

Change in Community Composition and Soil Carbon Stock Along Transitional Boundary in a Sub-Tropical Forest of Garhwal Himalaya

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Abstract

The aim of the present study was to assess the effect of transitional boundary on community composition and soil carbon stock. Five vegetation types were recognized horizontally along the transitional strip based on the dominance of tree species i.e., Pure *Anogeissus latifolia* forest (P.AL), mixed *Pinus roxburghii* and *Lannea coromandelica* forest (M.PR&LC), pure *Pinus roxburghii* forest (P.PR), mixed *Pinus roxburghii* and *Lannea coromandelica* (M.PR&LC) and pure *Anogeissus latifolia* forest (P.AL). The results revealed that *Anogeissus latifolia* was reported dominant tree in the outer transitional boundaries of the forest, which reduced dominance of trees towards middle where *Pinus roxburghii* was found dominant. The soil carbon stock was reported higher in the *Anogeissus latifolia* dominant forest and reduced with the dominance of *Pinus roxburghii* in the middle site. Both the species are growing close to one another and competing for survival, but the aggressive nature of *Anogeissus latifolia* particular in this region may change new growth of *Pinus roxburghii* and will enhance soil carbon stock. But high anthropogenic pressure on *Anogeissus latifolia* tree species could be limited chance to further its flourish.

Key Words: Transitional zone, Pure, mixed, competition, survival

Introduction

In transition zone more homogenous communities often correspond with sharp environmental and ecological gradients and depicted great influence of dominant plants on ecosystem structure, ecosystem properties and animal communities (Gosz 1993; Risser 1995).

Terrestrial carbon stocks consist of above and below ground carbon. Above ground carbon stock component includes biomass (stems, twigs, leaves, vines, epiphytes and understory) and necromass (dead trunks, standing dead trees and litter in the form of leaves, stem, twigs, flowers,

fruits and fire residues). Below ground carbon stock components are roots of live or dead plants, soil organisms and soil organic matter. Carbon stock of a land-use system is influenced by its vegetation. A land use system consisting of tree species with high wood density will have a higher biomass carbon compared to that with a low wood density and similar tree diameter.

In the sub-tropical region of Garhwal Himalaya *Anogeissus latifolia* and *Pinus roxburghii* are growing independently as pure forest but overlaps in certain areas which forms a transitional boundary/ecotone zone. In the present field study, a unique feature has been noticed in the

Received: November 14, 2012. Revised: July 25, 2013. Accepted: July 25, 2013.

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transitional boundaries of the forest, where *Anogeissus latifolia* (Bakli) and *Pinus roxburghii* (Chir pine) growing closely and forming the transitional boundary. In the transitional boundaries of present study the hypothesis was developed that: (i) Does transitional boundaries affects the community structure and distribution pattern of the species? (ii) Does changing species composition affect soil carbon stock? To test the hypothetical questions, the following objectives were selected; i) Effect of transitional boundaries on community structure and distribution pattern of species and ii) Effect of community structure change on soil carbon stock in transitional boundaries.

Materials and Methods

Study area

The study area was located between $30^{\circ} 29' N$ and $78^{\circ} 24' E$ at an elevation ranges from 700-1,000 m mean above sea level. Most of the present study area was situated towards south-west facing aspect with steep slope (Fig. 1, & Location map) climatic conditions of the area includes cold winters, very hot summers and enough rainfall in rainy seasons.

Vegetation and soil sampling analysis

A 200 m wide strip of forest was selected from the base to top along altitudinal gradient covering five different altitudes and each altitude was taken 50 m apart from each other approximately. The aim of 200 m wide strip was to cover *Anogeissus latifolia*, *Pinus roxburghii* and mixed *A. latifolia* and *P. roxburghii* forests in the transitional boundary. Five altitudinal strips were chosen along altitudinal gradient on the basis of species dominance i.e., pure *Anogeissus latifolia* forest (PAL), mixed *Pinus roxburghii* and *Lannea coromandelica* forest (M.PR.LC), pure *Pinus roxburghii* forest (PPR), mixed *Pinus roxburghii* and *Lannea coromandelica* (M.PR.LC) and pure *Anogeissus latifolia* forest (PAL).

Five quadrats (each of 10x10 m size) were used horizontally, from each forest type and repeated for five different altitudes therefore; a total of 25 quadrats were used for the vegetation analysis in entire transitional zone. Every quadrat was placed at 50 m interval horizontally and vertically both to create uniformity in data collection. Vegetation analysis of tree and shrub layers in each forest site was done on vertical transect, laid across the selected area in fixed interval to avoid biased sampling. Trees were considered to be an

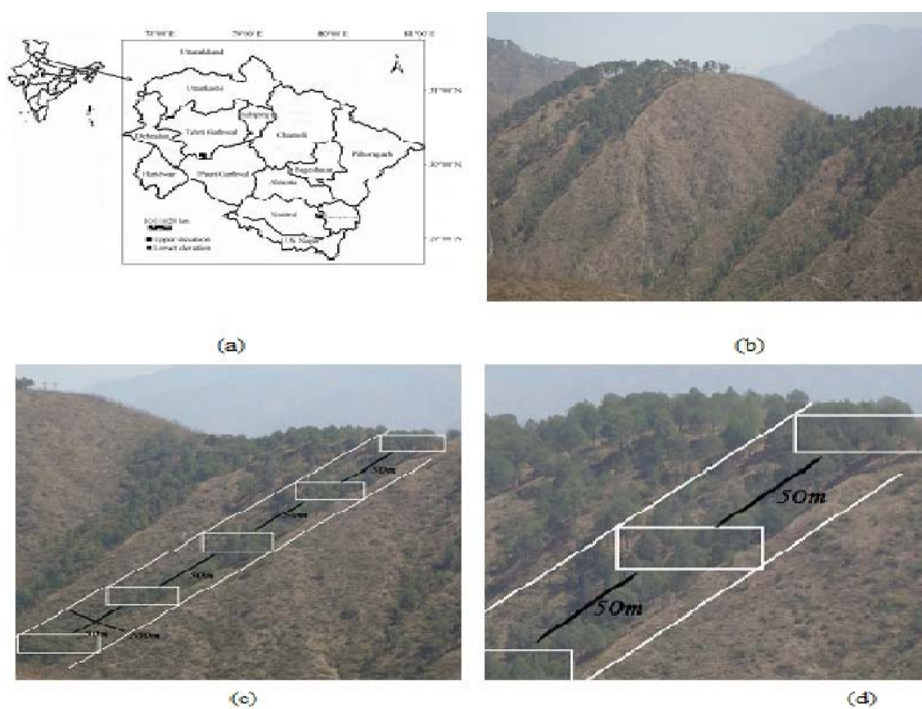


Fig. 1. Location map (a) and other site conditions (b-d) of the study area.

individuals > 30 cm cbh (circumference at breast height). The quantitative informations of vegetation were collected using methods described by Curtis and McIntosh (1950) and importance value index (IVI) as described by Curtis (1959).

The soil samples of each altitudinal strip were collected from 0-30 cm depth from each quadrat used for vegetation sampling, packed in polythene bags and brought to the laboratory for soil organic carbon analysis. Soil organic carbon was analyzed using methods of Walkley and Black (1934) and soil carbon stock was estimated with the method described by Jha et al. (2003).

Results and Discussion

Community composition along transition zone

In P.AL (site-I), *A. latifolia* was the dominant tree species with highest tree density but highest total basal cover was recorded for *Lannea coromandelica*. *Bauhinia retusa* and *Terminalia tomentosa* were found the associated species on this site. In shrub layer, *Carissa opaca* was dominant and co-dominated with *Rhus parviflora* while associated shrub species in this site were *Lantana camara*, *Murraya koenigii* and *Legrstroemia parviflora*.

In M.PR&LC (site-II) forest, the dominant tree species was *Pinus roxburghii* and co-dominated with *Lannea coromandelica*. *Anogeissus latifolia* was the third dominant species on this site. Other associated species recorded on the site were *Bauhinia retusa*, *Emblica officinalis* and *Terminalia tomentosa*. In shrub layer, again the aggressive growth was reported in *Carissa opaca* while *Rhus parviflora* and *Rhus wallichii* were associated shrub species.

In P.PR (site-III) forest, the dominant tree species was again *Pinus roxburghii* with highest values of density and total basal cover and *Terminalia tomentosa* and *Bauhinia retusa* were found the associated species. It was interesting to note that *Pinus roxburghii* increased their dominance towards pure forest and wiped out completely a growth of *Anogeissus latifolia* and *Lannea coromandelica*. Again *Carissa opaca* was dominant shrub in this forest layer but in the pure forest of *Pinus roxburghii* has emerged new shrub species of *Lanata camara* on this site. Other shrubs could not tolerate the canopy cover of the pure *Pinus roxburghii* site and no species of shrubs were reported. In M.PR&LC (site IV) forest, the

dominant tree was *Pinus roxburghii* with co-dominant tree *L. coromandelica* and least dominant tree reported was *Emblica officinalis*, again the dominance of *Pinus roxburghii* existed because of more shady conditions. In shrub layer the dominant species was again *Carissa opaca* with associated species *Rhus parviflora*, *Rhus wallichii* and new appeared species *Coolobrokia oppositifolia* and *Asparagus racemosus*. The appearance of new species on the site could be because of shady conditions on this site.

In the P.AL (site-V) forest again dominant tree was *A. latifolia* with co-dominant species *L. coromandelica*. Other associated trees were *Bauhinia retusa* and *Emblica officinalis*. In shrub layer the dominant shrub was *Carissa opaca* with other associated species i.e., *Rhus parviflora*, *Murraya koenigii*, *Woodfordia fruticosa* and *Rhus wallichii*.

Soil carbon stock along transitional zone

The soil carbon stock of P.AL was 69.60 t ha⁻¹ which reduced in M. PR.LC and reported the lowest 49.60 t ha⁻¹ in the middle zone of P.PR, which was dominated by *Pinus roxburghii* tree. It again increased in M.PR.LC forest which was 55.60 t ha⁻¹ and in the P.AL site again the value was highest compared to middle site (Table 1).

Among the forest types, highest tree density (1,250 trees/ha) was reported in P.AL (site-I), which reduced towards M.PR&LC (1,200 trees/ha) and followed by P.PR (Table 2) forest type (820 trees/ha). The reduction in tree density from outer site of transitional zone to middle site might be due to the result of toxic effect produced by *Pinus roxburghii* which reduced new growth and resulted into lower density of other species. However the density on M.PR&LC was lowest which represents narrow deep valley where the density of lower girth class trees was lower. But the density again increased in the P.AL forest as compared to M. PR&LC (site-II) because of higher density values of *Bauhinia retusa* and *Anogeissus latifolia*.

Total basal cover was found lower on both the P.AL forest (site-I and site-V) and this is because of both the transitional boundaries of forests were dominated by *Anogeissus latifolia* and such forest is under high anthropogenic pressure for the daily demand of the villagers for fodder and other needs. M. PR&LC and MP&LC vegetation types have higher total basal cover and it might be due to the mixed type of species composition which could not provide

Table 1. Density (ha^{-1}), total basal cover ($\text{m}^2 \text{ha}^{-1}$) and IVI on different forest sites in transitional boundary

Site/vegetation type	Site-I			Site-II			Site-III			Site-IV			Site-V		
	Density	TBC	IVI	Density	TBC	IVI	Density	TBC	IVI	Density	TBC	IVI	Density	TBC	IVI
Trees															
<i>Anogeissus latifolia</i>	360	4.19	72.14	280	2.61	34.83	-	-	-	-	-	-	100	2.73	65.75
<i>Laanica coromondica</i>	240	4.51	67.42	160	4.28	39.36	-	-	-	100	1.68	20.72	200	2.31	58.05
<i>Pinus roxburghii</i>	470	0.56	10.86	400	12.31	87.4	680	9.64	140.07	400	13.81	109.27	-	-	-
<i>Tomentos tomentosa</i>	180	0.33	17.15	280	0.19	16.05	40	0.32	9.72	20	0.26	6.26	300	0.10	17.04
<i>Emblicia officinalis</i>	-	-	-	40	0.19	5.74	-	-	-	20	0.20	5.93	60	0.56	16.61
Shrubs															
<i>Carissa opaca</i>	1,800	0.40	77.96	1,780	0.86	71.74	1,160	0.45	66.68	14	0.31	66.32	17.8	0.31	91.28
<i>Lantana camara</i>	120	0.01	7.95	-	-	-	100	0.02	9.06	-	-	-	-	-	-
<i>Murraya koenigii</i>	160	0.01	9.14	-	-	-	-	-	-	-	-	-	2	0.01	12.4
<i>Lagerstromisa</i>	120	0.09	7.92	-	-	-	-	-	-	-	-	-	-	-	-
<i>C. oppositifolia</i>	-	-	-	-	-	-	-	-	-	2	0.01	10.49	-	-	-
<i>Rhus parviflora</i>	420	0.44	29.45	540	0.44	31.85	240	0.19	31.4	5	0.29	29.75	2	0.12	19.71
<i>Rhus cordifolia</i>	-	-	-	100	0.006	6.5	400	0.03	25.17	4	0.01	25.11	1	0.007	8.97
<i>Syzygium cumini</i>	-	-	-	-	-	-	-	-	-	0.6	1.57	18.84	-	-	-
<i>Asparagus racemosa</i>	-	-	-	-	-	-	-	-	-	1	0.003	7.31	-	-	-
<i>Woodfordia fruticosa</i>	-	-	-	-	-	-	80	0.05	8.6	-	-	-	1	0.08	10.19

Table 2. Total density and total basal cover on different forest sites in transitional boundary

Parameter	P.AL (Site-I)	M. PR LC (Site-II)	PPR (Site-III)	M. PR LC Site-IV)	P.AL (Site-V)
Total density (tree ha ⁻¹)	1,250	1,200	820	540	660
Total TBC (m ² ha ⁻¹)	9.59	19.94	10.01	15.95	5.7
SOC (g kg ⁻¹)	17.4	16.7	12.4	13.9	16.6
Carbon stock (t ha ⁻¹)	69.60	66.80	49.60	55.60	66.40

easy accessibility to the villager and time consuming due to mixed species composition.

Between the P.AL forests (site-I and site-V), the higher value of carbon stock was reported in P.AL (site-I) which was 69.60 t/ha where the density of *Anogeissus latifolia* was higher. These results indicate that, *Anogeissus latifolia* species stocks more soil carbon than other recorded species. Similar trends were observed with other sites as soil carbon stock on site-I (P.AL) than on site-II (M.PR&LC) where density of *Anogeissus latifolia* was lower than on the site-I and again the carbon stock was lower on site-V, where the density was lower compared to site-I and site-II. The soil carbon stock on site-IV and site-III was lower because of non availability of *Anogeissus latifolia* and higher density of *Pinus roxburghii*.

Among the sites, the carbon stock of soil reduced from site-I to site-II and site-V to site-IV and lowest on site-III. Thus study suggested that carbon stock of soil increased with reducing presence of *Pinus roxburghii* and therefore highest value of carbon stock was reported where the *Pinus roxburghii* was almost absent and higher density of *Anogeissus latifolia* was recorded.

It has been reported that now-a-days *Anogeissus latifolia* is dominant on northern aspect with combination of *Lanmea coromandelica*, *Embllica officinalis* however *Pinus roxburghii* was dominant on southern aspect few years ago and now moving towards northern aspect and in some places *Pinus roxburghii* is restricted in the narrow gaze and forming transitional boundary with most of the sites which has already occupied by a *Anogeissus latifolia* in northwest, northern and eastern aspects.

It is unique to notice that wherever *Anogeissus latifolia* and *Pinus roxburghii* were growing closer, most of the areas were occupied by *Anogeissus latifolia* by replacing *Pinus roxburghii*. In the present study it has been observed that in the outer boundaries of transition zone, *Anogeissus latifolia* was dominant and no tree of *Pinus roxburghii* was reported (site-I and

site-V of P.AL forest). As we move for the vegetation analysis from the transitional boundaries towards the core sites, the density of *Pinus roxburghii* increased but here the density of *Anogeissus latifolia* was reduced. Thus the study revealed that both the forests (*Pinus roxburghii* and *Anogeissus latifolia*) are surviving intolerably. However, in the mixed site there is severe competition between the species for co-existence. In an earlier study Kumar et al. (2012) carried out a study of the same forest and reported a wider niche for *Anogeissus latifolia* (1.98) followed by *Pinus roxburghii* (1.96). Similarly in the present study soil carbon stock was also reported higher in *Anogeissus latifolia* dominant forest and reduced with the higher densities of *Pinus roxburghii*. In an earlier study Kumar et al. (2012) reported that soil organic carbon was higher in *Anogeissus latifolia* and reduced with the mixed forests of *Anogeissus latifolia* and *Pinus roxburghii*, both of these forests are still competing for the survival and follow the law of competitive exclusion principle which indicates that between the species competing for the resources in same place cannot co-exist for a longer period and one has to eliminate from the competition in due course of time. Thus the wider niche of *Anogeissus latifolia* may have chance to occupy the whole resources of *Pinus roxburghii* forests in future. Although the certain factors may retrieve the condition and also finish the *Anogeissus latifolia* forest from this area. Kumar et al. (2010) have reported that all the associated tree species of *A. latifolia* forests in this forest are severely lopped by the villagers for various purposes i.e., fuel, fodder, timber etc. However, relative lopping intensity among the species was significantly higher for *A. latifolia* (45 to 57%). Thus lopped whole branches may stop further regeneration of the species.

Conclusions

The study concluded that if both the species i.e.,

Anogeissus latifolia and *Pinus roxburghii* follow the law of competitive exclusion principle, one has to eliminate from the transitional boundary and only second will survive. In an earlier study, author revealed a wider niche of *Anogeissus latifolia* and species might have good chance to occupy the area of *Pinus roxburghii* in due course of time but it may also retrieve the condition if the high resource pressure remains continued on *Anogeissus latifolia* and such conditions increase the chances of the replacement of *Anogeissus latifolia* from the study site.

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