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Phytosociological analysis and carbon stocks for trees in different land uses in Senapati district of Manipur, India

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Abstract

The objective of this study is to analyse the tree diversity and carbon stocks in different form of land uses in Senapati district of Manipur (India). The natural undisturbed mixed Oak Forest (UOF) which is dominated by *Quercus serrata* Murray (IVI, 77.4) and co-dominated by *Lyonia ovalifolia* (Wall.) Drude (IVI 46.4); Disturbed mixed Oak forest (DOF) dominated by *Quercus serrata* Murray (IVI, 114) and co-dominated by *Quercus griffithii* Hook.f. & Thomson ex Miq. (IVI, 91.5); *Pinus kesiya* Royle ex Gordon Plantation Forest (PPF) and Orchard Plantation Forest (OPF) dominated by *Mangifera indica* L. (IVI, 87) and co-dominated by *Gmelina arborea* Roxb. (IVI : 43.5) with their corresponding GPS co-ordinates lying between 25° 12'067" to 25Ú12'145"N and 93Ú59'915" to 94°02'296"E and located at the elevation of 1146 – 1254 m amsl were studied. Species diversity, richness, basal area, tree density and tree carbon stocks attributes showed difference in different land uses. The recorded tree carbon stocks ranged from 25.51 – 164.81 t ha^{-1}. Thus the present study inferred that pine forest and oak forest which are important tree species play potential role in carbon storage in the vegetation if well conserved.

Key words: Tree diversity, Carbon stocks, Forest, Plantation, Land use

INTRODUCTION

Forest ecosystems play very important role in capturing large amount of atmospheric carbon through photosynthesis and can act both as sinks and sources of carbon. A forest has the largest potential to mitigate climate change through conservation of existing carbon pools and expansion of C sinks. For implication of carbon budgets and sink capacity, it is also important to analyse and understand the relationships between the species diversity and the accumulation of tree biomass and carbon stock in different land uses. There is a close relationship between carbon stocks and basal area (Borah *et al*. 2013; Mani & Parthasarathy 2007). Phytosociological studies of dominant tree species assists in understanding the potential role of these tree species in capturing maximum carbon and helps in mitigating climate change. Present status of forest in the Senapati district is facing high biotic pressure due to excessive increase in human population in the area, resulting into biodiversity loss, deforestation, burning of forest for shifting cultivation and fuelwood collection. There is an overall disturbance of biodiversity and storage and sink capacity of the forests. However, the study of carbon stock and carbon sequestration of the coniferous

forests of Manipur (Devi & Sharma 2015) and in Senapati district of Manipur is very limited (Yadava 2010). The present investigation was carried out to study the relationships between the ecological diversities and the tree carbon stocks in natural and human impacted ecosystem of Senapati district of Manipur.

Study area

The present study was conducted in the Senapati district of Manipu (India). Three study sites (Fig. 1) were demarcated at Thangal Ecological Park viz. (i) Undisturbed Oak Forest (UOF) (latitude 25°122 .113"N, longitude 93°592 .900"E, elevation 1,192 m a.m.s.l); (ii) Pine Plantation Forest (PPF) (latitude 25°122 .088"N, longitude 93°592 .828"E, elevation 1,146 m a.m.s.l); and (iii) Disturbed Oak Forest (DOF) (latitude 25°122 .067"N, longitude 93°592 .915"E, elevation 1,218 m a.m.s.l). Another, i.e. the 4th site was selected at Tunggam TNK village hill (Fig. 1) Orchard Plantation Forest (latitude 25°162 .145"N, longitude 94°022 .296"E, elevation 1,245 m a.m.s.l) which is privately owned. These three are community forests belonging to Mayangkhang people of Manipur and the study was conducted during the years 2015–2016. The planted pine forest is well-protected, 30 – 40 years old exclusively covered by *Pinus kesiya* Royle ex Gordon. The forest is classified as montane or hill forest of Manipur (Champion & Seth 1968). The study site receive an average annual rainfall of 1754.05 mm during the study period. The average monthly temperature varied from a maximum of 30.0° C in the month of July to a minimum 4.1° C in December.

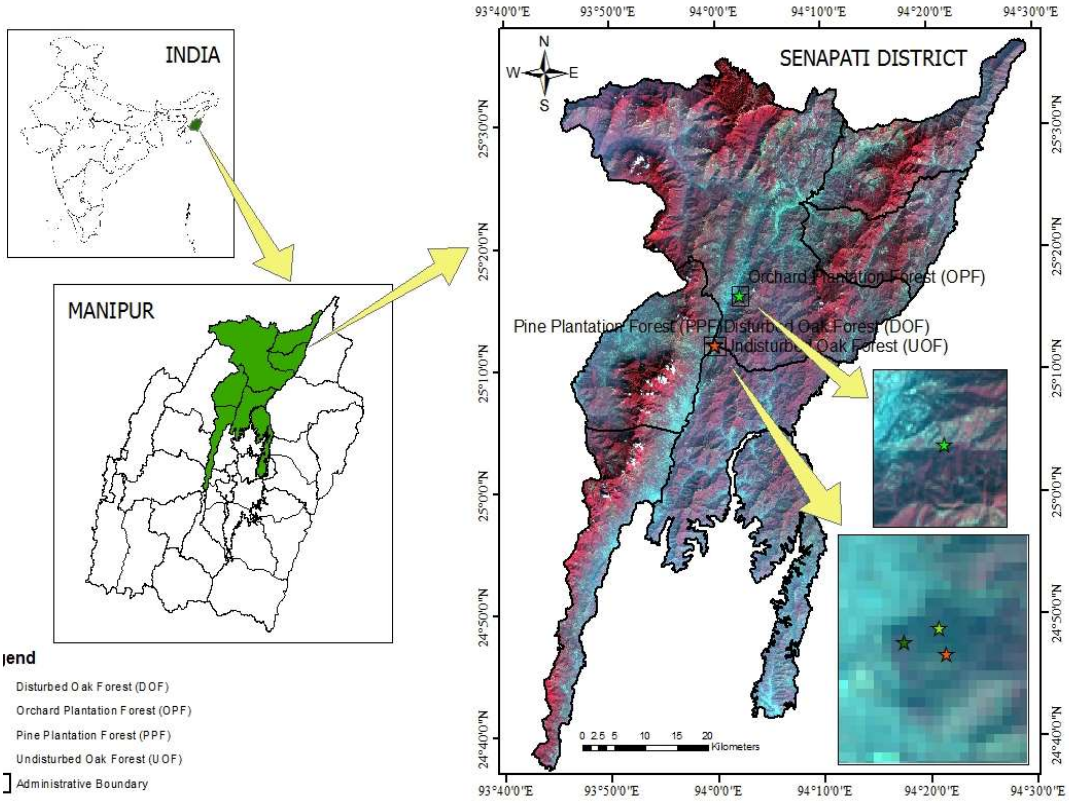

Fig. 1. Map showing the location of the study sites in Senapati District of Manipur.

METHODOLOGY

In each study site ten permanent quadrates of 10 m x10 m were laid and all the trees >10 cm DBH measured i.e. at 1.37 m above the ground level, and individual tree height were measured during the study using diameter tape and Hypsometer (Misra 1968). Tree species were identified at BSI, Shillong. Species diversity of the communities were analysed for Shannon diversity Index (Shannon & Weaver 1963), Evenness Index (Pielou1975), Margalef Index (Margalef 1968) and Simpson Dominance Index (Simpson 1949).

The aboveground biomass of tree species was estimated following regression equations model (Chambers *et al*. 2001) and FSI (1996) general volume equations for Pine plantation forest were evaluated based on r^2. Estimation of C -stocks of each tree was calculated by assuming 46 % of carbon contents for pine forest and 45 % for other broadleaved species (Negi *et al*. 2003; Manhas *et al*. 2006).

RESULTS

Tree density is found to be in the order UOF>DOF> PPF>OPF. Basal area is found to be in the order of PPF> UOF>DOF>OPF. In UOF and DOF *Quercus serrata* Murray (64.9 %) and *Quercus griffithii* Hook.f. & Thomson ex Miq. (29.3 %) contributes the highest tree carbon stocks and in OPF, *Gmelina arborea* Roxb. (22.3 %) and *Mangifera indica* L. (12.3 %) contributes the highest tree carbon stock (Table 1).

Table 1.Summary of tree diversity and carbon stocks in four land use types of Senapati district, Manipur

Land use types	Tree density ha^{-1}	Basal area m^2ha^{-1}	Shannon diversity	Simpson diversity	Species richness	Evenness	Carbon stock (t ha^{-1})
UOF	2690	57.09	2.27	0.13	2.50	2.71	133.00
DOF	2600	10.13	1.66	0.24	1.44	0.75	28.71
OPF	1230	10.14	2.31	0.10	2.27	0.93	25.59
PPF	1740	92.04	-	-	-	-	164.81

Tree carbon stocks ranged from 25.59 t ha^{-1} in OPF to 164.81 t ha^{-1} in PPF, and tree density ranged from 1230 tree ha^{-1} in OPF to 2690 tree ha^{-1} in UOF. Basal area ranges from10.13 m^2 ha^{-1} in DOF to 92.04 m^2ha^{-1} in PPF. Shannon diversity ranges from 1.66 (DOF) to 2.77(UOF) Simpson diversity index ranges from 0.10 (OPF) to 0.24(DOF). Species richness varies from1.44 (DOF) to 2.50(UOF), Evenness index varies from 0.75 (DOF) to 2.71(UOF)

Statistical Analysis

Tree basal area shows positive correlation with carbon stock ($r = 0.98$; $P<0.005$) in all the land uses. Tree density shows positive correlation with Shannon diversity ($r=0.90$; $P=0.002$) in all the land uses. Basal area is positively correlated with Shannon diversity($r=0.69$; $P<0.005$), Simpson diversity ($r=0.96$; $P<0.001$) and tree density ($r=0.90$: $P=0.04$) in UOF. In DOF basal area is positively correlated with Shannon diversity ($r=0.98$; $P<0.005$), Simpson diversity ($r=0.94$; $P<0.005$) and tree density ($r=0.82$; $P=0.02$). In OPF basal area is positively correlated with Shannon diversity ($r=0.044$; $P=0.09$), Simpson diversity ($r=0.94$; $P=0.07$) and tree density ($r=0.98$; $P= 0.021$) which were calculated at 0.05 significant level.

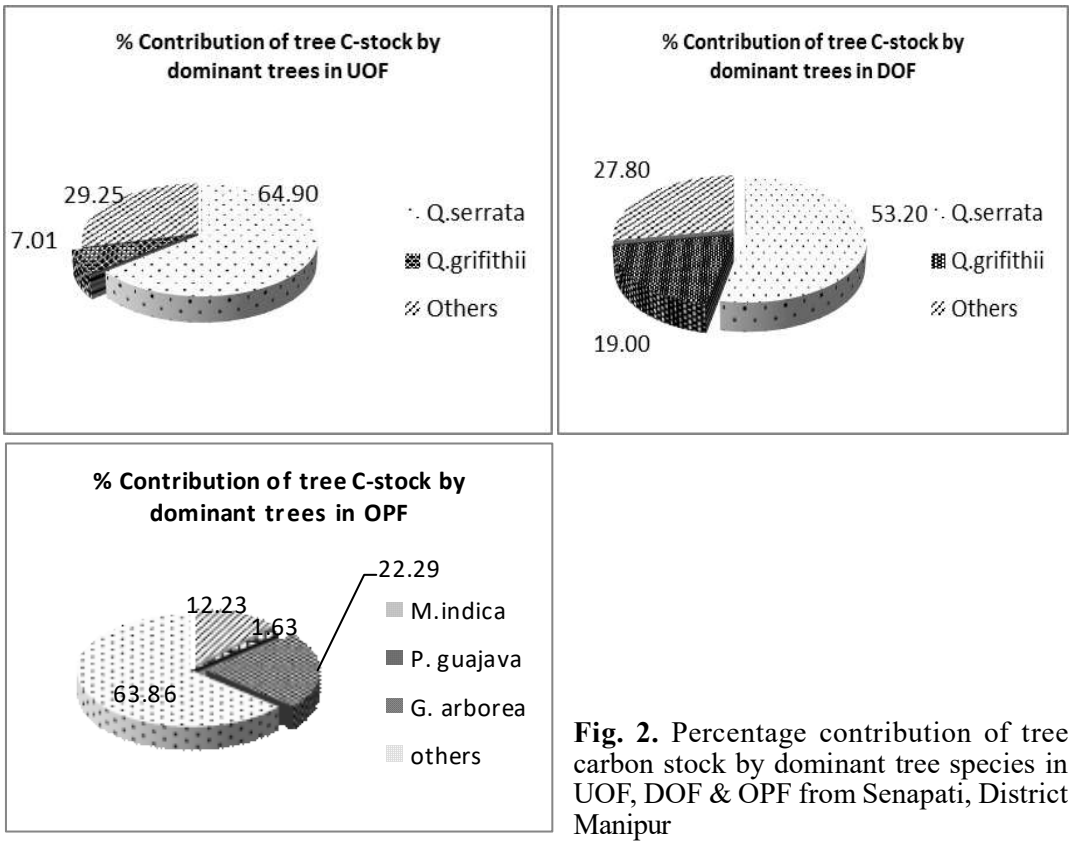

Fig. 2. Percentage contribution of tree carbon stock by dominant tree species in UOF, DOF & OPF from Senapati, District Manipur

DISCUSSION

The tree density in the present study is greater than in tropical forests of Western Ghats (446 – 1576 tree ha^{-1}) studied by Ayyapan and Parthasarathy (1999) and Ganesh *et al.* (1996). The tree basal area in present study lies in between 16 – 118 $m^2 ha^{-1}$ as reported by Kumar *et al*. (2006), greater than 6.12 – 49 $m^2 ha^{-1}$ in western Ghats reported by Reddy *et al*. (2008) and 9.47 – 42.12 $m^2 ha^{-1}$ in Barak valley of Assam by Borah and Garkoti (2011). The Shannon diversity in present study lies between 0.81 - 4.1 as reported by Parthasarathy (1999), Visalakshi (1995) and Mishra *et al*. (2000) for Indian forests. The tree carbon stock in the UOF, DOF and PPF of the present study is comparable with the non-degraded Oak forest, degraded forest and Chir Pine forest with carbon stock of forest biomass ranging between 242.56 – 290.62 tha^{-1}, 16.73 – 18.54 tha^{-1} and 81.31 – 115.40 tha^{-1} respectively as reported by Jina *et al*. (2008) in Kumuan Himalaya. The carbon stock in the present study is comparable with 591 tha^{-1} for subtropical pine forest of Manipur reported by Yadava (2010), Borah *et al.* (2013) with carbon stock 16.24 – 130.82 tha^{-1} and biomass carbon stock 138.60 tha^{-1} in pine forest reported by Aryal *et al*. (2013) in Nepal. The storage of higher carbon in pine forest emphasizes the importance of maintaining and conserving this land use type for future mitigation strategy. In DOF and OPF, the AGB and carbon stock is lesser than the value 67.40 tha^{-1} reported by Haripriya (2000) in Indian forests but its carbon stock is greater than the values 16.98 tha^{-1}, 17.12tha^{-1}, 21.66 t ha^{-1} and 20.66 tha^{-1}in different forests of India as computed by Manhas *et al*. (2006). Carbon stock in present UOF is greater than the biomass carbon stock of 103.79 t ha^{-1} in 1800 – 2100 m in Solan Forest division of Himachal Pradesh as reported by Sharma (2014). In

present study coniferous forests store higher weight of carbon per hectare than the broadleaved forest. Similar result was obtained by Sharma *et al*. (2010) in Garhwal Himalaya. Higher tree density and smaller carbon stock in OPF indicated the absence of larger girth size trees indicating a young forest. Casparsen and Pacala (2001) have pointed that there is positive relationship between productivity and species diversity. Similarly, in present study, there is positive correlation between basal area and Shannon diversity and Simpson index. A strong positive correlation was obtained between basal area and Carbon stock in all the different land use categories (Table 2) but there is negative correlation between tree density and carbon density (Sharma *et al*. 2010) in Gharhwal Himalaya which is in contrast with the present study. The dominant tree species (Figure 2) in the present study such as *Quercus serrata* Murray, *Quercus griffithii* Hook.f. & Thomson ex Miq., *Lyonia ovalifolia* (Wall.) Drude, *Gmelina arborea* Roxb., fruits trees like *Mangifera indica* L., *Psidium guajava* L. contribute maximum to the biomass and hence accordingly decide the magnitude in the carbon stock. Therefore, it is very important to understand and analyse the relationship between species diversity, tree density and carbon stock in different land uses.

CONCLUSION

Pine forest and Oak forest which are important tree species have significant amount of carbon storage in vegetation. This study suggests that avoiding deforestation and improving forest management, encouraging vast fruit trees and pine trees plantation which have the potential to fast growth are efficient in carbon storage. It is also important to analyse and understand the relationship between species diversity, tree density and carbon stock in different land uses. It can be concluded that the protected Oak dominated forest with higher density and greater basal area, Pine plantation forest which is very common in Senapati and Orchard forest which is yet to be fully mature have the potential to store large amount of additional carbon in the future.

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