RESEARCH ARTICLE

UNDERSTORY DYNAMICS IN DIFFERENT SITES OF SARGUJA FOREST DIVISION (CHHATTISGARH), INDIA

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Abstract: The rapid growth and development in urban area through industrialization leads rapid socio-economic deviations throughout the world, especially in Asian region which exert substantial impact over agricultural, forestry and other inter-related ecosystems. The increasing population also intensifies the global wood demand and these scenarios were more drastic in the developing countries due to demand and supply gap. These gaps can be overcome through the application of plantation forestry. In this connection we studied five vegetation stands (i.e., Teak, Sal, Mangium, Eucalyptus and Bamboo) of the Sarguja forest division in Chhattisgarh, India to assess the understory vegetation stratum, associated floral diversity and litter biomass through stratified random sampling technique. Total 6 herb species distributed into 4 families and 9 shrub species of 8 families were recorded across the sites. The total density of herb ranged from 72000-244000 individual ha^{-1} across the site being highest under teak plantation and lowest under bamboo stand. The shrub density ragned from 50-640 individual ha^{-1} in different sites being highest under teak stand and least in bamboo stand. The Shannon index for herb layer was lowest under bamboo stand and higher under mangium stand. In case of shrub the lowest value of Shannon index was recorded for sal stand and highest under both mangium and eucalyptus stand. The total forest floor biomass varied from 0.86-3.01 t/ha being lowest in bamboo stand and highest under sal stand. The information related to understory vegetation and its dynamics is essential towards management of vegetation stand.

Keywords: Herb, Diversity, Forest floor biomass, Plantation, Shrub

INTRODUCTION

The plantation forestry has gain special attention throughout the world due to it rapid growth, higher productivity and managerial perspectives over the natural forest ecosystem. However, plantations are less diverse in terms of biodiversity as compared to the natural stands (Ito *et al*. 2004; Jhariya and Yadav, 2018). The area under plantation is increasing throughout the world due to past enchrochment and felling of the natural forest land, population burst, unbanization, industrialization and pressure of the demand and supply of the forest based resources (Yadav *et al*. 2017; Jhariya *et al*. 2019). These figures are more drastic in the developing countries of the world. Therfore, the area under plantation is rapidly growing and increased in developing coutnries than the previous scenario. Plantation leads to simplified stand composition, structure and least biodiversity (Ito *et al*. 2004). Further, plantation also signify the ecological and environmental concern due to increase in short rotation forestry practices. Understory composition is altered and regulated by land-use pattern (Ito *et al*. 2004). The incorporation of leguminous species in plantation activities may be meet the sustainable development through improved site condition and soil sustainability (Jhariya *et al*. 2018).

Understory vegetation is diversified in nature and have substantial role in vegetational diversity and also supports to various ecological processes. Ground vegetation and its biodiversity is associated with both ecosystem services in and offereing

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several benefits for human civilization (Berendse et al. 2015; Jhariya, 2017a). The development of the understory in plantation sites depends upon the soil seed bank, canopy openness, natural and biotic disturbance regimes, edaphic condition, etc. (Zobel et al. 2007). The upperstory also influence and determined the flourishment of ground vegetation and its dynamics through resource partitioning and litter deposition (Barbier et al. 2008). There are few reports are available about understory species variation under the plantation of tropical decidous species. Forest floor biomass and litterfall have key role in nutrient cycling and improving the forests soil. Litterfall and forest floor biomass thererfore gains ecologists attention because these are an instrumental feature towards ecosystem dynamics (Jordan, 1985; Tandon et al. 2012; Jhariya, 2017b).

Therfore, in the present work, we investigated the understory vegetation composition, structure, diversity and forest floor biomass under the tropical deciduous species in the tropics of Chhattisgarh, India.

MATERIAL AND METHODS

Study Area

The state Chhattisgarh is one among the 29 states of India located towards centre-east of the country. The state is ranked 10th among the largest state on geographical area basis. The Chhattisgarh state is rich in natural resources. The northern and sourthern parts of the Chhattisgarh are hilly. The present study was carried out at Sarguja district which is located towards northern portion of Chhattisgarh (Figure 1). The entire area situated at 23o37’25” to 24o6’17” north latitude and 81o34’40” to 84o 4’40’’east longitude. The Sarguja district possses good and dense forest cover and rich in mineral deposits, coal reserves and the dense forests are rich in wildlife. The states Jharkhand, Orrissa, Uttar Pradesh and Madhya Pradesh are adjoining to the district. The Chhattisgarh is comes under tropical climate. The average height of the Sarguja district area is above 2000 ft (600 metres). There are three river basins in Sarguja district i.e., Hasdeo, Rihand and Kanhar river. The minimum and maximum temperature ranged between 50C to 460C. Monthly average temperature ranged from 15.340C in January and 31.540C in May, while it was 23.310C on mean annual basis. Average precipitation of the district is 1161.42 mm annually (Sinha et al. 2014, 2015; Yadav et al. 2015; Yadav and Jhariya, 2017; Jhariya and Yadav, 2018).

Experimental Design

The present investigation was carried out at 5 sites (comprising 4 plantations i.e., teak, mangium, eucalyptus and bamboo plantation and one is natural stand of sal) of Sarguja forest division. The stratified random sapling technique was opted to measure the understory vegetation. Total 150 quadrats were laid out to measure the herbs, shrub and forest floor biomass of different sites. The shrub was measured within 10 m x 10 m sized quadrates. While the herb and forest floor biomass was quantified through 50 cm x 50 cm sized quadrates. The herb and shrubs were counted at species level for each quadrats. Diameter at collar height of shrubs was measured by using callipers. As per Curtis and McIntosh (1950), we quantitatively analysed the collected data on understroy for frequency, density and abundance analysis. The distribution pattern was analysins by abundance to frequency (A/F) ratio (Curtis and Cotton, 1956) and the IVI (Importance Value Index) was calculated following Phillips (1959). The species rarity or commonness were calculated through species frequency class (Raunkiaer, 1934). The diversity indices for understory were evaluated using Shannon-Weaver diversity index (Shannon and Weaver, 1963), concentration of dominance through Simpson’s index (Simpson, 1949), species richness following Margalef (1958), equitability as suggested by Pielou (1966) and Beta diversity as advised by Whittaker (1972). The forest floor material was collected from different study sites and then characterised into diverse components. The weight of samples were taken after drying on component basis (Singh, 1995; Jhariya, 2017b).

RESULTS AND DISCUSSION

Understory Structure

Herb Layer

A total of 6 herb species with 4 families were recorded in different sites of Sarguja (Table 1). The highest herb species and density were found in teak plantation site. The total herb density ranged from 72000-244000 individual's ha-1 being lowest in bamboo plantation and highest under teak stand. In teak plantation site the maximum density was recorded for Cynodon dactylon (104000 individual's ha-1), while the minimum for Achyranthes aspera (4000 individual's ha-1).The frequency varied from 10-90 for individual herbaceous species. The importance value index (IVI) of individual herb species ranged between 40.83-109.24, highest for Cynodon dactylon and lowest for Melilotus alba, respectively. A/F ratio indicated that Tectona grandis was distributed regularly and Achyranthes aspera, Cynodon dactylon and Melilotus indica species were distributed randomly. The total herb density in sal forest was 168000 individuals ha-1 and the maximum density was recorded for Cynodon dactylon (116000 individuals ha-1), while the minimum for Bauteloua dactyloides. At mangium plantation it has total herb density of 104000 individuals ha-1 and the maximum density was recorded by Cynodon dactylon (52000 individuals ha-1), while the minimum for Bauteloua dactyloides (20000 individuals ha-1 for each). The frequency of individual herbaceous species varied from 20-40%. IVI of individual herb species ranged between 71.15-133.05. The eucalyptus plantation has total herb density of 168000 individuals ha-1 and the maximum density was recorded by Cynodon dactylon (116000 individuals ha-1. IVI of individual herb species ranged between 111.18-188.82. The bamboo plantation has total herb density of 72000 individuals ha-1 and the maximum density was recorded by Cynodon dactylon (56000 individuals ha-1. The frequency of individual herb varied from 20-40%. IVI of individual herb species ranged between 91.91-208.08.

The herbs structure and composition is regulated by soil moisture regimes, light availability at forest floor, site condition, species mix, microclimate, silvicultural operation, management regimes at stand level, disturbance regimes, etc. (Gilliam and Roberts, 2003; Jhariya, 2010, 2014; Oraon *et al*. 2014; Khan *et al*. 2019). The less species number of herb layer is due to moisture stress and season of investigation. The upperstory canopy openness is also determined the herbaceous composition, structure and its richness (Roberts, 2004). Jhariya and Yadav (2016) reported 18 herbs species under natural forest stand and 20 herbs species in teak plantation. The herb density ranged from 696000-832000 herbs/ha being lowest in teak stand and highest under natural forest. The higher herbaceous species were reported by Kumar et al. (2015) for tropics of northern Chhattisgarh. They found 43 herb species with 15 families in different plantation sites. Eucalyptus plantation representing a total of 26 species with 13 families, teak plantation contains 31 species with 13 families, whereas 25 species with 12 families were recorded under the mixed (Cassia+Mangium) plantation which were found higher than the present values. The herb density varied from 412000-708000 individuals ha-1 in different plantation which are higher then present estimated herb density.

The higher species number and density of herb was also reported by Sinha *et al*. (2015). They found 27 species distributed into 15 families with density of 776000 herb ha-1 for sal plantation in Sarguja. Oraon *et al*. (2014) found 108700-72000 herbs ha-1 in Bhoramdeo wildlife sanctuary, Chhattisgarh which is comparable with present findings. Jhariya *et al*. (2012) reported total herb density varied from 112000-668000 individuals ha-1 in protected area of Chhattisgarh. The favourable environmental condition leads toward ideal dispersal of species in addition to its adaptive potential. Species distribution in a given environment and site is regulated by site conditions and ecological interaction (Yadav *et al*. 2019; Jhariya *et al*. 2019).

The distribution of vegetation over an area is goverened by different biotic and abiotic factors. In natural environment the regular distribution was rarely found whereas contagious distribution and random distribution patterns are more common as also seen in present investigation (Odum, 1971).

Shrub Layer

A total of 9 shrub species distributed into 8 families were recorded in different sites of Sarguja (Table 2). The total shrub density varied from 50-640 individuals ha-1, being highest under teak stand and lowest under bamboo plantation site. In teak plantation the total shrub density was 640 individuals ha-1 and the maximum density was recorded by Flemingia chappar (240 individual's ha-1) whereas lowest by Casearia graveolens (20 individual's ha-1). The frequency varied from 10-50 for individual shrub species. IVI value of individual shrub species ranged between 14.45- 212.60. Sal stand revealed total shrub density of 360 individuals ha-1 and highest density was found for Carissa spinarum and lowest by Grewia rotchii. The frequency value 20 was recorded for each species found in sal stand. IVI values ranged between 45.61-196.11. In mangium plantation site total shrub density was 280 individuals ha-1 and the maximum density was recorded by Leonotis nepifolia (210 individuals ha-1), while the minimum for Ziziphus xylopyrus (20 individuals ha-1). The frequency of individual species varied from 10-30. IVI of individual shrub species ranged between 27.25-216.74. A total of 110 individuals ha-1 was found in eucalyptus plantation site and the maximum density was recorded by Lantana camara (60 individuals ha-1). The frequency of individual species varied from 20-40% and IVI from 48.35-168.23. The bamboo plantation site has total shrub density of 50 individuals ha-1 and the maximum density was recorded by Butea superba (30 individuals ha-1). The frequency of individual species varied from 10-20 and IVI from 119.23-180.77.

Jhariya and Yadav (2016) mentioned 5 shrub species in natural forest and 3 shrub species in teak stand. The density of shrub was 4500 individual ha-1 in natural forest and 5500 shrubs/ha in teak stand. The present values were also supported by Kumar *et al*. (2016), they found 7 shrub species with 6 families across the study sites and its density varied from 240-960 shrubs ha-1, respectively. Further they mentioned that eucalyptus plantation representing 2 species, teak plantation contains 5 species, whereas 4 species were recorded under the mixed plantation (Mangium + Cassia). Jhariya (2017a) reported that the shrub density and basal area ranged from 1250-3750 individuals ha−1 and 2.79-4.92 m2 ha−1. Similarly, Kumar et al. (2017a) mentioned nine shrub species representing eight families in different directions of study sites of northern Chhattisgarh. In the protected area of the Chhattisgarh, Jhariya et al. (2012) found 6-10 shrub species with the density of 1120-2480 shrubs/ha along with the basal area of 0.59-1.11 m2 ha−1 at pre-fire season while during the post-fire shrub species ranged between 12-15 with the density of 1920-3360 shrub/ha and basal area of 0.11-0.23 m2 ha−1. The higher shrub density was also reported by Gerwing and Vidal (2002) for Amazonia forest. They found 2500 individuals/ha for liana and shrubs.

Understory Rarity or Commeness

In teak plantation sites in herb layer 25% reflected under rare category, 25% species was intermediate and 50% speices were common or having high frequency class. Sal stand revealed that 50% of each species represented by intermediate and moderately high frequency class, respectively. At mangium plantation site 66.67% species represents low frequency class and remaining by intermediate class. Eucalpytus plantation site revealed 50% contribution each species in intermediate and moderately high frequency class. While in case of bamboo plantation low and intermediate frequency class were observed equally as 50% for each species in herb layer.

Shrub layer revealed that in teak stand 1/3rd of each species represented rare, low and intermediate frequency class. In sal stand all the species showed intermediate frequency class. Towards mangium stand 66.66% species showed rarity while the 33.33% revealed low frequency. In eucalyptus site 66.66% species have low frequency and the 33.33% species revealed intermediate frequency. In bamboo stand 50% each of the species showed rarity and low frequency.

The law of frequency is an ecological tools which reflects the uniformity or homogeneity within stand or among various vegetation stands. This also signifies towards identification of factors which controls and regulate the species presence, absence and its concentration. The frequency class distribution or occupancy of any species over an area is governed by species composition, adaptation range or ecological amplitude of the species, resistancy of species in limiting environment and competitiveness ability of a species, etc. In this connection Raunkiær (1934) suggests that species in a community are either rare or common, with only few species having intermediate occupancies which supports the present findings of species distribution as per the law of frequency. It is reported that biotic interference may directly or indirectly alter the regeneration of species which leads toward decline in frequency class (Stephenne and Lambin, 2004). Danjuma et al. (2017) found that frequency class A constitutes thirty three species (66%), class B constitute 8 (16%), C constitutes 5 species (10), class D has three species (6%) while class E has one species (2%) which is well comparable with present findings. In another study at Yabo area of Sokoto State revealed no occupancy of species in frequency classes D and E (Dangulla 2013). Kumar et al. (2017a) mentioned that the most of the plant life forms reflected that there were most of the species which occurred singly in a habitat. They also reported that most of species were of rare category and of low frequency class which supports the present findings.

Understory Diversity

The diversity indices (Table 3) of the herb layer showed that the value of Shannon index in different sites ranged between 0.77-1.48, being highest in mangium stand while lowest for bamboo stand. Simpsons index for herbs varied from 0.38-0.66, which refelected reverse trend when compared with Shannon index. The equitability value ranged from 0.70-1.44, richness from 0.08-0.31 and beta diversity from 1.75-3.50, respectively.

Shrubs diversity indices revealed that Shannon index in different sites ranged between 0.80-1.44, Simpsons index from 0.40-0.71, equitability from 0.25-1.31, richness from 0.14-0.43 and beta diversity from 3.0-5.50, respectively (Table 3).

The diversity of a stand or habitat entails the occurrence, distribution, species richness and degree of revolutation in species composition. The structure and diversity of vegetation stands have substantial role in regulating and function of ecosystem process. The biodiversity of natural ecosystem is higher as compare to the planted forest ecosystem. Therefore, increase in planted forests and its management is issues of concerns for making balance for sustainable production and towards conservation of biological diversity (Carnus *et al*., 2006; Jhariya and Yadav, 2018). The present findings on shrub diversity are comparable with Jhariya (2017a). He revelaed the value of Shannon index ranged from 2.32-3.77, Simpson's index or concentration of dominance (Cd) from 0.08-0.20, species richness from 0.56-1.58, equitability from 1.41-1.44, and beta diversity from 1.50-4.20, respectively. Kumar *et al*. (2015) mentioned the Shannon index in different plantation sites varied from 3.96-4.62, equitability from 1.22-1.36, species richness from 1.85-2.26, Simpsons index from 0.05-0.10 and beta diversity from 1.39-1.72 for herbs. Jhariya and Yadav (2016) mentioned the diversity indices for shrub layer revealed that Shannon index ranged from 1.10-2.20, least for teak stand and highest under natural forest. Simpson index was found higher in teak stand (0.57) and lowest under natural forest (0.23). Margalef index ranged from 0.23-0.48, being less in plantation site and higher under natural forest. Equitability was also higher in natural forest (1.37) and lowest in plantation site (1.0) and beta diversity showed reverse trend as it was found higher in plantation site (2.0) and lowest under natural stand (1.20). Herb layer revealed that the value of Shannon index, species richness and equitability values were higher in teak plantation while the Simpsons index and beta diversity were found more in natural forest.

Forest Floor Biomass

The forest floor biomass of different sites are presentd in Table 4. The total forest floor biomass of different sites varied from 0.86-3.01 ton ha-1, being highest in sal forest while lowest at bamboo plantation site. The total forest floor biomass was follows the order as Sal forest > Teak plantation > Eucalyptus plantation > Mangium plantation > Bamboo plantation, respectively. While concerning the components the wood litter and fresh leaf litter were found to higher under sal forest, whereas partially decompose leaf litter was more in teak stand and the seed was found to be higher under mangium plantation. The mean average value of forest floor bimass was found as 0.23 ton ha-1 for wood litter, 1.16 ton ha-1 for fresh leaf litter, 0.38 ton ha-1 for partially decompose leaf litter, 0.10 ton ha-1 for seed and 1.88 ton ha-1 total forest floor, respectively. From the total average mean value of site the three plantation sites namely mangium, eucalyptus and bamboo were found to lesser in terms of forest floor biomass accumulation.

The littermass on forest floor thorough litterfall is chief source for biogeochemical cycling. Higher litter mass improves soil health and its biota which leads toward diverse and rich vegetation stand (Jhariya, 2017b; Kumar et al. 2017a). Kumar et al. (2017b) found that the total forest floor biomass varied from 2.61-6.07 t ha-1 which is comparable with present findings. Kumar et al. (2016) reported that in different plantation sites the total litter biomass ranged from 1.98-4.01 t ha-1,being lowest in teak stand and maximum in eucalyptus stand. Sahu et al. (2013) found that forest floor mass at teak stand ranged from 2.19-2.66 t ha-1. Similar to present findings Pawar et al. (2014) found the total forest floor biomass between 2.75-3.55 t ha-1. The higher (4.20-5.65 t/ha) forest floor bimass was reported by Kumar et al (2017a). Kumar et al. (2016) mentioned very close value in between 1.98-4.01 t/ha for plantation sites of Sarguja. Jhariya and Yadav (2018) found the forest floor biomass in natural stand was twice (5.89 t ha-1) as compared to the teak stand (2.43 t ha-1). The component of forest floor biomass revealed that leaf litter was higher in natural forest while the wood litter was measure higher in teak stand. The present estimated value of forest floor biomass was well comparable with Jhariya (2017b). He mentioned the seasonal mean total forest floor biomass among different sites were ranged from 2.00-3.65 t ha-1.

Nativity of Understory Vegetation

The nativity of the understroy vegetation found in the different sites of Sarguja were represented in Table 5. Out of 15 species only 26.27% have its origin from India while the other are non-native. The most of the speices were originated from African, European and Asian countries. In herb and shrub layer only 33.33% species for each were found to be indigenous and rest of the species are non-native of the region.

The exotic species are key concern due to biodiversity loss at global scale (Vargas et al. 2013). The exotic species inhibits the germination, growth and colonization of indigenous species and alters the local biodiversity. Heywood (1989) reported that nearly half of the species was found to be non-native during study in New Zealand. In this context Binggeli et al. (1998) found nearly 45% exotic species in the tropics. The gap formation and canopy exposure leads towards establishment and naturalization of non-native species over indigenous flora due to resource competitionon and resource portioning (Denslow 2003). Further, the level and magnitude of disturbance regimes may prosper the non-native flora under such circumstances (Gorchov et al. 2011; Vargas et al. 2013). The increment in resource availability such as light in forest stand may impose towards more abundance of non-native vegetation (Muth and Bazzaz 2002). The diversity in the present finding seems to very less which may be due to more abundancy of non-native flora in understory. In this connection Vargas et al. (2013) mentioned that non-native flora alter indigenous plant species diversity in greater scale.

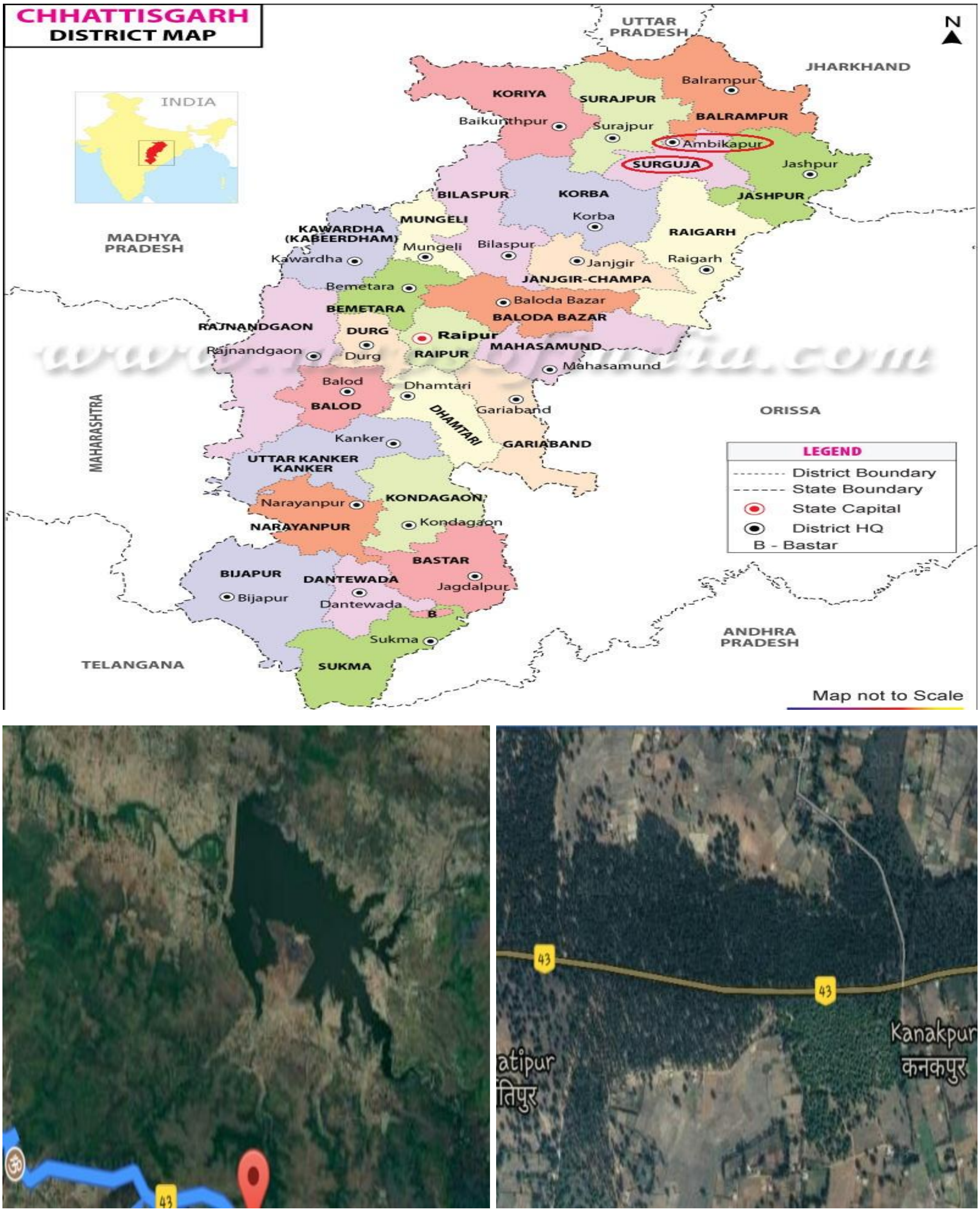

Figure 1. Location map of the study area

Table 1. Structure of Herb layer in different sites of Sarguja

	Teak					Sal					Mangium					Eucalyptus					Bamboo				
Species	**F**	**D**	**A**	**IVI**	**A/F**	**F**	**D**	**A**	**IVI**	**A/F**	**F**	**D**	**A**	**IVI**	**A/F**	**F**	**D**	**A**	**IVI**	**A/F**	**F**	**D**	**A**	**IVI**	**A/F**
Achyranthes aspera L.	40	4000	0.19	51.57	0.06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cynodon dactylon L.	90	120000	0.25	109.24	0.04	70	116000	0.61	188.82	0.06	40	52000	0.38	133.05	0.081	70	116000	0.61	188.82	0.06	40	56000	0.36	208.08	0.08
Melilotus indica L.	80	104000	0.24	98.34	0.04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	16000	0.36	91.91	0.1
Melilotus abla L.	10	16000	0.04	40.83	0.40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ocimum tenuiflorum L.	-	-	-	-	-	-	-	-	-	-	30	32000	0.31	95.78	0.088	-	-	-	-	-	-	-	-	-	-
Bauteloua dactyloides Nutt.	-	-	-	-	-	50	52000	0.38	111.17	0.05	20	20000	0.29	71.15	0.125	50	52000	0.38	111.18	0.05	-	-	-	-	-
Total		**244000**		**300**			**168000**		**300**			**104000**		**300**			**168000**		**300**			**72000**		**300**	

*Note: F= Frequency, D= Density/ha, A= Abundance, IVI= Important value index, A/F= Abundance to frequency ratio

Table 2. Structure of Shrub layer in different sites of Sarguja

	Teak					Sal					Mangium					Eucalyptus					Bamboo				
Species	**F**	**D**	**BA**	**IVI**	**A/F**	**F**	**D**	**BA**	**IVI**	**A/F**	**F**	**D**	**BA**	**IVI**	**A/F**	**F**	**D**	**BA**	**IVI**	**A/F**	**F**	**D**	**BA**	**IVI**	**A/F**
Lantana camara L.	50	380	0.19	212.60	0.15	-	-	-	-	-	-	-	-	-	-	40	60	0.0025	168.23	0.037	10	20	0.00034	119.23	0.2
Flemingia chappar Benth.	30	240	0.0042	72.95	0.26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Casearia graveolens Dalz.	10	20	0.0004	14.45	0.2	20	40	0.001	58.27	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Butea superba Roxb.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	0.0008	83.41	0.033	20	30	0.0004	180.77	0.075
Grewia rotchii DC	-	-	-	-	-	20	20	0.00048	45.61	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carissa spinarum L.	-	-	-	-	-	20	300	0.00048	196.11	0.75	10	50	0.001	56.0	0.5	-	-	-	-	-	-	-	-	-	-
Ziziphus xylopyrus Retz.	-	-	-	-	-	-	-	-	-	-	10	20	0.00001	27.25	0.2	-	-	-	-	-	-	-	-	-	-
Leonotis nepifolia L.	-	-	-	-	-	-	-	-	-	-	30	210	0.0045	216.74	0.23333	-	-	-	-	-	-	-	-	-	-
Helicteres isora L.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	20	0.0002	48.35	0.05	-	-	-	-	-
Total		**640**	**0.19**	**300**			**360**	**0.00196**	**300**			**280**	**0.006**	**300**			**110**	**0.0036**	**300**			**50**	**0.00074**	**300**	

*Note: F= Frequency, D= Density/ha, BA= Basal area, IVI= Important value index, A/F= Abundance to frequency ratio

Table 3. Diversity indices of understory vegetation in Sarguja forest division

		Sites				
Layer	**Diversity indices**	**Teak**	**Sal**	**Mangium**	**Eucalyptus**	**Bamboo**
Herb	Shannon index(H)	1.13	0.99	1.48	0.89	0.77
	Simpsons index(Cd)	0.49	0.50	0.38	0.57	0.66
	Species richness(d)	0.31	0.18	0.17	0.08	0.09
	Equitability(e)	1.03	1.44	1.35	1.29	0.70
	Beta diversity(βd)	1.75	3.50	2.33	3.50	3.50
Shrub	Shannon index(H)	1.20	0.80	1.44	1.44	0.99
	Simpsons index(Cd)	0.48	0.71	0.40	0.41	0.50
	Species richness(d)	0.31	0.34	0.43	0.43	0.14
	Equitability(e)	1.09	0.73	1.31	1.31	0.25
	Beta diversity(βd)	3.67	3.00	3.00	3.00	5.50

Table 4. Forest floor biomass in different sites of Sarguja forest division

Components	**Teak**	**Sal**	**Mangium**	**Eucalyptus**	**Bamboo**
Wood litter	0.26 ± 0.18	0.32 ± 0.04	0.22 ± 0.05	0.25 ± 0.13	0.09 ± 0.11
Fresh leaf	1.35 ± 0.40	2.21 ± 0.60	0.70 ± 0.15	0.90 ± 0.23	0.64 ± 0.17
Partially decompose leaf	0.63 ± 0.12	0.43 ± 0.07	0.28 ± 0.06	0.44 ± 0.05	0.12 ± 0.10
Seed	0.04 ± 0.05	0.03 ± 0.08	0.37 ± 0.07	0.06 ± 0.12	0.006 ± 0.04
Total	**2.29 ± 0.42**	**3.01 ± 0.54**	**1.58 ± 0.15**	**1.66 ± 0.22**	**0.86 ± 0.22**

Table 5. Nativity of understory vegetation found in the different sites of Sarguja

Vegetation stratum	**Family**	**Origin**
Herb		
Achyranthes aspera L.	Amaranthaceae	South Africa and India
Bauteloua dactyloides Nutt.	Poaceae	North America
Cynodon dactylon L.	Poaceae	Africa
Melilotus indica L.	Fabaceae	Northern Africa, Europe, Asia
Melilotus alba L.	Fabaceae	Northern Africa, Europe, Asia
Ocimum tenuiflorum L.	Lamiaceae	India
Shrub		
Butea superba Roxb.	Fabaceae	Thailand, Vietnam, India
Carissa spinarum L.	Apocynaceae	Africa, Southern Asia, Australia
Casearia graveolens Dalz.	Salicaceae	Asia
Flemingia chappar Benth.	Fabaceae	Tropical region
Grewia rotchii DC	Tiliaceae	India and Sri Lanka
Helicteres isora L.	Malvaceae	Asia and Australia
Lantana camara L.	Verbenaceae	South America
Leonotis nepifolia L.	Lamiaceae	Tropical Africa & southern India
Ziziphus xylopyrus Retz.	Rhamnaceae	South-east Asia

CONCLUSION

The understory vegetation forms an important stratification of forest ecosystem. Besides, their direct benefits, they also significantly contributes towards tropical biodiversity, ecological processes and various functions. From plantation forestry perspective these understory vegetation (herbs and shrubs) become major challenges towards quality timber production and to plantation manager. The findings of present investigation revealed that resource availability and canopy openness provide opportunity for growth and development of understroy vegetation. The non-native species was found to more and established under different stands of the study area. The highest count of understory density was recorded under teak stand and most of the dominated species were non-native throughout the studied sites. Further, the most of the species were represent the rare category as per their occurrence over the area. Therefore, conservation of the rare indigenous species should be done on priority basis to sustain their population in this regions. Further in all the stand the understory manipulation by altering the structure and composition at stand level by opting indigenous vegetation should be done through plantation activity and eliminating the exotic or non-native vegetation of less socio-economc concern. This would leads towards ecological balance of the stand and promoting the indigenous biodiversity and resilience of the stands towards invasion of non-native vegetation.

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REFERENCES

Barbier, S., Gosselin, F. and Blandier, P. (2008). Influence of tree species on understory vegetation diversity and mechanisms involved- a critical review for temperate and boreal forests. *For Ecol Manage*, 254:1-15.

Berendse, F., Van Ruijven, J., Jongejans, E. and Keesstra, S.D. (2015). Loss of plant species diversity reduces soil erosion resistance of embankments that are crucial for the safety of human societies in low-lying areas. *Ecosystems*, 18(5):881–888.

Binggeli, P., Hall, J.B. and Healey, R. (1998). An overview of invasive woody plants in the tropics. School of Agriculture and Forest Science, University of Wales, Bangor Publication No. 13, 83 pp.

Carnus, J.M., Parrotta, J., Brockerhoff, E., Arbez, M., Jactel, H., Kremer, A., Lamb, D., O'Harra, K. and Walters, B. (2006). Planted forests and biodiversity. *J Forestry*, 104:65-77.

Curtis, J.T. and McIntosh, R.P. (1950). The interrelations of certain analytic and synthetic phytosociological characters. *Ecology*, 31:434–455.

Curtis, J.T. and Cotton, G. (1956). Plant Ecology Workbook: Laboratory Field Reference Manual. Burgess Publishing Co., Minnesota. p. 193.

Dangulla, M. (2013). The Diversity and Spatial Variability of Woody Species in Yabo Area, Sokoto State. MSc thesis, Ahmadu Bello University, Zaria, Nigeria.

Danjuma, M.N., Bindawa, A.A., Babankowa, I.A. and Maiwada, B. (2017). Frequency Class Distribution of Vegetation in the Dryland of Northwestern Nigeria. *American J Biol Life Sci*, 5(2):7-12.

Denslow, J.S. (2003). Weeds in paradise: thoughts on the invisibility of tropical islands. *Annals of the Missouri Botanical Garden*, 90(1):119.

Gerwing, J.J. and Vidal, E. (2002). Changes in liana abun-dance and species diversity eight years after liana cut-ting and logging in an Amazonia forest. *Conserv Biol*, 16:544-548.

Gilliam, F.S. and Roberts, M.R. (2003). Conceptual framework for studies of the herbaceous layer. In: Gilliam FS, Roberts MR (eds) The herbaceous layer in forests of Eastern North America. Oxford University Press, Oxford, Pp. 3–11.

Gorchov, D.L., Thompson, E., O'Neill, J., Whigham, D. and Noes, D. (2011). Treefall gaps required for establishment, but not survival, of invasive Rubus phoenicolasius in deciduous forest, Maryland, USA. *Plant Species Biology*, 26:221-234.

Heywood, V.H. (1989). Patterns, extents and modes of invasions by terrestrial plants. In: Drake JA, Mooney HA, di Castri F, Groves RH, Kruger FJ, Rejmánek M, Williamson M (eds) *Biological Invasions: A Global Perspective*. Scope 37/John Wiley & Sons, New York, Pp. 31-60

Ito, S., Nakayama, R. and Buckley, G.P. (2004). Effects of previous land-use on plant species diversity in seminatural and plantation forests in a warm-temperate region in southeastern Kyushu, Japan. *For Ecol Manage*, 196:213-255.

Jhariya, M.K., Banerjee, A., Meena, R.S. and Yadav, D.K. (2019). Sustainable Agriculture, Forest and Environmental Management. Springer Nature Singapore Pte Ltd., 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore**.** eISBN: 978-981-13-6830-1, Hardcover ISBN: 978-981-13-6829-5. DOI: 10.1007/978-981-13-6830-1. Pp. 606.

Jhariya, M.K., Banerjee, A., Yadav, D.K. and Raj, A. (2018). *Leguminous Trees an Innovative Tool for Soil Sustainability*. Pp. 315-345. In: Legumes for Soil Health and Sustainable Management. R.S. Meena, A. Das, G.S. Yadav and R. Lal (Eds.). Springer, ISBN 978-981-13-0253-4 (eBook), ISBN: 978-981-13-0252-7 (Hardcover). https://doi.org/10.1007/978-981-13-0253-4_10.

Jhariya, M.K. and Yadav, D.K. (2018). Biomass and carbon storage pattern in natural and plantation forest ecosystem of Chhattisgarh, India. *Journal of Forest and Environmental Science*, 34(1):1-11. Doi: 10.7747/JFES.2018.34.1.1.

Jhariya, M.K. (2017a). Vegetation ecology and carbon sequestration potential of shrubs in tropics of Chhattisgarh, India. *Environmental Monitoring and Assessment*, 189(10):1-15. 518, Doi:10.1007/s10661-017-6246-2.

Jhariya, M.K. (2017b). Influences of forest fire on forest floor and litterfall dynamics in Bhoramdeo Wildlife Sanctuary (C.G.), India. *J For Environ Sci*, 33(4):330-341.

Jhariya, M.K. and Yadav, D.K. (2016). Understory vegetation in natural and plantation forest ecosystem of Sarguja (C.G.), India. *J Appl Nat Sci*, 8(2):668-673.

Jhariya, M.K. (2014). Effect of forest fire on microbial biomass, storage and sequestration of carbon in a tropical deciduous forest of Chhattisgarh. PhD thesis. Indira Gandhi Krishi Vishwavidyalaya, Raipur, India.

Jhariya, M.K., Bargali, S.S., Swamy, S.L. and Kittur, B. (2012). Vegetational Structure, Diversity and Fuel Loads in Fire Affected areas of Tropical Dry Deciduous Forests in Chhattisgarh. *Vegetos*, 25(1):210-224.

Jhariya, M.K. (2010). Analysis of vegetational structure, diversity and fuel load in fire affected areas of tropical dry deciduous forests in Chhattisgarh. MSc thesis. Indira Gandhi Krishi Vishwavidyalaya, Raipur, India.

Jordan, C.F. (1985). Nutrient cycling in tropical forest ecosystems. Wiley, Chichester, UK, pp 190.

Khan, N., Jhariya, M.K. and Yadav, D.K. (2019). Population structure of vegetation in urban environment of Sarguja, Chhattisgarh, India. *Journal of Plant Development Sciences*, 11(3):133-142.

Kumar, A., Jhariya, M.K. and Yadav, D.K. (2015). Community characters of herbaceous species in plantation sites of Coal mine. *J Plant Dev Sci*, 7(11):809-814.

Kumar, A., Jhariya, M.K. and Yadav, D.K. (2016). Vegetation Dynamics in Plantation Sites of Collieries. *Nat Environ Pollut Technol*, 15(4):1285-1291.

Kumar, A., Jhariya, M.K., Yadav, D.K. and Banerjee, A. (2017a). Vegetation dynamics in Bishrampur collieries of northern Chhattisgarh, India: eco-restoration and management perspectives. *Environ Monit Assess*, 189:371.

Kumar, Amit, Jhariya, M.K. and Yadav, D.K. (2017b). Tree stratum and Forest Floor Biomass in the Proximity of Collieries. *Van Sangyan*, 4(1):55-60.

Margalef, R. (1958). Perspective in ecological theory. Uni-versity of Chicago Press, Chicago.

Muth, C.C. and Bazzaz, F.A. (2002). Tree canopy displacement at forest gap edges. *Canadian J For Res*, 32:247-254.

Odum, E.P. (1971). Fundamental of Ecology. Saunders Co., Philadelphia.

Oraon, P.R., Singh, L. and Jhariya, M.K. (2014). Variations in herbaceous composition of dry tropics following Anthropogenic disturbed environment. *Current World Environment*, 9(3):967-979.

Pawar, G.V., Singh, L., Sarvade, S. and Lal, C. (2014). Litter production and soil physico-chemical properties influenced by different degraded sites of tropical deciduous forest, Chhattisgarh, India. *The Ecoscan*, 8(3&4):349-352.

Phillips, E.A. (1959). *Methods of Vegetation Study*. Holt R and Winston New York USA. pp. 105.

Pielou, E.C. (1966). Species diversity and pattern diversity in the study of ecological succession. *J Theor Biol*, 10:370-383.

Raunkiaer, C. (1934). The Life Form of Plants and Statistical Plant Geography. Claredon Press ISBN 9978–40–943-2, Oxford.

Roberts, M.R. (2004). Response of the herbaceous layer to natural disturbance in North American forests. *Can J Bot*, 82:1273–1283.

Sahu, K.P., Singh, L. and Jhariya, M.K. (2013). Fine root biomass, forest floor and nutrient status of soil in an age series of teak plantation in dry tropics. *The Bioscan*, 8(4):1149-1152.

Shannon, C.E. and Weaver, W. (1963). The Mathematical Theory of Communication. Urbana, USA: University of Illinois Press.

Singh, L. (1995). Seasonal variation in biomass and nutrient content of the forest floor in a dry tropical forest. *Oecol Mont*, 4:21-26.

Sinha, R., Yadav, D.K. and Jhariya, M.K. (2014). Growth performance of Sal in Mahamaya central forest nursery (Ambikapur), Chhattisgarh. *Int J Sci Res*, 3:246-248.

Sinha, R., Jhariya, M.K. and Yadav, D.K. (2015). Assessment of Sal Seedlings and Herbaceous Flora in the Khairbar Plantation of Sarguja Forest Division, Chhattisgarh. *Curr World Environ*, 10:330-337.

Simpson, E.H. (1949). Measurement of diversity. *Nature*, 163:688.

Stephenne, N. and Lambin, E.F. (2004). Scenarios of land-use change in Sudano-sahelian countries of Africa to better understand driving forces. *GeoJournal*, 61:365-379.

Tandon, S., Sahu, S.K., Mishra, A.S.P. and Mishra, P.C. (2012). Litter disappearance in ash mound plantation site. *The Ecoscan*, 1:83-86.

Vargas, R., Gartner, S., Alvarez, M., Hagen, E. and Reif, A. (2013). Does restoration help the conservation of the threatened forest of Robinson Crusoe Island? The impact of forest gap attributes on endemic plant species richness and exotic invasions. *Biodivers Conserv*, 22:1283-1300.

Whittaker, R.H. (1972). Evolution and measurement of species diversity. *Taxon*, 21:213-251.

Yadav, D.K., Jhariya, M.K., Kumar, A. and Sinha, R. (2015). Documentation and ethnobotanical importance of medicinal plants found in Sarguja district. *J Plant Dev Sci*, 7:439-446.

Yadav, D.K. and Jhariya, M.K. (2017). Tree community structure, regeneration and patterns of diversity in natural and plantation forest ecosystem. *Res Environ Life Sci*, 10:383-389.

Yadav, D.K., Ghosh, L. and Jhariya, M.K. (2017). Forest Fragmentation and Stand Structure in Tropics: Stand Structure, Diversity and Biomass. Lap Lambert Academic Publishing, Saarbrucken, 116 pp.

Yadav D.K., Jhariya, M.K. and Ghosh, L. (2019). Vegetation inter-relationship and regeneration status in tropical forest stands of central India. *Journal of Plant Development Sciences*, 11(3):151-159.

Zobel, M., Kalamees, R., Pussa, K., Roosaluste, E. and Moora, M. (2007). Soil seed bank and vegetation in mixed coniferous forest stands with different disturbance regimes. *For Ecol Manage*, 250:71-76.