

# Growing Stock and Regeneration Status Assessment in Thinned and Un-thinned Stands of Community Managed Pine Plantation



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## Abstract

The forests of Nepal are experiencing new forest management practices in the recent scenario. Silvicultural treatments such as thinning have been practiced over the years; however, proper thinning according to the thinning guidelines has recently been introduced to most of the community forests in Nepal. Thus, this research was carried out to assess and compare the growing stock and regeneration status in thinned and un-thinned stands of three different community forests in Sindhupalchowk, Nepal. Moreover, the species richness was also evaluated. Total 30 circular sample plots having an area of 100m<sup>2</sup> were established in each of the community forests to perform forest resource inventory. Statistical tests such as independent samples t-test and Mann-Whitney U test were applied for analysis and comparison of growing stock and regeneration status between thinned and un-thinned stands.

In Sansari Danda Community Forest, there were 554stems/ha in un-thinned stand which was significantly more in comparison to 312stems/ha in thinned stand. Also, the total volume of trees in un-thinned stand were 210m<sup>3</sup>/ha, however it was only 148m<sup>3</sup>/ha in the thinned stand. Although, 12,867 seedlings/ha were found in the un-thinned stand of Sansari Danda, it was less in comparison to 14,000 seedlings/ha in thinned stand of the same community forest. This research illustrates the effect of thinning on pine plantation. Therefore, it will be helpful tool for scientific community and decision makers who are involved in forest management and silviculture science.

**Keywords:** Thinning, growing stock; Regeneration; Community forest; Pine forest

## Introduction

Forest management intends to create stability between biodiversity conservation and sustainability of livelihood [1]. These environmental and economic goals can only be achieved by the application of silvicultural treatments such as thinning. Thinning, defined as the reduction of trees in an immature stand for the purpose of improving growth and form of residual trees without permanently breaking the canopy [2], has been applied time and again to manage the dense and overstocked stands. It can also be used in attaining other objectives such as varying the species composition, disturbing an established ground flora to enhance opportunities for natural regeneration [3], reducing above and below ground plant competition among residual trees [4] and reducing fire hazard and stand mortality [5].

Thinning of the trees has observed to have great effect on the regeneration and growing stock of trees. Growing stock can be defined as the volume over bark of all living trees with a minimum diameter of 10cm at breast height [6]. According to

Hunt et al. [7], there is inverse impact of stocking density (trees/ha) on the growth of the trees; and only possible way to maintain normal growing stock is silvicultural treatments like thinning. Moreover, thinning is supposed to have induced regeneration in the plantation forests. However, heavy thinning might cause immediate decrease in the understory vegetation [8] since there may have substantial ground disturbances during thinning operation [9]. If the aim of management is to gradually convert into broadleaved forest, coniferous are thinned out to promote the broadleaves [10].

Pine plantation holds a three-decade long history in the mid-hills of Nepal namely in Sindhupalchowk and Kavrepalanchowk district. Forestry in Nepal has been circumscribed to protection, plantation and to some extent thinning, pruning, fodder and grass cutting [11,12]. However, recently some silvicultural operations are being implemented to manage those planted pine forests. The pine forest is generally established in the degraded soil

which makes regeneration a challenging issue [13]. The seeds germinate under moderately dense canopy and mortality of seedlings is high in open canopy as well. Nevertheless, reduction in the canopy density of mature stands promotes seedling growth [14]. Moreover, in the past the forests were found to

be overstocked due to the lack of silvicultural operations like thinning itself. In this context, this research assesses growing stock and regeneration status in newly thinned stands and compare the same parameters with un-thinned stands in order to address the effect of thinning.

**Materials and Methods**

**Study area**

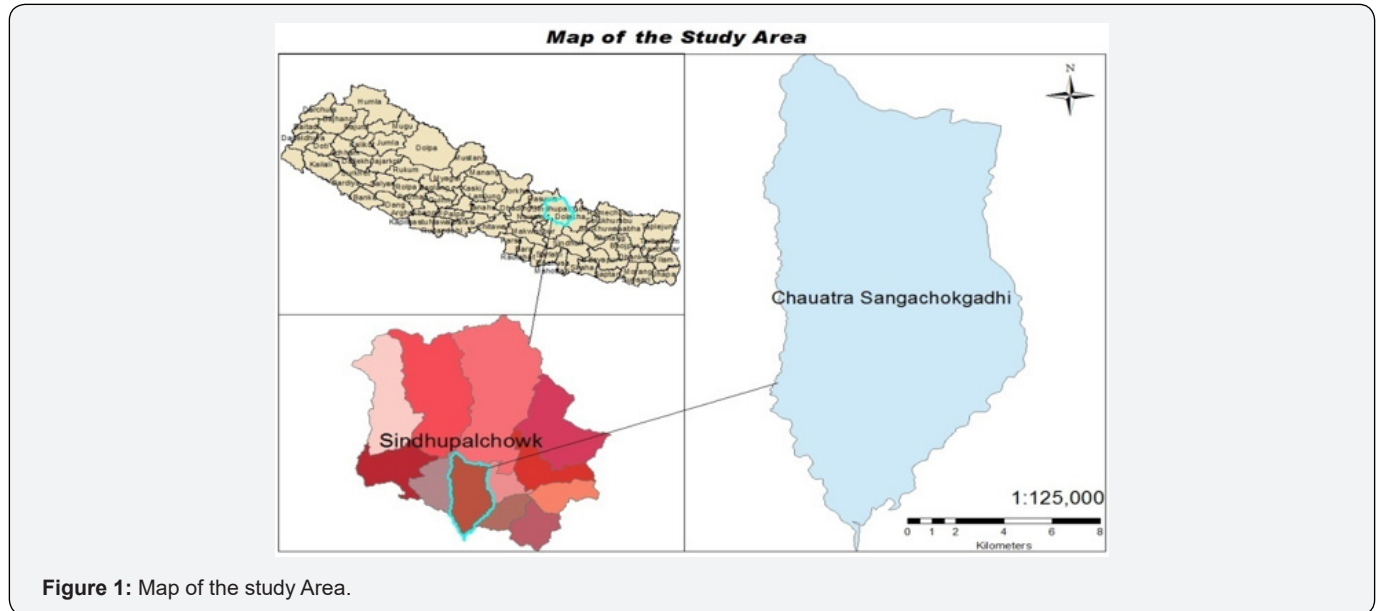


Figure 1: Map of the study Area.

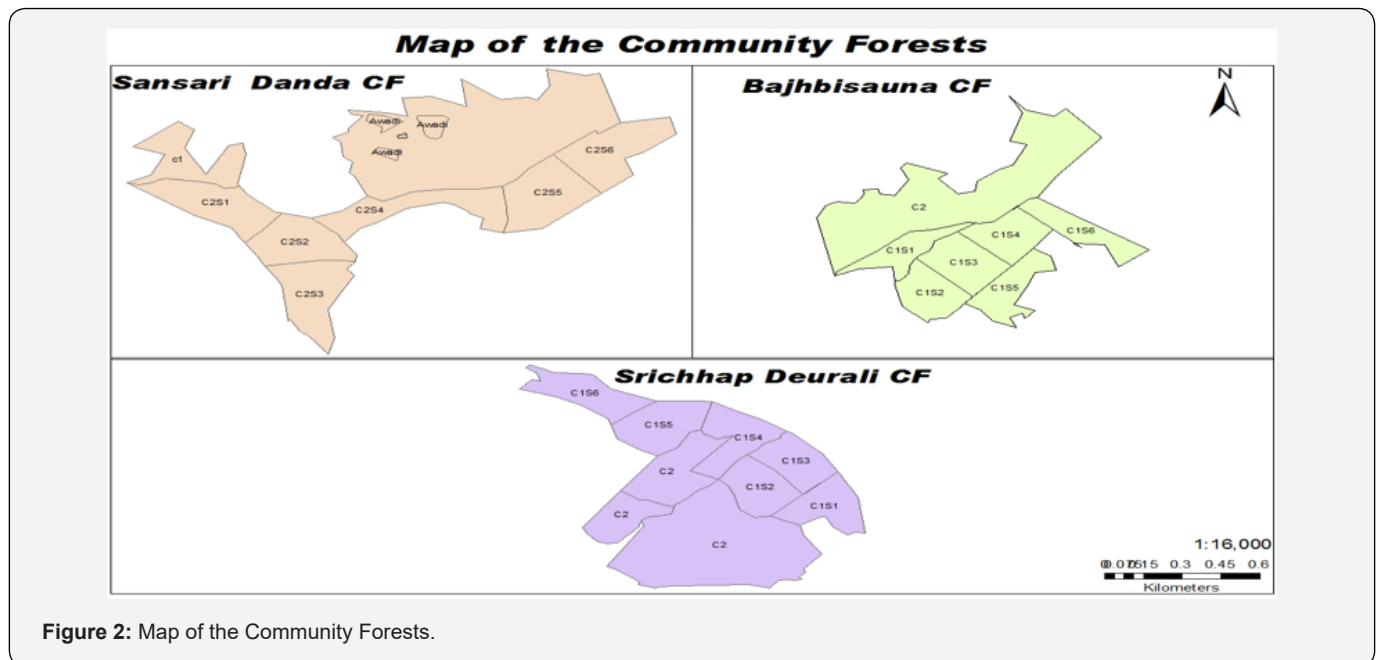


Figure 2: Map of the Community Forests.

Sindhupalchowk, a part of Province No. 3, has total forest area of 77567ha. There are in total 518 community forest user groups and the total land occupied by community forest is 29,056ha in which pine plantation is the most prevalent (13,000ha). Three community forests (CF) namely, Sansari Danda, Srichhap and Bajhbisauna were taken as study site. In

all three community forests, pine species like *Pinus roxburghii* and *Pinus patula* are dominant. The poles of *Schima wallichii* are prevalent in all three community forests. Other tree species like *Rhododendron arboreum*, *Lyonia ovalifolia* and *Myrica esculenta* are also established (Figure 1 & 2).

### Sampling process

The digital map of the study area was extracted from GIS. The already stratified thinned and un-thinned stands having equivalent areas were chosen from operational plan of Community Forests. After that, the number of sample plots was allocated using Geographical Information System. Altogether, 90 samples were collected from three CFs. Moreover, 15 circular plots were established in each thinned and un-thinned stand of three community forests. The sample plot size for trees and poles was taken as 100m<sup>2</sup> with radius of 5.64m, for saplings 25m<sup>2</sup> with radius of 2.82m and for seedlings 10m<sup>2</sup> with radius 1.78m.

### Measurement and recording

For the calculation of growing stock, diameter at breast height (DBH) and height were directly measured using diameter tape and range finder respectively. Moreover, the numbers of stems (DBH>10cm) in each plot were counted. For the regeneration assessment, all the species in regeneration layer were counted.

### Data analysis

Growing stock includes basal area, volume and stem densities which were calculated using following forest mensuration formula:

- a) Basal Area (BA)= DBH<sup>2</sup>\*π/4
- b) Volume= Basal area\*height\*form factor
- c) Stem Density= No. of stems (DBH>10cm)/Area(ha)

Parametric test such as Independent-samples t-test and non-parametric test such as Mann-Whitney U test was performed to analyze data.

### Results

The results of the findings indicate that stem density, volume and regeneration status varied in thinned and un-thinned stands of different community forests.

### Comparison of growing stock (stem density and volume) in thinned and un-thinned stands of community forests

The result in Sansari Danda community forest shows that the stem density was more in un-thinned stand i.e. 554 stems/ha than the thinned one i.e. 312 stems/ha. Moreover, the application of Independent samples t-test showed that there was significant difference (P=0.001) in overall stem density in thinned and un-thinned stands at 5% level of significance. Similarly, the total volume of trees and poles were greater in un-thinned stands (210.8m<sup>3</sup>/ha) in comparison to thinned one (148m<sup>3</sup>/ha). However, the application of Mann-Whitney U test showed that the overall volume per hectare did not differ significantly (P=0.443) at 5% level significance in between thinned and un-thinned stands of Sansari Danda Community Forest.

In Srichhap Deurali Community Forest, the total stem density was found to be more in un-thinned stand i.e. 494stems/ha in comparison to thinned stand i.e. 446stems/ha which were not significant (P=0.513) statistically. The volume occupied by trees and poles in thinned stand was 238m<sup>3</sup>/ha which was greater in comparison to volume occupied by trees and poles in un-thinned stand i.e. 227.38m<sup>3</sup>/ha without any significant differences (P=0.694).

In Bajhbisauna community forest, the result depicts that the total stem density was found to be higher in un-thinned stand i.e. 452stems/ha than the thinned stand i.e. 320stems/ha of Bajhbisauna CF. The application of Mann-Whitney U test showed that there were significant differences (P=0.016) in overall stem density at 5% level of significance between thinned and un-thinned stands of pine forest. The volume occupied by plants was maximum in un-thinned stands (287.45m<sup>3</sup>/ha) in comparison with the thinned stands (150.93m<sup>3</sup>/ha) which was statistically insignificant (P=0.23) (Table 1).

**Table 1:** Summary of plant density and volume in thinned and un-thinned stands of Community Forests.

Community Forests (CF)	Stands	Growing Stock	DBH Classes				Overall Classes
			< 20cm	20-30	30-40	Above 40	
Sansari Danda	Un-thinned (Area=8.8ha)	Stem Density (N/ha)	267	167	93	27	554
		Volume (m <sup>3</sup> /ha)	17.23	63.83	86.57	43.15	210.18
	Thinned (Area= 8.35ha)	Stem Density (N/ha)	93	133	73	13	312
		Volume (m <sup>3</sup> /ha)	10.48	62.62	57.36	17.55	148
Srichhap Deurali	Un-thinned (Area=7.29ha)	Stem Density (N/ha)	207	167	80	40	494
		Volume (m <sup>3</sup> /ha)	16.12	76.97	73	61.29	227.38
	Thinned (Area=7.26ha)	Stem Density (N/ha)	153	73	200	20	446
		Volume (m <sup>3</sup> /ha)	15.02	29.91	165	28	238
Bajhbisauna	Un-thinned (Area=3.95ha)	Stem Density (N/ha)	155	88	142	67	452
		Volume (m <sup>3</sup> /ha)	11.69	38.84	122.41	114.51	287.45
	Thinned (Area=4.76ha)	Stem Density (N/ha)	114	73	120	13	320
		Volume (m <sup>3</sup> /ha)	11.9	26.56	94.48	17.99	150.93

(Source: Field Survey, 2018).

**Comparison of regeneration status in thinned and un-thinned stands of different community forests**

In Sansari Danda Community forest, it was found that the number of seedlings per ha in the un-thinned stand were 12,867, lesser than the seedlings per hectare in thinned stand i.e. 14,000 (Table 2). The statistical analysis shows that there was no

significant difference (P=0.819) in number of seedlings at 5% level of significance between thinned and un-thinned stands as they differ by very few margins. Similarly, the number of saplings per hectare was also found to be more in thinned stand i.e. 773 saplings/ha whilst it was found to be 294 saplings/hectare in un-thinned stands which were significantly different (P=0.003).

**Table 2:** Regeneration status of un-thinned and thinned stands of Sansari Danda CF.

Seedlings Status				Sapling Status			
Un-thinned Stand (C2S6) Area: 8.8ha		Thinned Stand (C2S2) Area: 8.35ha		Un-thinned Stand (C2S6) Area: 8.8ha		Thinned Stand (C2S2) Area: 8.35ha	
Species	Density(N/ha)	Species	Density (N/ha)	Species	Density(N/ha)	Species	Density (N/ha)
<i>Lyonia ovalifolia</i>	267	<i>Lyonia ovalifolia</i>	1,067	<i>Schima wallichii</i>	160	<i>Schima wallichii</i>	320
<i>Emblica officinalis</i>	67	<i>Emblica officinalis</i>	667	<i>Rhododendron arboretum</i>	53	<i>Pinus species</i>	453
<i>Schima wallichii</i>	1,000	<i>Schima wallichii</i>	5,133	<i>Litsea monopetala</i>	27		
<i>Myrica esculenta</i>	267	<i>Pinus spp</i>	4,400	<i>Myrica esculenta</i>	27		
<i>Castonopsis indica</i>	733	<i>Endosperma chanensis</i>	1,133	<i>Endosperma chanensis</i>	27		
<i>Pinus sps</i>	7,267	<i>Litsea monopetala</i>	933	Total	294	Total	773
<i>Endosperma Chanensis</i>	1,000	Others	667				
<i>Mahua longifolia</i>	933						
<i>Litsea monopetala</i>	467						
<i>Rhododendron arboreum</i>	467						
Others	399						
Total	12,867		14,000		294		773

(Source: Field Survey, 2018).

In Srichhap community forest, the result shows that the number of seedlings per hectare in the un-thinned stand of Srichhap Community Forest was 2,667 while the number of seedlings per hectare in thinned stand was 2,933. It further concludes that thinning is having positive impact on the forest regeneration. On the other hand, the statistical analysis

shows that there was no significant difference in seedling status (P=0.533) between thinned and un-thinned stands. The number of saplings was found to be more in un-thinned stand i.e. 346saplings/ha whilst it was found to be 213 saplings/hectare in thinned stand; the result was statistically insignificant (P=0.147) (Table 3).

**Table 3:** Regeneration status of un-thinned and thinned stands of Srichhap Deurali CF.

Seedlings Status				Sapling Status			
Un-thinned Stand(C1S2) Area: 7.29ha		Thinned Stand (C1S1) Area: 7.26ha		Un-thinned Stand(C1S2) Area: 7.29ha		Thinned Stand (C1S1) Area: 7.26ha	
Species	Density(N/ha)	Species	Density (N/ha)	Species	Density(N/ha)	Species	Density (N/ha)
<i>Schima wallichii</i>	1333	<i>Schima wallichii</i>	2133	<i>Schima wallichii</i>	213	<i>Schima wallichii</i>	213
<i>Castonopsis indica</i>	200	<i>Castonopsis indica</i>	200	<i>Lyonia ovalifolia</i>	80		
<i>Litsea monopetla</i>	267	<i>Litsea monopetala</i>	133	Others	53		

<i>Lyonia ovalifolia</i>	267	Others	467				
<i>Phyllanthus emblica</i>	67						
<i>Pinus sps</i>	67						
<i>Alnus nepalensis</i>	133						
Others	333						
Total	2,667		2,933	Total	346		213

(Source: Field Survey, 2018).

In Bajhbisauna community forest, the number of seedlings/ha in the un-thinned stand was 8,200 which is less than the seedlings/ha in thinned stand i.e. 9,800 with no significant difference (P=0.720) at 5% level of significance. The number of

saplings per hectare was found to be more in un-thinned stand i.e. 533saplings/ha while it was found to be 160saplings/ha in thinned stand with no significant difference (P=0.07) at 5% level of significance (Table 4).

**Table 4:** Regeneration status of un-thinned and thinned stands of Srichhap Deurali CF.

Seedlings Status				Sapling Status			
Un-thinned stand (C1S1) Area: 3.95ha		Thinned stand (C1S2) Area: 4.76ha		Un-thinned stand (C1S1) Area: 3.95ha		Thinned stand (C1S2) Area: 4.76ha	
<i>Schima wallichii</i>	1533	<i>Lyonia ovalifolia</i>	600	<i>Schima wallichii</i>	160	<i>Schima wallichii</i>	160
<i>Castonopsis indica</i>	1200	<i>Emblica officinalis</i>	67	<i>Myrica esculenta</i>	133		
<i>Mahua longifolia</i>	267	<i>Schima wallichii</i>	3600	<i>Castonopsis indica</i>	53		
<i>Pinus sps</i>	1067	<i>Myrica esculenta</i>	533	<i>Pinus species</i>	107		
<i>Myrica esculenta</i>	600	<i>Castonopsis indica</i>	867	<i>Rhododendron arboretum</i>	80		
<i>Rhododendron arboretum</i>	133	<i>Pinus sps</i>	267	Total	533		160
<i>Endospermachanensis</i>	3400	<i>Endospermachanensis</i>	3133				
		Others	733				
Total	8,200	Total	9,800				

(Source: Field Survey, 2018).

## Discussion

### Variation in growing stock of thinned and un-thinned stands of pine plantation

From the study carried out in three community forest, the result illustrates that the stem density was higher in the un-thinned stands of all three CFs than thinned stands and statistically significant as well. These results of this report regarding stem densities of stands are in line with the previous results. In a study carried out by Lin et al. [15], the stand densities for each stand after thinning in the same year decreased significantly for both medium and heavy thinning. Moreover, L.S. Khanna in his book Principles and Practices of Silviculture, 2011, has rightly mentioned that thinning reduces the number of trees, which this study justifies. The result is similar in study carried out by Harrod et al. [16] to examine the response of thinning to insect outbreaks where thinning modified the forest structure by reducing the overall stocking by less than fifty percent. The

average stocking density in the un-thinned stands of planted pine forest was medium (500stems/ha) while it was 360trees/ha (medium) in thinned stands as per [17].

Moreover, the volume per hectare was found to be more in un-thinned stands in two of the community forests (Sansari Danda and Bajhbisauna) but not in the third (Srichhap). In Srichhap, the volume per hectare was found to be more in un-thinned stand most probably due to presence of maximum number of trees having good height and DBH 30-40cm with volume 165m<sup>3</sup>/ha. However, there were no significant differences in volume per hectare in any of the community forest sampled. According to thinning hypothesis, thinning does not affect the volume growth of stands significantly for a wide range of stocking densities [18]. The effect of thinning on volume of stand is strongly site dependent but heavy thinning usually reduces in growth of volume growth in comparison to un-thinned stands growing on similar site conditions [19], the result being like this research.



## Variation in regeneration status of thinned and un-thinned stands of pine plantation

The report on Douglas- Fir clearly indicates that average seedling density was significantly higher in thinned stands (1433/ha) than the un-thinned stands (233/ha) [20]. However, in this research, the numbers of seedlings were not significantly different in any of the CFs-- the main reason assumed being time factor. The Douglas-Fir report was published on 1998 whereas the thinning was done in 1969-1984, at least after 10-24 years, which clearly indicates that for the proper result regarding the effects of thinning, time factor is essential. Similarly, the numbers of saplings were found to be significantly different in only one Community forest (Sansari Danda) and not in other two.

Utsugi et al. [21] noted that thinning creates species diversity in conifer plantation sooner and with more consistency. However, in this research more species richness was seen in un-thinned stands. The result also indicates that many broadleaved species like *Schima wallichii*, *Endosperma chanensis*, *Myrica esculenta*, *Castanopsis indica* and *Rhododendron arboreum* were emerging in the planted forest. In a research carried out by Thomas et al. [22], thinning was found out to be an effective option to create species diversity in the regeneration layer. In this study, the seedlings and saplings of *Schima wallichii* were in maximum number in the thinned stands which might be the effect of thinning.

## Conclusion

The study shows that the stem density is significantly higher in the un-thinned stands of community forests than the thinned one. Moreover, the *Schima wallichii*'s stem density was more prevalent in DBH class 10-20cm which illustrates that the forest is progressively changing into broad leaved. The volume of trees and poles are also found to be more in un-thinned stands. Similarly, the number of seedlings per hectare is more in thinned stands, the statistical difference being insignificant. The numbers of saplings are more in un-thinned stands; nevertheless, they are not significantly different. The most widespread sapling found in all three community forests is *Schima wallichii* followed by *Pinus species*. Moreover, there is more species richness in the un-thinned stands. More researches should be carried out every year to represent the annual effect of thinning as most of the results are not significant at present. Similarly, it is recommended that thinning should be carried out annually in different compartments to promote regeneration as well as to maintain normal growing stock.

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