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Forest observational studies in India: Past developments and considerations for the future

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ABSTRACT

Long term forest research sites in India, going by different names including *Linear Tree Increment Plots*, *Linear Increment Plots*, *Linear Sample Plots* and *Permanent Preservation Plots*, cover diverse plant communities and environmental conditions. Presently, some of these long-term observational studies are functional, some are disturbed and others have almost been lost. The accumulated data will become increasingly important in the context of environmental modelling and climate change, especially if the plots and data can be maintained and/or revived. This contribution presents the history and current state of forest research plots in India, including details of locations and re-measurements. We provide a brief introduction of the National Forest Inventory (NFI), Preservation Plots in natural forests, the 50-ha Mudumalai Forest Dynamics Plot as part of the Centre for Tropical Forest Science and Smithsonian Institution Global Earth Observatories network (CTFS–SIGEO), and research plots established in plantations for tree growth studies and modelling. We also present some methodological details including assessment and analysis for two types of observational studies, the Tree Count Plots (TCP) and Tree Re-measurement Plots (TRP). Arguments are presented in favour of enumeration and analysis methods which are consistent with current approaches in forest ecological research.

1. Introduction

Forest monitoring is especially important in India because of the high level of plant species diversity and endemism in the country. This is especially true in the tropical forests where rates of forest degradation and fragmentation are high. In India, forest monitoring is mainly done by the Forest Survey of India and State Forest Departments. However, other organisations like the Indian Council of Forestry Research and Education, the Indian Institute of Science (IISc), State Forest Research Institutes and Universities are also engaged in long-term ecological monitoring and growth research by establishing observational field studies in forests and plantations. A summary of these studies and assessments are presented in Table 1.

Field studies can be classified as *manipulated experiments* and *observational studies* (Gadow and Kleinn, 2005). A *manipulated experiment* is an investigation that attempts to establish a particular set of conditions under a specified protocol with the aim of testing a hypothesis. A *manipulated* experiment deliberately imposes treatments on experimental plots with the aim of observing a particular response. In contrast, a *comparative observational study* involves collecting and analysing data from different site conditions but without actively pre-defining these conditions (Kuehl, 1994). Comparative observational studies are also known as *quasi-experiments* (Campbell and Stanley, 1963;Cook and Campbell, 1979). Typical *quasi-experiments* are long-term forest observational studies.

1.1. Diversity of ecosystems and conservation

The diverse physical features and climatic conditions in India have given rise to a unique complement of forests, grasslands, wetlands, coastal and marine habitats, and desert ecosystems across a wide altitudinal gradient; thus, India has been described as a "mega-biodiverse" country (MoEF, 2001; Venkataraman and Swarna Latha, 2008; Sahu, 2011). Biogeographically, India is located at the tri-junction of three realms – the Afro-tropical, Indo-Malayan and Paleo-Arctic realm – and thus has characteristic elements from each of them (MoEF, 2001), making the country rich in biological diversity. The country is also one of 12 primary centres of origin

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Table 1
Summarised information about forest observation plots in India.

Description	*N*	Established	Plot area	Timing	Remarks
Early plots					
Tropical rain forests (*Hopea parviflora*) Karnataka	4	1911–1920	4–6 ha	5-year intervals till 1976; dbh	SFD; paper, good
Tropical rain forests (Karnataka)	7	1937–1939	1.09–5.6 ha	5-year intervals till 1993; dbh	SFD; paper; good
Tropical moist deciduous forest (Karnataka)	16	1950–1953	0.4–3.2 ha	5-year intervals till 1994; dbh	SFD; paper; 3 good, 13 poor
Tropical rain forests (Assam)	2	1958	2–3.27 ha	5-year intervals; dbh	SFD; paper; good
Tropical rain forests (Kerala and Tamil Nadu)	4	1938	1.6–4.48 ha	5-year intervals, measured till 1955 in Kerala and 1994 in Tamil Nadu; dbh	SFD; paper; 2 good; 2 degraded
Teak (Maharashtra)	2	1931	2.69–6.64 ha	10 year's interval; dbh	SFD; paper; 5 good, 6 poor
Teak (Karnataka)	11	1951–1953	1.6–3.2 ha	5-year intervals, till 1994; dbh	SFD; paper; good
Teak (Kerala)	1	1938	2.69 ha	5-year intervals, till 1994; dbh	SFD; paper; good
Shorea robusta (Utter Pradesh)	32	1935–1939	1.76–8.55 ha	5-year intervals, till 1990; dbh	SFD; paper; 14 good; 18 poor
Shorea robusta (Bihar)	5	1936–1959	3.2 ha	5-year intervals, till 1994; dbh	SFD; paper; 2 good, 3 poor
Shorea robusta (West Bengal)	5	1924–1926	1.21–4 ha	5-year intervals, till 1994; dbh	SFD; paper; 3 good, 2 poor
Santalium album (Karnataka)	Many	1934–1935	Approx. 1 ha	5-year intervals; dbh; till 1952	SFD; paper; lost
Santalium album (Andhra Pradesh)	2	1937	1.6 ha	5-year intervals; dbh; till 1955	SFD; paper; lost
Santalium album (Tamil Nadu)	3	1936	1.6 ha	5-year intervals; dbh; now lost	SFD; paper; lost
Pterocarpus santalinus (Andhra Pradesh)	1	1938	Approx. 1 ha	5-year intervals, now annual measurements; dbh	SFD; paper; degraded
Long Term Research Sites (LTRS)					
Linear Tree Increment plots (LTI)					
Karnataka (Coorg, Shimoga, Honnavar, Sirsi, Haliyal, Yellapur)	23	1937–1940 (7) 1950–1953 (16)	1.09–5.6 ha	5-year intervals; till 1994; dbh	SFD; paper; 10 good, 13 degraded
Kerala (Wynad)	3	1934–1940	2.24–4.48 ha	5-year intervals; till 1955; dbh	SFD; paper; 2 good, 1 poor
Tamil Nadu (Coimbatore, Nilgiris, Salem)	7	1934–1937	1.6–14.72 ha	5-year intervals; till 1994; dbh, two plots lost	SFD; paper; 4 good, 1 degraded, 2 lost
Bihar (Daltonganj, Kolhan, Saranda, Porahat)	5	1936–1958	3.2 ha	5-year intervals; till 1981; dbh	SFD; paper; 2 good, 3 poor
Maharashtra (Chanda, Melghat)	7	1931–1985	1.6–6.64 ha	10 year's interval; dbh	SFD; paper; 3 good, 4 poor
Andhra Pradesh (Chittor, Anant Pur, Cudappah)	3	1935–1938	1.6 ha	5-year intervals; dbh, now lost	paper with SFD; lost
Linear Increment Plots (LIP)					
Assam (Dibrugarh, Digboi)	3	1958–1978	2–3.27 ha	5-year intervals; dbh	SFD; paper; good
Uttar Pradesh (Haldwani, Kalagarh, Ram Nagar, North Kheri, West Baharaich, Dehradun)	32	1935–1939	1.76–8.55 ha	5-year intervals, till 1990; dbh	SFD; paper; 14 good; 18 degraded
Linear Sample Plots (LSP)					
West Bengal (Jalpaiguri, Buxa, Cooch Bihar)	7	1924–1926	1.21–4 ha	5-year intervals, till 1994; dbh, mortality	SFD; paper; 5 good, 2 degraded
Permanent Preservation Plots (PPP)					
Shorea robusta	38	1905–1985	0.01–4000 ha	5-year interval, till 1994; dbh	SFD; paper; some are good, some degraded and some lost
Tectona grandis	39				
Himalayan conifers (*Abies pindrow*, *A. spectablis*, *Cedrus deodara*, *Picea smithiana*, *Pinus roxburghii*, *P. wallichiana*)	12				
Mixed/others (non-plantations)	98				
Forest Dynamics Plot					
Mudumalai Wildlife Sanctuary, Tamil Nadu	1	1988	50 ha (1000 × 500 m)	dbh (>1 cm) 4 year intervals; Recensused for recruitment and mortality every year	Established by CES, IISc, Bangalore; paper and electronic
Tree growth modelling plots					
Tectona grandis (UP, Madhya Pradesh, Maharashtra, Orissa, Karnataka, Kerala)	150	1950–1991	Approx. 0.2 ha	Measurements at intervals of 4–10 years, but mostly at an interval of 5 years; Height, dbh, age and stem numbers recorded	Established by FRI, Dehradun; paper
Tectona grandis (Kerala)	1170	1996	0.0314 ha; circular plot (10 m radius)	Measured once; Height, girth, age, stand density recorded	Temporary plots; established by KFRI, Peechi; paper and electronically
Tectona grandis (Kerala)	69	1993–1994 and 2000–2001	0.25 ha (50 m × 50 m), few plots 0.04 ha (20 m × 20 m)	Measured at interval of 2–4 years; Height, girth, age, stand density recorded	Established by KFRI, Peechi; data in both, paper and electronic form
Tectona grandis (Kerala)	193	1989–1992	0.4 ha (63.25 m × 63.25 m)	Measured annually; Height, dbh, age, stand density recorded	Established by KAU, Thrissur; data in both, paper and electronic form
Eucalyptus camaldulensis (Rajasthan)	36	1995	0.04–0.1 ha	Annual measurements; Height, dbh, age, stand density recorded	Established by AFRI, Jodhpur; paper and electronically

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