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SEED BANKS IN A SUBTROPICAL RAIN FOREST

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ABSTRACT

The seasonal populations and vertical distribution of seed banks in a subtropical rain forest were assessed,. No seasonal variations were indicated in either the species composition or the size of seed bank over a year period. The numbers of seeds were 550 — 603 m^{-2}, and mostly composed of secondary species. This population decreased with increasing soil depths.

ABSTRAK

Populasi bank biji di tanah hutan subtropika basah ditelaah, meliputi variasi musim dan persebarannya secara vertikal Populasi bank biji tidak memperlihatkan adanya variasi musiman selama satu tahun baik komposisi maupun jumlah bijinya. Jumlah biji tercatat sebanyak 550 — 603 m-2, dan sebagian besar merupakan jenis-jenis sekunder, Populasi bank biji ini menurun sejalan dengan kedalaman tanah yang semakin bertambah.

INTRODUCTION

The seed bank is defined as the number of viable seed stored in or on the soil. The occurence of seed bank beneath the rain forest communities was likely firstly demonstrated by Symington (1933), although he ignored whether those seeds were long term members of a dormant pool or had only recently arrived. More recently many other scientists such as Keay (1960), Guevara and Gomez-Pompa (1972), Liew (1973), Checke *et al.* (1979), Hall and Swaine (1980), Hopkins and Graham (1983), Knight (1985) and Graham (1988) have attempted to elucidate the size and composition of seed banks in rain forests in the tropics. The conclusion emerging from this work has been that the viable seed bank is dominated by pioneers or secondary species. However, no similar studies have been carried out in sub-tropical rain forests.

The present study was designed to assess the seasonal size, composition and the vertical distribution of the viable seed bank in an undisturbed sub-tropical rain forest.

STUDY AREA AND METHODS

Study was carried out in the vicinity of O'Reilly's Guest House, the Lamington National Park (28° 14' S and 153° 7' E), Queensland (Figure 1). The topography is dominated by a series plateaux and intervening valleys (Lamb, 1980) and lies at 900 m above sea level. The soil is a kraznozem derived form tertiary basalt (Stevens, 1977).

Rainfall in the area is annually about 1,880 mm. It is seasonal and dry conditions are likely to exist during the winter (July-October). The wettest months are recorded for the summer between November and April.

Vegetation in the study area is subtropical rain forest, which is classified as Complex Notophyll Vine Forest (Webb, 1968). It is close to the young regrowth forest and pasture area.

Soil samples were collected over a 12 month period, at three times (August 1985, January 1986 and July 1986). On each occasion, ten soil samples of 50 x 25 x 5 cm were collected from 5 transects.

Successive soil samples of 50 x 25 cm in area with a depth of 5 cm were also collected to a total depth of 25 cm in February 1986. Five replications were collected, one sample from each' transect. To avoid any possibility of contamination from adjacent soil, the point sample was trenched beforehand. Soil samples were taken to the glass house immediately.

On the following day of each sampling time, every soil sample was mixed and all live vegetative material was carefully removed. Each sample was then spread over vermiculite in two germination trays (each being 34 x 28 cm) in the glass house. Six control trays containing steam sterilized soil were placed among the samples to monitor contamination. The soil samples were kept moist by daily watering in the early morning and late afternoon. Additionally, to help promote the germination of buried seed, the soil was subsequently carefully disturbed twice i.e., on week 15 and week 30.

Seedling emergence was monitored weekly for 40 weeks. Each seedling emerging was marked by a coloured toothpick coded to show the date. Samples of all seedling types were transplanted to pots of 15 cm diameter, and allowed to mature until they could be identified. Herbarium specimens were made of representative samples of each species.

RESULTS

During the observation period in the glass house two species *Cardamine hirsuta* and *Portulaca oleracea* were found in the control trays. Both species are common weeds and grow nearby outside the glass house. These seedlings, therefore, have been removed from the records discussed below.

Size and composition of seed bank

The size of the viable seed bank is expressed on a per m2 basis and is the mean of the germination recorded for the 10 soil samples at each site over 40 weeks.

The variation of the seed bank over a year is given in Table 1. The number of seeds slightly decreased from 603 per m2 in August 1985 to 545 per m2 in July 1986. However, results of an analysis of variance of the data obtained from the three sampling times indicated no significance differences between the sampling times (P>0.1). A similar result was also found for each life form.

Table 1. Seasonal variation in number of seed in seed bank according to their life forms (means of 10 replicates).

	Number of seeds per m2			Significance
	August '85	January '86	July '86	level
Primary trees	56.8	53.6	64.8	NS
Secondary trees	175.2	210.4	208.8	NS
Vines	191.2	288:6	135.2	NS
Herbs	131.2	89.6	96.0	NS
Shrubs	37.6	264.	31.2	NS
Other	12.2	17.6	14.4	NS
Total	603.2	583.2	550.4	NS

NS. Not significantly different (P>0.05)

The species richness of soil seed banks in undisturbed forest was similar in the dry season and the wet season (Table 2). The numbers of species present in August 1985, Januari 1986 and July 1986 were 58, 56 and 52 species respectively. Additionally, a similar number of species was also recorded for each life form. The floristic similarity in the wet season (February 86) and two dry seasons using Sorensen Index was 74 — 78%. The floristic similarity in the two dry seasons was 70%.

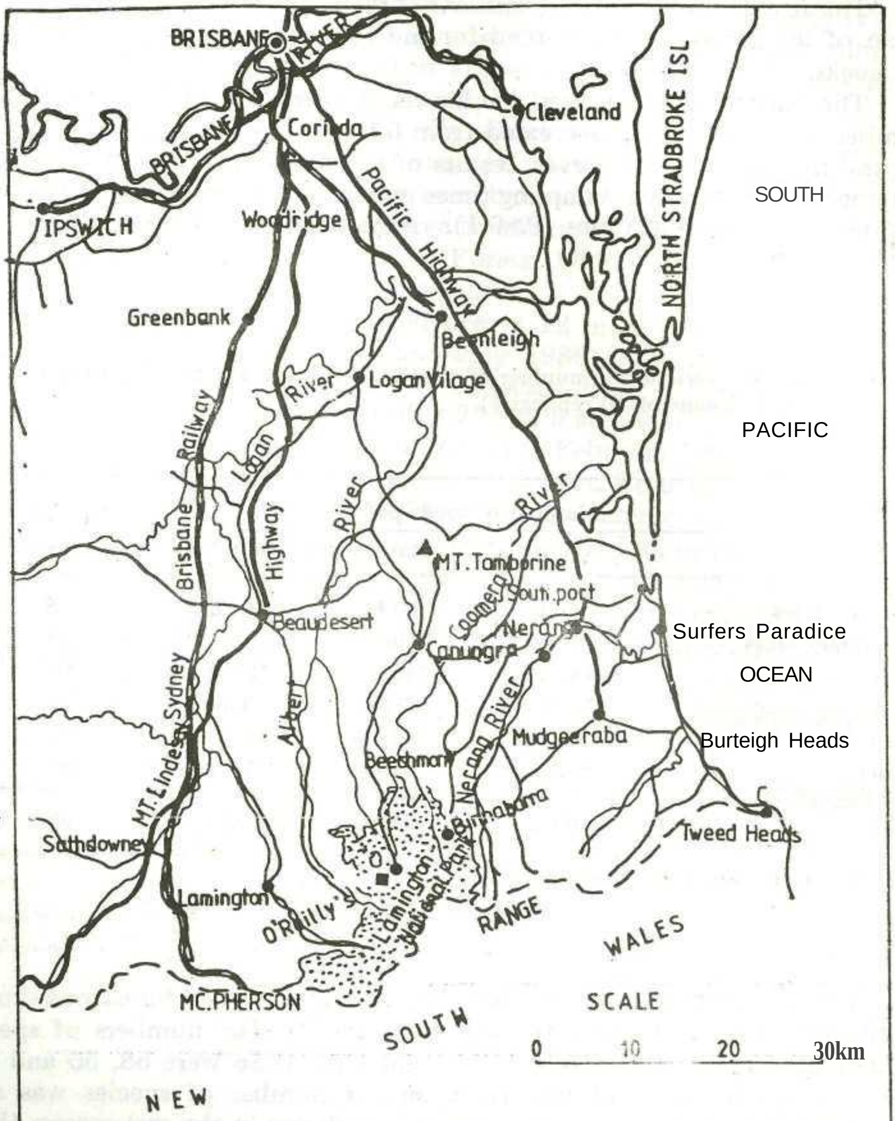

Figure 1. Map showing the location of the Lamington National Park and O'Reilly's Guest House in South-east Queensland.

Table 2. Seasonal variation of number of species according to their life forms (totals of 10 replicates).

	Number of species per 1.25 m2		
	August 1985	January 1986	July 1986
Primary trees	5	5	5
Secondary trees	12	9	12
Vines	13	12	11
Herbs	19	20	16
Shrubs	6	7	6
Other	3	3	2
Total	58	56	52

Table 3. The numbers of seeds germinating (per m2) from various soil depths and the correlation between these numbers (means of 5 replicates) and soil depths.

	Number of seed per square metre					Correlation
Depth (cm)	0-5	5—10	10—15	15—20	20—25	coefficient
Primary trees	54.4	0	0	0	0	—
Secondary trees	152.0	27.2	12.8	4.8	3.2	- 0.7990*
Shrubs	38.4	12.8	16.0	8.0	3.2	— 0.8746**
Vines	193,6	32.0	11.2	9.6	1,6	- 0.7906*
Herbs	97.6	38.4	17.6	6.4	1.6	— 0.9047**
Grass	3.2	0	0	0	0	—
Unknown	6.4	0	0	0	0	—
Total	555.2	99.2	57.6	28.8	9.6	— 0.8021*

* =P<0.05
** = P<0.01

Vertical distribution of seed banks

The numbers of seed and the numbers of species both drastically decreased with increasing soil depth. However, number of species, especially herbs, were proportionally found at depths of more than 10 cm (Figure 2).

Of 50 species recorded in the all level of depths, one secondary tree species, two vines, three shrubs and three herbs were distributed to at least 20 cm deep (Figure 3). These were *Dendrocnide excelsa,* (the only tree), *Cle-*

Table 4. A comparison of soil seed banks in rain forest communities.

Authors	Location	Vegetation type	Sample area (cm^{2})	Number of species	Number of seeds (m-2)
Keay(1960)	Nigeria	LRF	5200	42	233
Guevara & Gomex Pompa (1972)	Mexico	LRF, site 1	640 (x8 repeats)	13	175 — 689
		LRF, site 2	640 (x 8 repeats)	26	344 — 862
Cheke *et al.* (1979)	Thailand	LRF	10000	27	**182**
Hall & Swaine (1980)	Ghana	SDF	10000	30 & 43	633 & 696
		EF	10000	17 & 22	45 & 163
Uhl & Clark (1983)	Venezuela	LRF (mixed forest)	5200	13	180
		LRF (caatinga)	12000	14	200
Hopkins & Graham (1983)	North Queensland	CMVF, site 1	15000	64	588
		NMVF, site 2	15000	64	516
		MMVF, site 3	15000	79	1069
		CMVF, site 4	15000	60	593
Putz & Apannah (1987)	Malaysia	LRF	4241	30	131 .
Present study	South-east Queensland	CMVF	12500 (x3 repeats)	52 — 58	550 — 603

LRF. Lowland rain forest
SDF. Semideciduous forest
EF. Evergreen forest
CMVF. Complex Mesophyll Vine forest
NMVF. Nothophyll-Mesophyll Vine forest
MMVF. Mixed Mesophyll Vine forest

matis glycinoides, Rubus rosifolius, Conyza sp., *Hydrocotyle pedicellosa, Urtica incisa, Solarium aviculare,* and *Solanum inaquilaterum.* Three of these species occurred at 25 cm deep. All these species had seeds smaller than two mm in size. No primary species occurred below five cm deep.

The number of seeds germinating, are given in Table 3. For several life form groups these numbers were negatively correlated with soil depth.

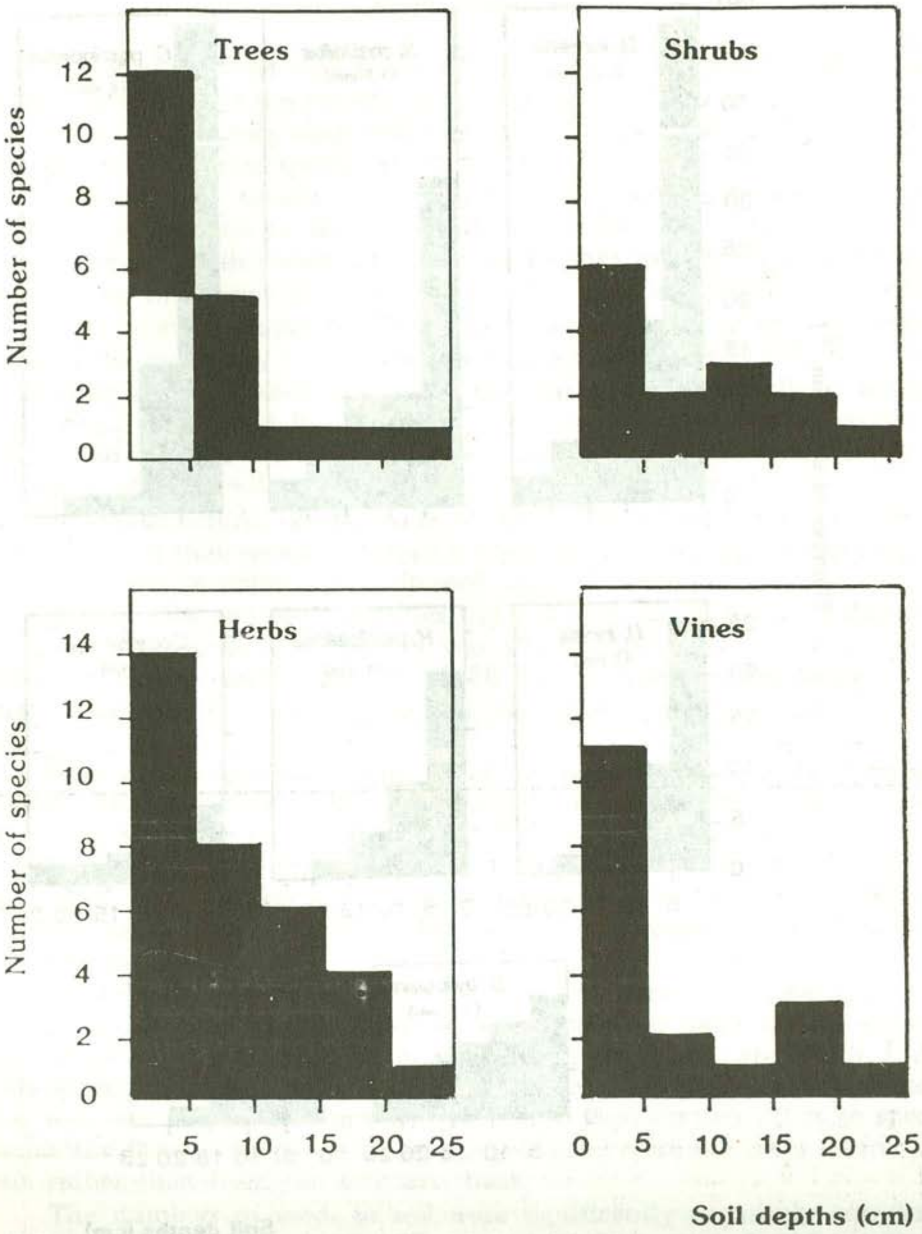

Figure 2. Number of species germinated from different soil depths in various life forms. Open bar indicated the number of primary species.

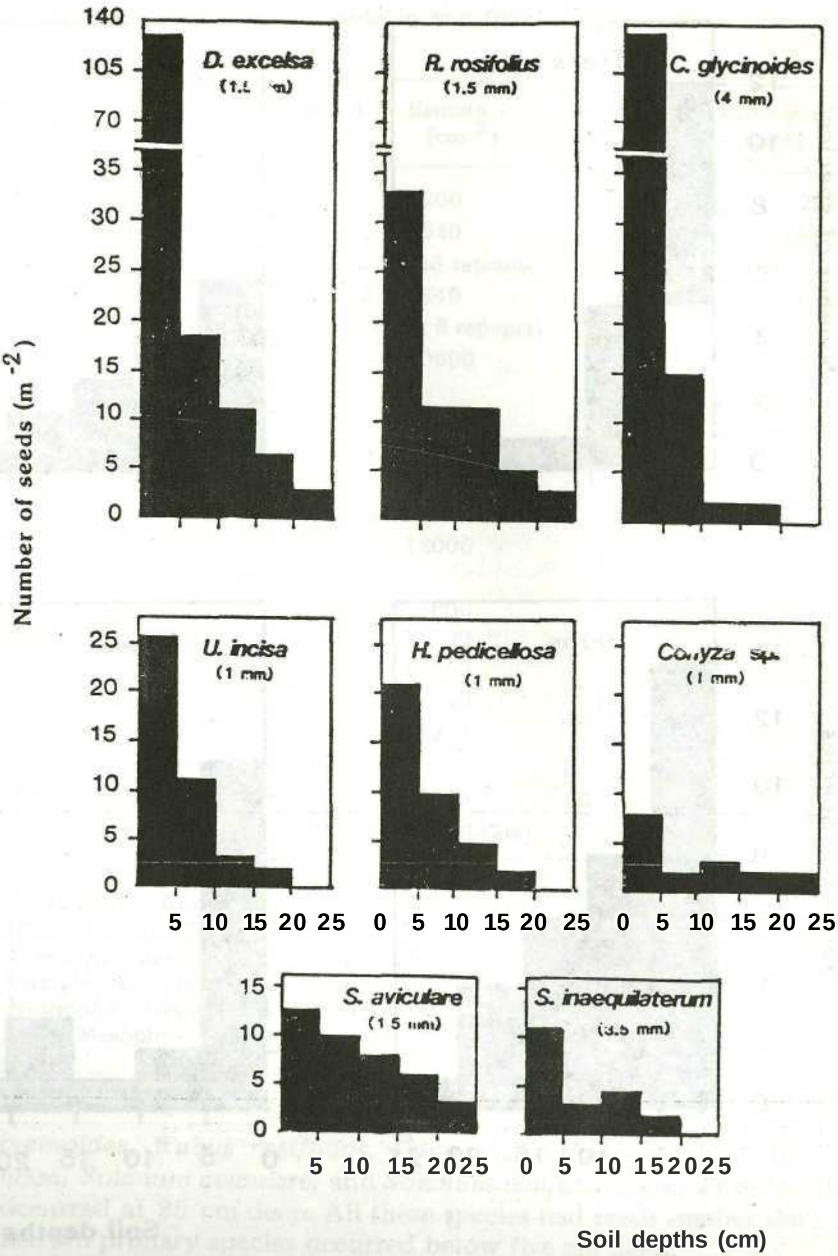

Figure 3. Number of individuals of the common species germinated from soil samples taken from different deptha

DISCUSSION

It was anticipated that the germination technique used in this study should indicate both the density and diversity of seeds in the soil seed bank. But the technique may underestimate the numbers of seeds of certain species, particularly those species which are slow to germinate (Roberts, 1981). The present study sought to minimize these problems by extending the period of observation to 40 weeks and periodically disturbing the soil.

Compared with other studies of seed banks in other rain forest soils, the number of species and seed densities found in the undisturbed forests in this study were comparable (Table 4). However, this number is lower than those in the secondary forest nearby (Abdulhadi & Lamb, 1987), even is so small compared with seed banks in Australian Savannah Woodland and Dry Sclerophyll Forest and in other forests in temperate regions. For example, Carrol and Ashton (1965) and Clifford and Mott (1986) found 2,772 — 25,589 seeds per m2 in both Queensland and Victoria. Likewise, in Conifer forests in U.S.A., Livingston & Allesio (1968) found 1289—5178 seeds per m2. From their review, Clifford & Mott *(he. cit.)* concluded that tropical soil have fewer germinable seeds in seed banks than temperate soils.

The species and seed densities did not vary significantly in different seasons. The species composition was almost similar, with the Sorensen similarity values reaching up to of 78 %. Likewise, the similarity of the seed bank density at the different sampling times was comparatively high.

Seasonal changes have been found in other forests, and Guevara and Gomez - Pompa (1972) attributed these to seed production by different species at different times of the year. Pulses in seed rain do occur in this forest (Abdulhadi, 1989). Despite such pulses the long lived and large soil seed pool of secondary trees, shrubs, herbs and vines apparently provide a buffer against such change and provide a high degree of constancy for the soil seed store.

In the case of primary forest species these were only present in small numbers in the undisturbed forest soils. On the other hand, seed of primary forest species were common in the seed rain in this forest (Abdulhadi, 1989). This suggests the seed of these species is only present for a short period in the soil seed banks. The implication is that regeneration of these species under the forest canopy or in gaps is primarily recruited from recent seed rain rather than from the soil seed bank.

The numbers of seeds in soil were significantly negatively correlated with the soil depths and only 25 percent of seeds were found below five centimetre soil depth. Similar observations have been reported elsewhere (Major & Pyott, 1966; Howard & Ashton, 1967 and Kellman, 1970).

It has been suggested that seeds become burried by several mechanisms such as being washed down through coarse-textured soil, or through worm and ant activities (Carrol & Ashton, 1965; McRill & Sagar, 1973 and Hopkins & Graham, 1983). These mechanisms were probably important in burying seeds in this undisturbed forest. In fact, most of the more common species found below 10 cm depth had small seeds. By contrast, shade tolerant species which tend to have larger seeds such as understorey shrubs and primary forest tree species, were restricted to the top 5 cm of soil.

The extent to which small seeds enter the soil and move down the profile is probably determined in part by soil texture. Hopkins and Graham (1983) noted a higher proportion of seeds below 5 cm depth in a coarse-textured soil than in a fine-textured soil and attributed the difference to the ease with which seed could ebter the profiles.

In most situations seed stored at the lower depth are ecologically unimportant in that they are unlikely to be responsived to the usual dormancv-breaking environmental cues and are too deep for any seedling to emerge above ground. About the only situation in which such seed can become part of the plant community is when trees are uprooted and soil from the lower depth containing the seed is brought to the surface (Putz, 1983). However, Graham (pers. com.) found in North Queensland that a late secondary tree species, *Aleurites moluccana*, which has a large (up to 3 cm in maximum dimension) seed with a hard coat was able to germinate from seed stores below 15 cm in granitic, coarse-textured soil following a gap opening. Seed of this size must have been burried by surface soil movement and were presumably only able to germinate and reach the soil surface because of the large endosperm and food reserves and the coarse textures of the soil.

In conclusion it seems that 1) the species richness and density of the soil seed bank in undisturbed sub-tropical rain forest were comparable to that found in many tropical rain forest soils. 2) The seed bank in undisturbed forest was relatively stable due to seed pools of large number of long lived, secondary species of grass, herbs, trees and vines, 3) The size of seed banks decreased with increasing soil depth.

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