecosystem, secondary forests provide both tangible and intangible goods and services. Secondary forests contribute to carbon sequestration, the protection of soil and the conservation of biodiversity. They help recover the fertility of soils exhausted by cultivation. Secondary forests also provide many products such as construction timber, small poles, fuelwood, bush meat, honey, medicinal plants, yams and other food (personal observation, Table 4). The use of these products from secondary forests reduces the pressure on high forests. Changing weather patterns, particularly prolonged droughts, make dry zone rain-fed agriculture risk-prone, and often lead to crop failures. In addition, lack of water for irrigated cultivation, threats to permanent crops from wild elephants and inability to afford fertilisers limit crop yields. Then, secondary forests help to bridge seasonal gaps in local peoples' livelihoods. Young fallow secondary forests are also used as grazing grounds for domestic cattle and goats as well as many wild herbivores.

Threats to secondary forests

Activities that reduce the cover of secondary forest are clearance for sedentary or short-rotation swidden agriculture, the implementation of government development projects, intensive cattle grazing and conversion into plantations and other land use types. Fire and the related invasion of grasses, ferns or exotic plant species (e.g. *Prosopis juliflora* in the southern dry forests of Sri Lanka) and cyclones, to a lesser extent, also reduce the area of secondary forests. However, some of the anthropogenic activities are more common in certain areas of the country and may be related to both the ecological environment and the social and cultural background of the local people.

Cultivation of tea, rubber, coffee, coconut or other permanent crops together with intensive timber harvesting resulted in a dramatic reduction of the area of natural high forest cover between 1900 and 1983 (Table 5). The government implemented many development projects in the 1980s and as a result, the destruction of both natural high forests and secondary forests has continued. One of these projects, the Accelerated Mahaweli Development Project, resulted in a loss of 242 820 ha of natural forests, including some secondary forests, within

Table 4 Some forest products harvested from swidden fallow secondary forests of Sri Lanka

Category of secondary forest product	Some examples	Approximate age (in years) of forest	Scale of harvesting
Food	Fruits of *Momordica* sp.	< 3	Semi-commercial
	Leaves of *Wattakaka volubilis*	< 3	Subsistence
	Yams of *Dioscorea pentaphylla*	8–18	Subsistence
	Edible fungi	1–25	Subsistence
Poles	*Pleurostylia opposita*	25–35	Subsistence
	Pterospermum suberifolium	25–35	Subsistence
Construction timber	*Pterospermum suberifolium*	25–35	Semi-commercial
Fuelwood	Many different species depending on availability	forests of all ages	Semi-commercial/ Subsistence
Medicine	*Salacia reticulata*	20–35	Semi-commercial/ Commercial
	Azadirachta indica	10–35	Subsistence
	Cassia fistula	4–15	Subsistence
	Allophylus cobbe	4–30	Subsistence
	Streblus asper	4–30	Subsistence
Others:			
to make baskets	Canes and rattans	20–30	Semi-commercial/ Commercial
for binding	*Ichnocarpus frutescens*	< 25	Subsistence
to make handles for agricultural tools	*Diplodiscus verrucosus*	20–30	Subsistence

Table 5 Decline in forest cover in Sri Lanka (Nanayakkara 1996)

Year	Area of closed forests (ha)	Area of sparse forests (ha)
1884	5 540 000	*
1900	4 610 000	*
1953	3 295 000	*
1956	2 900 000	*
1983	1 760 000	625 000
1992	1 582 756	463 000

*Data not available

a period of eight years. At present, however, the government has stopped the planning and implementation of such major development projects.

The high population growth in the rural areas of the dry zone of Sri Lanka increased the need for agricultural lands. As more and more people practise swidden farming, the length of the fallow period generally decreases with land scarcity. This may lead to soil deterioration (Bayliss-Smith 1982) resulting in a regressive succession to vegetation dominated by grasses and ferns (Leburn 1936, Riswan & Hartanti 1995). In the dry zone of Sri Lanka, grasses such as *Imperata cylindrica* invade land that has been cultivated continuously for long periods, whereas in the wet zone *Pteridium* sp. and *Imperata cylindrica* invade such lands.

Fire, used with the preparation of agricultural land, very often escapes and spreads into adjacent secondary forests. Due to the frequent burning of the vegetation, deflected succession of secondary forests takes place. Grasses such as *Imperata cylindrica* and *Cymbopogon nardus* and ferns like *Pteridium* sp. thrive on such land. Although cyclones are not very common in Sri Lanka, in 1964 and 1979 cyclones damaged many secondary forests, especially in the dry zone of the country. However, while destroying some secondary forest these cyclones also created new secondary forests with subsequent regeneration.

The ecology of secondary forests in the dry zone of Sri Lanka

Very little research has been performed on the ecology of Sri Lanka's dry deciduous secondary forests. Most of the information on the ecology comes from the author's own research findings. Immediately after the abandonment of the swidden field, the forest regenerates almost entirely by vegetative re-growth rather than from seeds (Perera 1998). The vegetation is therefore very similar to that which existed prior to cultivation (Table 6). All the tree seedlings burn when preparing the swidden. The vegetation in young secondary forests consists mostly of pioneer species that can reproduce from root suckers. A study done at Sigiriya, Sri Lanka reveals that 67% of the species and 57% of the individuals that sprouted immediately after swidden farming are early and late seral species (Perera 1998). Possibly, this secondary forest vegetation has undergone a selection to establish itself by vegetative means as a result of repeated cycles of cutting and burning throughout the recent history.

Typical swidden fallow secondary forest vegetation includes many forest patches at different stages of succession. The structure of swidden fallow secondary forests changes rapidly at the young stages. The principal structural changes include increased canopy height and tree diameter, a stratification of the tree vegetation and a reduction in the number of stems per individual. One can identify several plant associations in secondary forests at different ages of succession (Table 7). However, even within a given age category, the composition of these plant associations may change slightly depending on available soil moisture content (Dittus 1977) and on human or animal disturbances (personal observation).

It is difficult to distinguish a definite plant association in swidden fallow secondary forest younger then three years. The vegetation of such forests depends on the plant species that existed prior to cultivation (i.e. on their light tolerance and sprouting abilities), the nature of the disturbance and the microclimate of the site. After four to five years, *Phyllanthus polyphyllus, Croton laccifer* and *Securinega leucopyrus* dominate the vegetation, occurring in dense stands (Table 7). After about 12 to 15 years, thorny climbers such as *Ziziphus oenoplia, Lantana camara* and *Catunaregam spinosa* grow luxuriantly and compete with tree species for light, space and water. After about 17 years, many light-demanding shrub species die, leaving behind the trees and shade-tolerating shrubs stratified into two layers.

Table 6 Similarity of species before and immediately after shifting cultivation at Sigiriya area in the dry zone of Sri Lanka. Dominant species and families in the vegetation which composed 75% of the vegetation are given in descending order of abundance. Species and families common to both vegetation types (i.e. the vegetation before and after shifting cultivation) are underlined

Value of Sorenson coefficient		Before shifting cultivation (12–15-year-old secondary forest)	After shifting cultivation (1-month-old fallow forest)
0.759 ± 0.106	Dominant species	<u>*Chromolaena odorata*</u>	<u>*Pterospermum suberifolium*</u>
		<u>*Pterospermum suberifolium*</u>	<u>*Securinega leucopyrus*</u>
		<u>*Securinega leucopyrus*</u>	<u>*Chromolaena odorata*</u>
		<u>*Catunaregam spinosa*</u>	*Grewia orientalis*
		<u>*Toddalia asiatica*</u>	<u>*Mallotus philippensis*</u>
		Lantana camara	<u>*Grewia damine*</u>
		<u>*Grewia damine*</u>	<u>*Catunaregam spinosa*</u>
		<u>*Mallotus philippensis*</u>	<u>*Toddalia asiatica*</u>
		Ziziphus oenoplia	
		Salacia oblonga	
	Dominant families	<u>Euphorbiaceae</u>	<u>Euphorbiaceae</u>
		<u>Asteraceae</u>	<u>Sterculiaceae</u>
		<u>Sterculiaceae</u>	Tiliaceae
		Rutaceae	<u>Asteraceae</u>
		Verbenaceae	
		Rubiaceae	
		Leguminosae	

Source: Perera 1998

Table 7 Common plant associations in dry deciduous secondary forests

Age of forest	Plant associations	Other characteristics
> 3 years	Many resprouted individuals	Many agricultural weed and grass species grow. The soil is exposed to direct sunlight
4–11 years	*Phyllanthus polyphyllus* - *Croton laccifer* - *Catunaregam spinosa** - *Securinega leucopyrus**	Pseudo-canopy appears. Individuals have many stems. *Croton laccifer* grows well in somewhat shady/moist places (Dittus 1977).
12–17 years	*Ziziphus oenoplia** - *Lantana camara** - *Catunaregam spinosa**- *Securinega leucopyrus**	Thorny shrub species dominate the land.
~18 years to old growth forest	*Grewia* spp. - *Pterospermum suberifolium* - *Premna* spp. - *Walsura trifoliolata*	Tree species dominate the forest.

*Shrubs with thorns or prickles

The species (Alpha) diversity in dry deciduous regenerating forests initially increases with succession but decreases slightly at a later stage. It is high in 20- to 25-year-old forests, but low in old growth forests (Perera 1998). Habitat (Beta) diversity increases with time and is high in both 20- to 25-year-old forests and in high forests (Perera 1998). This demonstrates that forests in mid-successional stages have high species and habitat diversities in agreement with Connell's (1978) and Swaine and Hall's (1983) findings for the humid tropics. The higher diversity is partly due to the survival of secondary forest species and partly due to the invasion of new primary forest species, which arrive from seeds brought in by frugivorous animals.

The diversity of plant families is low in young fallow forests but comparatively higher in mature swidden fallow secondary forests. Table 8 shows the dominant families estimated by counting the families of common species which represent 75% of all individuals in a secondary forest area at Sigiriya, Sri Lanka.

Table 8 Dominant families estimated by counting the families of common species which comprised 75% of all individuals. (Families are arranged in descending order of abundance.)

1-month-old	1 year	4–7 years	12–15 years	20–25 years
Once-disturbed	*Once-disturbed*	*Once-disturbed*	*Once-disturbed*	*Once-disturbed*
Euphorbiaceae	Asteraceae	Euphorbiaceae	Euphorbiaceae	Rutaceae
Sterculiaceae	Euphorbiaceae	Asteraceae	Asteraceae	Euphorbiaceae
Tiliaceae	Sterculiaceae	Myrtaceae	Rubiaceae	Annonaceae
Asteraceae	Leguminosae	Sterculiaceae	Sterculiaceae	Rubiaceae
			Verbenaceae	Asteraceae
			Tiliaceae	Sapindaceae
				Sterculiaceae
				Tiliaceae
			Repeatedly disturbed	*Repeatedly disturbed*
			Asteraceae	Euphorbiaceae
			Verbenaceae	Rubiaceae
			Euphorbiaceae	Sterculiaceae
			Leguminosae	Rutaceae
			Rubiaceae	Verbenaceae

Source: Perera 1998

Seed production, dispersal and storage in dry deciduous swidden fallow secondary forests

In recently abandoned swidden agricultural land, many grass and agricultural weed species produce seeds in very large numbers that are mainly dispersed by the wind. Seeds of these grass and agricultural weed species, especially the seeds of the shrub *Chromolaena odorata,* cause a high seed density in young fallow forest soil. Many pioneer species which grow in young fallow forest also produce seeds in large quantities but individuals of late seral and climax forest tree species in such forests may not be mature enough to produce fruits. In contrast, mature secondary forests have some mature individuals of late seral and primary forest species that are able to produce seeds *in situ.* Therefore, mature secondary forests attract many animals and this facilitates the arrival of seeds from outside sources (Perera 1998).

The composition and abundance of the seed rain vary with the age of the secondary forest, and also with the time of the year (Perera 1998). In general, the diversity and density of the seed rain is high in rainy seasons. The soil seed bank also varies seasonally and with the age of the secondary forest (Perera 1998). Spatial variability in seed source, seed dispersal patterns, seed predation, seed germination, loss of viability as a result of the microclimatic conditions, and variable intensity and duration of fire cause clumping of seeds.

The number of seedlings in young secondary forests in the dry zone of Sri Lanka is low, and they consist of few species. Many of them are agricultural weed species with a few individuals of pioneer species. When farmers prepare land for agriculture, they destroy tree and shrub seedlings. In addition, lack of sufficient seed dispersal, unfavourable climatic conditions for seed germination and seedling establishment, high post-dispersal seed and seedling predation explain the low numbers of seedlings. In contrast, some climax forest tree and shrub seedlings grow in mature secondary forests.

Recovery and resilience of swidden fallow secondary forests in the dry zone of Sri Lanka

Studies done in secondary forests suggest that the forest recovers within a 10–12 year period and that secondary dry forests have a high resilience (Perera 1998). Possibly the selection for centuries of species that re-grow after burning and cultivation have resulted in this adaptation to anthropogenic disturbances. This supports Denslow's (1980) hypothesis of disturbance-derived regeneration.

Minor disturbances superimposed on those caused by swidden farming may have different impacts on differently aged forests. The time since last disturbance is the principal factor that affects the forest structure, microclimate, species composition and plant diversity (Perera 1998). Annual burning in young fallow forests may encourage the growth of many agricultural weeds such as *Chromolaena odorata* and grasses such as *Imperata cylindrica* (personal observation). However, minor disturbances of older secondary forests may not result in such a deflected succession.

Management options for dry deciduous swidden fallow secondary forests

The term "forest management" has a broad meaning, ranging from strict forest protection at one extreme to nearly complete forest conversion at the other (Bawa & Krugman 1991). In Sri Lanka, some of the secondary forests are situated within protected areas (e.g. Wasgomuwa National Park) and continue to grow with minimum disturbances. However, most of the secondary forests are still liable to be disturbed by human activities. When considering management options for secondary forests, it is important to remember that the term "secondary forests" is an umbrella term for successional forests at different ages that have been disturbed in different degrees and in different ways. Therefore, secondary forest managers should select management options depending on the age and ecology of the forest, the soil type of the site, the degree of disturbance, as well as impact of present and past human activities. Also, in dry seasonal environments, it is essential to consider the season of the year and the microclimate of the site when implementing management practices.

Some secondary forest management options that are possible in other regions of Asia are not applicable to the dry zone of Sri Lanka. For instance, there are many difficulties with applying improved fallow management. First, farmers abandon swidden land at the beginning of the dry season. It is, therefore, difficult to grow mulch or nitrogen-fixing species due to lack of water. Even when one plants these species at the onset of the rainy season, there is still the risk of unpredictable weather patterns. Second, the resprouting roots and stumps may compete with introduced mulch or nitrogen-fixing species. Finally, the growing of mulch or nitrogen-fixing species will attract large herbivores, including elephants and wild buffaloes. These large herbivores not only destroy mulch or nitrogen-fixing species but are also a danger to local people who collect firewood or other forest products from secondary forests, or they may invade and destroy nearby rice fields. Also, community participation in such activities is low because of insecure tenure rights. Potential options available for secondary forest management in the dry zone of Sri Lanka include managing for conservation, timber production or multiple use.

Conservation management

Secondary forests situated on river banks, on steep slopes and those situated adjacent to natural high forests may need to be conserved for soil and watershed protection. Secondary forests situated adjacent to mature high forests could be conserved as buffer zones. Local people however, would still need rights to extract some fuelwood, medicinal plants and other products for subsistence.

Having some secondary forests near high forests may help in maintaining high wildlife diversity because high forests provide most of the required habitats for wildlife, but secondary forests contain more foods for animals. As Whitmore (1990) stated, pioneer species which are common in secondary forests do have little or no mechanical or chemical protection against herbivores and this may be one reason that most herbivores feed in secondary forests. Also, many early and late seral tree species in secondary forests produce edible fruits in large quantities (personal observation). This leads to the conclusion that conservation management of the forest ecosystem could include some swidden farming to maintain some secondary forests (including 20- to 25-year-old forests) to maximise biodiversity. Areas of secondary forest under such a regime need not necessarily be very large as the species diversity in 20- to 25-year-old forests is high.

Management of forests for multiple uses

Local people use and manage dry deciduous secondary forests. Improving current management practices could increase the value of secondary forests and reduce pressure on primary forests. The Forestry Department could support the management of secondary forest at the village level to achieve an increased supply of multiple products, especially timber, construction poles, fuelwood and medicinal plants. Suitable policies and rules for equitable tenure and cost-benefit sharing are required. Timber and construction poles could be harvested from swidden fallow secondary forests in rotations of 25–30 years, and the sites used for swidden farming after each cycle.

Management of secondary forests for timber production

The forestry community has a growing interest in the production of timber from the long-lived pioneers (late seral species) in secondary forests despite the fact that the timbers are relatively light and lack natural durability (Finegan 1992). There is a high local demand for light timber in the dry areas of Sri Lanka. Many individuals of fast growing light timber species such as *Pterospermum suberifolium* are abundant in swidden fallow secondary forests and applying suitable silvicultural treatments can support their growth. Also, *Chloroxylon swietenia* (Satin wood), which provides class one timber, easily coppices in abandoned swiddens. However, the silviculture of this species needs further study.

As many coppiced individuals have several stems (Perera 1998), timber production in these stands could include removing additional stems, and leaving only the best one. Self-thinning of forest stands takes place after five to seven years. After self-thinning, the stand density of trees of desirable species is not high (Perera 1998). If forest managers carry out artificial thinning after five to six years, a high stand density of desirable timber species could be maintained. Removal of thorny scrub species (*Ziziphus oenoplia, Catunaregam spinosa*) avoids the suppression of trees that normally takes place in 10- to 15-year-old forests. Thinning at the beginning of the long dry period may suppress the re-growth of thorny climbers.

Cleaning as well as protection from fire and from grazing may support the growth of timber species. However, cleaning after self-thinning results in more sunlight reaching the forest floor. Then fire-prone grasses (e.g. *Imperata cylindrica*) increase their presence on the forest floor. This type of stand will need protection from fire for the natural regeneration to survive but this is very costly (Popham, pers. comm.).

Rehabilitation of degraded lands and degraded forests

Secondary regeneration is limited on land subject to continuous or frequent cultivation with short rotations, especially when these forests occur on sloping land (personal observation). Where logging of natural forests has taken place on slopes, pioneer shrub (e.g. *Croton laccifer* and *Ziziphus oenoplia*) and grass species fill the gaps. Such areas will burn easily in the dry season and need some sort of assistance to promote natural regeneration of forest species while protecting them from fire. Most of the native primary forest species would not develop in these open places, even when seeds are provided, as the conditions for seed germination and establishment are not favourable on such sites. In such instances, a mixture of seeds of both pioneer and climax forest species can be used. Pioneer seeds will germinate and establish themselves easily and the seedlings of pioneer species will protect climax forest tree seedlings from strong sunlight.

Degraded secondary forests could be enriched by planting seedlings or sowing seeds of desirable species during the long rainy period. A 20- to 25-year-old secondary forest has a high soil moisture content and low root competition, which are appropriate conditions for enrichment efforts (Perera 1998). When valuable timber species such as *Chloroxylon swietenia* (Satin wood) and *Berrya cordifolia* (Halmilla) are planted or sown in such forests they will most likely do well.

In the dry environment, planting has to be carried out at the beginning of the long rainy period and other measures such as trenching need to be implemented to retain soil moisture and reduce root competition on the site (Holmes 1956). Also, soil erosion has to be reduced on slopes, and the sites protected from fire, grazing and trampling by wild elephants.

However, it must be emphasised that the above-mentioned management options can only be implemented after a thorough survey of the area because, within the dry zone of Sri Lanka, the geography, regional climate patterns, population density and human activities vary from place to place. Consequently, the ecology of secondary forests (e.g. microclimate, species composition and abundance as well as density of healthy parent timber trees) and the patterns of forest regeneration and succession vary. Depending on these variations, suitable management options need to be selected. For instance, secondary forests situated in remote, less populated areas are less disturbed and may have many climax forest species which provide valuable timber. These secondary forests can be improved for timber production. If the secondary forests are situated close to densely populated areas and the people need to use these forests, it is advisable to manage them with the participation of local people to get multiple forest products.

Conclusion and recommendations

Most secondary forests are situated in the dry zone of Sri Lanka and arise from swidden agriculture. There are also some secondary forests arising from intensive logging and the abandonment of permanent agriculture and plantations. Since the colonial time, government officers have considered the young secondary forests of Sri Lanka as bare, unproductive or waste land. Policy makers and scientists tend to undervalue the potential of secondary forests. Such a perception of secondary forests as unproductive land contributes to their destruction and degradation. Secondary forests could be managed for the conservation of biodiversity, or to obtain timber or multiple forest products. Regional climate, the ecology of secondary forests and anthropogenic pressures need to be considered when selecting suitable management options for a given site. However, as almost all of these forests are highly degraded, they need to be restored first to receive productive or protective benefits. New secondary forests could also be developed on degraded lands with assistance. Local participation may be crucial for the success of such efforts and the local knowledge of the rural farmers could be favourably used in formulating necessary policies, and in planning and implementing management practices.

At the same time, it is vital to take actions to prevent the destruction of secondary forests. These include:

(1) Increasing the awareness of the importance of swidden fallow secondary forests.
(2) Policy formulation and implementation for the protection and sustainable management of secondary forests. Measures are required to facilitate income generation from secondary forests and improve the tenure situation for secondary forests.
(3) Exploring alternative livelihood options to reduce local pressures on secondary forests.
(4) Increasing information on the ecology and silviculture of secondary forests.

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References

ANONYMOUS. 1991. *Natural Resources of Sri Lanka: Conditions and Trends.* A report prepared for the Natural Resources, Energy and Science Authority of Sri Lanka, Colombo, Sri Lanka.

BAWA, K. S. & KRUGMAN, S. L. 1991. Reproductive biology and genetics of tropical trees in relation to conservation and management. Pp. 119–136 in Gómez-Pompa, A., Whitmore, T. C. & Hadley, M. (Eds.) *Rain Forest Regeneration and Management.* UNESCO/ Parthenon, Paris and Carnforth.

BAYLISS-SMITH, T. P. 1982. *The Ecology of Agricultural Systems.* Cambridge University Press, Cambridge.

CHOKKALINGAM, U., DE JONG, W., SMITH, J. & SABOGAL, C. 2000. Tropical secondary forests in Asia: introduction and synthesis. Paper prepared for the "Tropical secondary forests in Asia: Reality and perspectives' workshop". 10–14 April 2000. Samarinda, Indonesia. Center for International Forestry Research, Bogor, Indonesia.

CONNELL, J. H. 1978. Diversity in tropical rain forests and coral reefs. *Science* 199: 1302–1310.

DE ROSAYRO, R. A. 1961. The nature and the origin of secondary vegetational communities in Ceylon. *Ceylon Forester* 5: 23–49.

DENSLOW, J. S. 1980. Patterns of plant species diversity during succession under different disturbance regimes. *Oecologia* 46: 18–21.

DITTUS, W. P. J. 1977. The ecology of a semi-evergreen forest community in Sri Lanka. *Biotropica* 9: 268–286.

FINEGAN, B. 1992. The management potential of neotropical secondary lowland rain forest. *Forest Ecology and Management* 47: 295–321.

FORESTRY PLANNING UNIT. 1995. *Sri Lanka Forestry Sector Master Plan.* Ministry of Agriculture, Lands and Forestry, Battaramulla, Sri Lanka.

GUNAWARDENA, D. 1993. Ancient society of Vaedda tribe and the environment. *Soba* 4: 32–35.
HOLMES, C. H. 1954. Seed germination and seedling studies of timber trees of Ceylon. *Ceylon Forester* 1: 3–51.
HOLMES, C. H. 1956. The natural regeneration of the wet and dry evergreen forests of Ceylon. *Ceylon Forester* 2: 151–164.
HOLMES, C. H. 1957. The natural regeneration of the wet and dry evergreen forests of Ceylon. *Ceylon Forester* 3: 111–127.
LEBURN, J. 1936. Répartition de la forêt équatoriale et des formations végétales limitrophes. Ministr. Colon., Direct. Gén. Agr. Elev., Brussels.
LEGG, C. & JEWELL, N. 1995. A 1:50000-scale forest map of Sri Lanka: the basis for a National Forest Geographic Information System. Pp 3–24 in *The Sri Lanka Forester.* Special issue.
LIYANAGE, S. 1996. Environmental consequences of deforestation in Sri Lanka. Pp. 9–11 in *Economic Review* (April).
NANAYAKKARA, V. R. 1996. *Forests and Forestry in Sri Lanka: An Historical Perspective.* Commonwealth Secretariat, UK.
NAVARATHNE, V. T. 1985. Another approach to rural development: the Sri Lankan experience in diversification of the national economy. Ahmad, Q. K. and Chowdhury, F. A. (Eds.) Malaysia.
PARANAVITHANA, S. 1960. The withdrawal of Sinhalese from the ancient capitals. *History of Ceylon.* Volume I. University of Ceylon, Peradeniya.
PERERA, G. A. D. 1994. Restoration of degraded dry zone woodlands in Sri Lanka using natural regeneration. M.Sc. dissertation, University of Oxford, UK.
PERERA, G. A. D. 1998. Regeneration and succession following shifting cultivation of dry tropical deciduous forests of Sri Lanka. D.Phil. thesis, University of Oxford, UK.
PERERA, W. R. H. 1962. The development of forest plantations in Ceylon since the 17th century. *Ceylon Forester* 5: 142–156.
RANASINGHE, D. M. S. H. K. 1996. Agroforestry in Sri Lanka: an overview. Pp. 1–18 in Huxley, P. & Ranasinghe, D. M. S. H. K. (Eds.) *Agroforestry for Sustainable Development in Sri Lanka.* University of Wales, Bangor and University of Sri Jayawardenapura, Sri Lanka.
RISWAN, S. & HARTANTI, L. 1995. Human impacts on tropical forest dynamics. *Vegetatio* 121: 41–52.
SURVEY DEPARTMENT. 1988. *The National Atlas of Sri Lanka.* Colombo, Sri Lanka.
SWAINE, M. D. & HALL, J. B. 1983. Early succession on cleared forest land in Ghana. *Journal of Ecology* 71: 601–627.
TISSEVERASINGHE, A. E. K. 1956. Land tenure and forest low in ancient Ceylon. *Ceylon Forester* 2: 124–130.
WHITMORE, T. C. 1990. *An Introduction to Tropical Rain Forests.* Clarendon Press, Oxford.