

Structural and Functional Aspects of Sal (*Shorea robusta* Gaertn. f.) Forests in Kanha Tiger Reserve (KTR)

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Abstract

Shorea robusta is threatened these days due to sal borer attack, sal mortality, poor regeneration potential, edapho-climatic changes and various biotic interferences. No systematic attempts were made in India, to understand dynamism of its natural regeneration and to suggest management inputs to encourage its regeneration. The present study deals with the natural regeneration with particular reference to crop composition and community structure in Kanha Tiger Reserve in India. The results indicated that the average number of regeneration of sal seedlings per hectare worked out to be 1557 in core zone, 3446 in buffer zone and 7137 in in phen wild life sanctuary which are quite adequate. The distribution pattern of individuals of *Shorea robusta* trees in different girth classes was also seemed to be uninterrupted in most of the stands studied. This trend of uninterrupted distribution of *Shorea robusta* in different growth phases with plenty of established regeneration is the healthy sign of establishment and growth of *Shorea robusta* crop in the past in this area.

Keywords: Natural regeneration, stand structure, crop composition, distribution, phyto-sociology.

1. Introduction

Sal is the most important timber species and has high production potential in the forest of Madhya Pradesh. The Kanha Tiger Reserve is falling in the district of Mandla and Balaghat. It lies within the Maikal hills, situated between the Mahadev hills of Pachmarhi and Chhota Nagpur. Area of core zone (National Park) is 940 sq km. and that of the buffer zone is 1009 sq. km. The area of Phen Wildlife Sanctuary is 110 sq. km. In Core Zone of Kanha Tiger reserve, sal forest is mostly occurring in 5 forest ranges namely Kanha, Kisli, Bhisanghat, Mukki and Supkhar. The Phen Wildlife sanctuary also comes under Core Zone. In buffer sal occurs in ranges namely Khatia, Sighora, Garhi, Samnapur, Khapa. Topographically, most of the sal forest of this area is found in undulating plains, foothills and plain habitats. Sal forest of this area was under sal borer infestation (*Hoplocerambyx spinicornis*) from time to time. During 1997-98, epidemic of sal borer occurred over large forest of Madhya Pradesh, including Kanha Tiger Reserve.

Scattered information is available in literature on status of *Shorea robusta* regeneration in relation to soil pH (Gupta, 1953), accumulation of leaf litter in moist forests (Champion and Seth, 1968) damage by wild animals (Sirkar, 1954), effect of grazing closure (Chaubey and Jamaluddin, 1989), Shrubby growth and ground flora richness (Khan and Gupta, 1960). Srivastava (1963) studied phyto-sociological studies of *Shorea robusta* forests in U.P. with special reference to regeneration. Dabral *et.al.* (1980) studied micro-climatic variations in naturally regenerating *Shorea robusta* forest in West Dehradun. They advocated that temperature and moisture regimes of the surface soil are related with mortality of *Shorea robusta* seedlings. Jha and Pandey (1980) studied the comparative

loss of soil moisture during decomposition of leaf litter in Poplar, *Eucalyptus*, Chir, Teak and *Shorea robusta* and suggested that moisture loss is least in *Shorea robusta* as compared to other species. No systematic attempts were made in India, to understand dynamism of natural regeneration of *Shorea robusta* and to suggest management inputs to encourage its regeneration, particularly in M.P. The natural regeneration aspect received very little attention with particular reference to crop composition and community type. Ecology of natural regeneration of *Shorea robusta* with special reference to crop composition and community types was attempted by Khan and Gupta (1960) in Dehradun Valley. After Champion and Seth (1968), Sal forests of Tiger Reserve are falling under following three categories –

1. Moist peninsular high-level sal - 3C/C₂e (i)
2. Moist peninsular low-level sal - 3C/C₂e (ii)
3. Moist peninsular valley sal - 3C/C₂e (iii)

The present paper contains the status of sal regeneration and standing crop of sal in Kanha Tiger Reserve including core zone, buffer zone and Phen Wild life Sanctuary.

2. Materials and Methods

In order to assess the status of sal regeneration and standing crop, total 40 compartments out of total 602 compartments (including mixed forest and sal forests) were studied in KTR adopting standard survey methods. The list of compartments including sal forests and mixed miscellaneous forests of the KTR (core zones, buffer zone & Phen WLS) is given in Table-1. In all, more than 10% of the total sal bearing compartments were selected systematically from the list of total compartments of the tiger reserve covering both sal forests and mixed forests. The latitude and longitude of the center point of the compartment were noted with the help of GPS, and the sample plot of 0.1 ha was laid in the center of the compartment. The regeneration status of sal and other associates were studied using standard methods (Mishra, 1989; Philips, 1959) and also approved for the working plans of the state of Madhya Pradesh.

The phytosociology of tree vegetation studied in each sample plots for determining the crop composition, stand structure and dominance of tree species in the community. In order to represent the population structure of each species and to determine the distribution pattern of density of different tree species following GBH classes were established (Ralhan *et. al.* 1982).

Class	Range in gbh/cbh (cm)
A	0-10 (Seedlings)
B	> 10-20 (Saplings)
C	> 20-40
D	> 40-60
E	> 60-80
F	> 80-100
G	> 100-120
H	> 120-140
I	> 140-160
J	> 160-180
K	> 180-200 and above

The total number of individuals belonging to above girth classes was computed for each species. The database is useful for determining the trend of establishment and growth of each species. The number of individuals in each girth class, for each species,

was divided by the total number of individuals in all girth classes of that species. The resultant value was multiplied by 100 to yield per cent density for each girth class for each species.

Table 1. Compartment Wise Details of Different Forests of Kanha Tiger Reserve

S. No.	Range	Circle	Comptt. No.	Area (ha)
1	Kanha	Bamhnidadar	737, 738, 739, 745, 746, 747, 763, 764, 736, 741, 742, 734, 735, 740, 743, 744, 761, 759, 760, 762	4911.88
		Bhilwani	680, 723, 724, 681, 715, 716, 721, 722, 753, 674, 676, 678, 720, 679, 682, 668, 677, 669, 675	6100.61
		Chandan	709, 710, 713, 714, 754, 755, 637, 638, 647, 636, 673, 704, 705, 702, 703, 707, 708, 706, 717, 718, 719	4445.05
		Jhapul	726, 727, 725, 729, 730, 731, 732, 733, 685, 728	3165.04
		Kanha	765, 766, 699, 700, 701, 772, 773, 774, 711, 712, 756, 757, 758, 748, 749, 750, 751, 752, 770, 771, 784, 767, 768, 769	4608.95
		Kariwah	655, 657, 670, 671, 672, 648, 649, 660, 661, 662, 663	3527.23
2.	Supkhar	Jaglikheda	583, 582, 584, 593, 585, 586, 587, 576, 577, 578, 588, 589, 590, 580, 581	4398.92
		Patua	199, 208, 209, 210, 214, 215, 216, 202, 200, 201, 195, 196, 197, 198, 182, 211, 212, 213	5686.14
		Piparwada	219, 598, 599, 600, 204, 205, 218, 192, 193, 194, 203, 591, 592, 594, 579, 595, 596, 597, 206, 207, 217	5937.04
		Supkhar	148, 149, 166, 172, 173, 187, 188, 189, 165, 174, 175, 181, 183, 184, 185, 186, 146, 147, 167, 168, 169, 170, 171, 190, 191	6655.82
3.	Kisli	Ghanghar	775, 780, 781, 690, 793, 794, 797, 789, 790, 791, 798, 782, 783, 785, 786, 691, 795, 796, 787, 788, 792	5164.37
		Kisli	695, 696, 697, 693, 694, 777, 698, 776, 778, 779, 634, 635, 633, 692	3769.26
		Sondar	642, 643, 650, 654, 632, 640, 645, 646, 652, 653, 639, 641, 644, 651	4961.95
4.	Bhaisanghat	Adwar	98, 99, 101, 155, 159, 160, 119, 154, 156, 82, 102, 100, 157, 158	5970.04
		Garhi	103, 107, 108, 110, 111, 75, 104, 105, 106, 109	4543.15
		Kugaon	117, 118, 115, 116, 113, 114	2163.04
		Sukdi	153, 164, 161, 162, 178, 176, 177, 163, 97, 179, 152, 96, 180	4635.68
5.	Mukki	Khapa	10, 11, 6, 7, 31, 8,30, 26, 27, 29, 9, 28, 1, 2, 3, 32, 4, 5	4366.95
		Mukki	14, 15, 17, 12, 13, 25, 18, 19, 20, 22, 62, 63, 23, 24, 48, 16, 21, 64	5330.11
		Samnapur	66, 112, 69, 70, 73, 74, 71, 72, 65, 67, 68	3603.06

S. No.	Range	Circle	Comptt. No.	Area (ha)
6.	Phen Sanctuary	Jhurgidadar	505, 506, 512, 503, 504, 516, 445, 513, 514, 515, 446, 447, 449, 450	4030.65
		Khudrahi	493, 501, 502, 494, 499, 500, 520, 521, 523, 517, 518, 519	3537.20
		Sajalagan	471, 491, 492, 488, 489, 490, 451, 452, 510, 507, 508, 509, 511, 484B, 485B	3502.60
7.	Khatia	Khatia	346, 347, 768, 769, 353, 354, 355, 767, 799, 800, 352, 348, 796, 797, 798	3681.92
		Aroli	344, 345, 765, 766, 343, 770, 771, 772	2267.71
		Kariwah	338, 340, 341, 342, 336, 337, 339, 335, 349, 740	3535.43
8.	Sijhora	Magdha	350, 351, 738, 739, P1280 P1281	1378.46
		Majhipur	664, 665, 666, P1278, P1279, 667, 679A, 683A, 683B, P1282, P1283, P1284, P1285, P1295B	2403.90
		Sijhora-I	P1296, 557, 558, 684, 681A, 682A, P1286, P1287A, P1287B, P1288, P1289, P1291A, P1291B, P1292, P1293, P1294, P1290	2751.70
		Sijhora-II	562, 563, P1256, P1257, P1258, P1259, P1160, 561, 564, 565, 566, P1150, P1154, P1151, P1153, P1155	2648.63
9.	Garhi	Motinala	P1364, P1365A, P1365B, P1366, 538A, 538B, 537A, 537B, 536A, 536B, 539A, 539B, 424A, 424B, 424C, 429A, 429B, 535A, 535B, 430A, 430B, 138, 140, 141, P1147, P1148, P1149, P1152, 567, 568, 569, 570	4678.82
		Murkuta	135, 139, 142, 571, 572, 573, 574, 575, 133, 134, 143, 144, 145, 132, 130, 131	5233.10
		Garhi	136, 137, P1144, P1145, P1146, 120, 121, 127, P1135, P1136, P1137, P1134, 122, 123, 124, 150, 151, 125, 126, 128, 129, P1138, P1139, P1140, P1141, P1142, P1143	5201.65
10.	Samnapur	Akalpur	84, 85, 86, 87, 81, 83, 1110, 1113, 1114, 79, 80, 1109	3157.99
		Pandrapani	76, 77, P1122, P1123, P1124, 78, 88, 89, P1121, P1120, P1125, P1129, P1130, P1131, P1132, P1133	2432.06
11.	Khapa	Kareli	P1057, P1058, P1064, P1065, P1062, 47, 46, 45, P1060, P1059, P1054, P1053, P1061, 53, 54, P1051, P1052, 49, 50, 51, 52, P1050, 40, 44, P1055, P1056	4083.61
		Khapa	41, 42, 43, P1047, P1048, 33, 34, P1037, P1044, P1045, P1046	1854.87
		Sarekha	P1032, P1033, P1034, P1035, P1036, P1038, P1042, P1039, P1040, P1041, P1043, P1049	993.09
Total				151317.70

3. Results

3.1. Core Zone of Kanha Tiger Reserve

3.1.1. Population structure of standing crop in core zone: The status of standing crop of sal and its associates, pertaining to crop composition, density of standing trees per ha, percent composition of sal and its associates in different girth classes, current status of borer infestation etc. In the compartments studied in different ranges of Kanha Tiger Reserve is described in Table-2. The growth phase of sal showed uninterrupted trend of regeneration from saplings to mature stage. Other associates like *Syzygium cumini*, *Terminalia tomentosa*, *Diospyros melanoxylon*, *Emblica officinalis*, *Lagerstroemia parviflora*, *Ougeinia dalbergioides*, *Schleichera oleosa* and *Semecarpus anacardium* also showed uninterrupted trend of regeneration from sapling to mature stage. This is the good indication of establishment and development of sal and other associates. Besides these species, other species (Table -2) showed interrupted trend of growth and need conservation strategies for development of their population structure in the ecosystem. These species require detailed study on reproductive biology and eco-silvicultural requirements at different growth stages.

Table 2. Population Structure of Different Trees Species in Various Girth Classes with Percent Density in Core Zone of Kanha Tiger Reserve (KTR)

S. No.	Species	Trees per ha in different girth classes (cm) / Percent Density									
		>10-20	>20-40	>40-60	>60-80	>80-100	>100-120	>120-140	>140-160	>160-180	>180-200 and above
		B	C	D	E	F	G	H	I	J	K
1	<i>Adina cordifolia</i> (Roxb.) Hook.f.ex Brandis	-	-	2.5 (17)	5 (33)	-	-	-	2.5 (17)	-	5 (33)
2	<i>Ailanthus excelsa</i> Roxb.	10 (100)	-	-	-	-	-	-	-	-	-
3	<i>Anogeissus latifolia</i> (Roxb.ex DC.) Wall.ex Bedd.	4.38 (26)	5.66 (33)	-	5 (30)	0.63 (4)	0.63 (4)	0.63 (4)	-	-	-
4	<i>Bauhinia racemosa</i> Lamk.	5 (9)	30 (55)	5 (9)	10 (18)	5 (9)	-	-	-	-	-
5	<i>Bauhinia vahlii</i> Wight. & Arn.	2 (13)	2 (13)	2 (13)	2 (13)	4 (25)	-	4 (25)	-	-	-
6	<i>Bauhinia variegata</i> L.	20 (32)	18 (29)	10 (16)	4 (6)	8 (13)	-	2 (3)	-	-	-
7	<i>Bombax ceiba</i> L.	-	-	-	-	10 (100)	-	-	-	-	-
8	<i>Boswellia serrata</i> Roxb.	10 (50)	-	-	5 (25)	-	-	-	5 (25)	-	-
9	<i>Bridelia retusa</i> (L.) Spreng.	4 (22)	10 (56)	4 (22)	-	-	-	-	-	-	-
10	<i>Buchanania lanzan</i> Spreng.	-	4 (40)	2 (20)	2 (20)	-	2 (20)	-	-	-	-
11	<i>Butea monosperma</i> (Lam.) Taub.	-	5 (50)	-	-	5 (50)	-	-	-	-	-
12	<i>Casearia graveolens</i> Dalz.	38.57 (69)	14.29 (26)	2.86 (5)	-	-	-	-	-	-	-
13	<i>Cassia fistula</i> L.	8.33 (45)	5 (27)	1.67 (9)	1.67 (9)	-	-	-	-	-	1.67 (9)

S. No.	Species	Trees per ha in different girth classes (cm) / Percent Density									
		>10-20	>20-40	>40-60	>60-80	>80-100	>100-120	>120-140	>140-160	>160-180	>180-200 and above
		B	C	D	E	F	G	H	I	J	K
14	<i>Chloroxylon swietenia</i> DC.	-	10 (100)	-	-	-	-	-	-	-	-
15	<i>Cordia macleodii</i> (Griff.) Hook.f.& Thomson	10 (100)	-	-	-	-	-	-	-	-	-
16	<i>Dalbergia paniculata</i> Roxb.	-	5 (33)	-	-	5 (33)	-	5 (33)	-	-	-
17	<i>Dendrocalamus strictus</i> (Roxb.) Nees	13.33 (50)	-	-	3.33 (12)	10 (38)	-	-	-	-	-
18	<i>Diospyros melanoxylon</i> Roxb.	30.91 (51)	22.73 (37)	1.82 (3)	1.82 (3)	3.64 (6)	-	-	-	-	-
19	<i>Embllica officinalis</i> Gaertn	13.75 (55)	5 (20)	3.75 (15)	1.25 (5)	-	1.25 (5)	-	-	-	-
20	<i>Flacourtia indica</i> (Burm.f.) Merr.	10 (80)	2.5 (20)	-	-	-	-	-	-	-	-
21	<i>Grewia tiliiaefolia</i> Vahl	17.5 (74)	6.25 (26)	-	-	-	-	-	-	-	-
22	<i>Kydia calycina</i> Roxb.	18 (50)	14 (39)	2 (6)	-	-	-	2 (6)	-	-	-
23	<i>Lagerstroemia parviflora</i> Roxb.	14 (44)	11 (34)	2 (6)	4 (13)	1 (3)	-	-	-	-	-
24	<i>Lannea coromandelica</i> (Houtt.) Merr.	10 (29)	10 (29)	10 (29)	-	5 (14)	-	-	-	-	-
25	<i>Mallotus philippensis</i> (Lam.) Muell.	50 (74)	16 (24)	-	-	-	2 (3)	-	-	-	-
26	<i>Milium tomentosa</i> (Roxb.) Sinclair	11.25 (50)	7.5 (33)	2.5 (11)	-	-	-	-	-	-	1.25 (6)
27	<i>Mitragyna parviflora</i> (Roxb.) Korth	13.33 (100)	-	-	-	-	-	-	-	-	-
28	<i>Nyctanthes arbor-tristis</i> L.	15 (64)	5 (21)	-	1.67 (7)	1.67 (7)	-	-	-	-	-
29	<i>Ougeinia dalbergioides</i> Benth.	11.11 (26)	23.33 (55)	6.67 (16)	1.11 (3)	-	-	-	-	-	-
30	<i>Pterocarpus marsupium</i> Roxb.	6 (38)	4 (25)	-	2 (13)	-	4 (25)	-	-	-	-
31	<i>Randia dumetorum</i> (Retz.) Poir.	-	10 (100)	-	-	-	-	-	-	-	-
32	<i>Schleichera oleosa</i> (Lour.) Oken.	6.67 (40)	6.67 (40)	3.33 (20)	-	-	-	-	-	-	-
33	<i>Semecarpus anacardium</i> L.f.	6 (33)	6 (33)	2 (11)	4 (22)	-	-	-	-	-	-
34	<i>Shorea robusta</i> Gaertn. f.	129 (21)	128 (21)	102 (16)	74.5 (12)	76.5 (12)	33 (5)	32.5 (5)	17.5 (3)	13.5 (2)	12 (2)
35	<i>Sterculia urens</i> Roxb.	-	10 (100)	-	-	-	-	-	-	-	-
36	<i>Sterospermum chelonoides</i> (L.f.) DC.	3.33 (25)	3.33 (25)	-	-	3.33 (25)	-	3.33 (25)	-	-	-
37	<i>Syzygium cumini</i> (L.) skeels	14.71 (28)	10 (19)	9.41 (18)	4.12 (8)	5.88 (11)	2.35 (4)	2.35 (4)	1.18 (2)	-	2.35 (4)
38	<i>Terminalia arjuna</i> (Roxb. ex DC.) Wight	10 (100)	-	-	-	-	-	-	-	-	-

S. No.	Species	Trees per ha in different girth classes (cm) / Percent Density									
		>10-20	>20-40	>40-60	>60-80	>80-100	>100-120	>120-140	>140-160	>160-180	>180-200 and above
		B	C	D	E	F	G	H	I	J	K
39	<i>Terminalia belerica</i> (Gaertn.) Roxb.	10 (100)	-	-	-	-	-	-	-	-	-
40	<i>Terminalia chebula</i> Retz.	8 (44)	4 (22)	-	4 (22)	-	2 (11)	-	-	-	-
41	<i>Terminalia tomentosa</i> (Roxb.ex DC.)	9.17 (15)	15.83 (25)	17.5 (28)	10 (16)	4.17 (7)	1.67 (3)	4.17 (7)	-	-	-
42	<i>Ziziphus mauritiana</i> Lamk.	10 (100)	-	-	-	-	-	-	-	-	-
43	<i>Ziziphus rugosus</i> Lamk.	50 (69)	17.5 (24)	2.5 (3)	-	2.5 (3)	-	-	-	-	-
44	<i>Ziziphus xylopyrus</i> (Retz.) Willd.	-	10 (57)	2.5 (14)	2.5 (14)	-	2.5 (14)	-	-	-	-

Note: The values in parentheses are the percent plant density in various girth classes

3.1.2. Regeneration status of sal and its associates in core zone: On perusal of the compartment wise details summarized in Table-3, it reveals that the regeneration of sal (seedlings per ha) varied from 1291 to 22917. The average number of regeneration per hectare worked out to be 1557, which is quite adequate. Besides this adequate regeneration of sal, the distribution pattern of individuals of sal trees in different girth classes was also seemed to be uninterrupted in most of the stands studied (Table-2). This trend of uninterrupted distribution of sal in different growth phases with plenty of established regeneration is the healthy sign of establishment and growth of sal crop in the past in this area. Though, in some cases interrupted/gap phase of regeneration also occurred which may indicate that one are more climatic and/or bio-edaphic factors inhibited the regeneration completely for certain periods of time, and with the return of favorable conditions, the species was able to regenerate again. No indication of any disease/borer infestation was found in the study area. The presence of healthy sal trees in all age groups suggests the sustainable development of the sal crop and its associates in this area.

Among other associates of sal, maximum established regeneration was found in *Dendrocalamus strictus* followed by *Holarrhena pubescens*, *Ventilago calyculata*, *Syzygium cumini*, *Pterocarpus marsupium*, *Emblica officinalis*, *Diospyros melanoxylon*, *Kydia calycina*, *Cassia fistula*, *Ougeinia dalbergioides*, *Celastrus paniculatus*, *Milium tomentosa*, *Mallotus philippensis*, *Bauhinia vahlii*, *Bauhinia variegata*, *Casearia graveolens*, *Lagerstroemia parviflora*, *Stereospermum chelonoides*, *Dalbergia paniculata*, *Schleichera oleosa*, *Buchanania lanzan*, *Terminalia chebula*, *Ziziphus rugosus*, *Bridelia retusa*, *Ehretia laevis*, *Grewia tiliaefolia*, *Randia dumetorum*, *Terminalia tomentosa*, *Careya arborea*, *Flacourtia indica*, *Anogeissus latifolia*, *Butea monosperma*, *Cordia dichotoma*, *Woodfordia fruticosa* and *Ziziphus xylopyrus* (Table-4).

Table 3. Population Structure in Terms of Plant Density of Sal Crop in Different Girth Classes (Growth Phases) in Different Compartments Studied in Kanha Tiger Reserve

S. N o.	Comptt. No./ site quality	Plant density per ha in different girth classes (cm)										
		Established regeneration per ha	10-20 (saplings)	> 20-40	>40-60	>60-80	>80-100	>100-120	>120-140	>140-160	>160-180	>180-200 and above
1.	21 (MP III)	1819	50	150	210	120	140	40	40			
2.	65 (MP II&III)	9986	680	400	70	30	40	20	30	20		
3.	66 (MP II&III)	7931	580	140	60	60	120	40	60		40	
4.	113 (MP IVa)	6667	50	180	120	110	20	60	40		10	20
5.	149 (MP III)	17500	40	70	30	10	10	10		20	10	20
6.	170 (MP IVa)	18958	80	170	210	140	90	20	20		10	
7.	184 (MP IVa)	22083	40	260	150	120	70	50	20	10	20	20
8.	195 (MP IVa)	16875	110	90	150	50	90	10	20		10	10
9.	199 (MP II&III)	10278	10	30	80	150	120		30	30	30	30
10.	599 (MP IVb)	8125	20	100	190	90	70	10	30	10		
11.	641 (MP IVa & IVb)	3472		90	100	40	60	80	70	50	10	20
12.	643 (MP IVa & IVb)	22917	10	100	110	50	10	20	10	10	20	10
13.	676 (MP III)	6194	60	80	90	80	80	10	60	50	10	
14.	690 (MP IVb)	3291				10	10		10	10	50	50
15.	704 (MP IVb)	1972	10	70	200	160	140	110	30	10		
16.	710 (MP III & IVa)	1291				40	70	50	40	30	10	20
17.	756 (MP III)	Nil		10		10	130	100	50	50	20	10
18.	777 (MP II&III)	9541	10	10	30	40	60	30	30	40	10	20
19.	784 (MP II)	12778	820	480	20	-	70	30	20	-	10	10
20.	797 (MP III)	7263	10	130	220	180	130	70	40	10		
Average		1556.94										

Table 4. Average Established Regeneration of Different Tree Species in Core Zone of Kanha Tiger Reserve

S.N.	Name of Species	Av. established regeneration (plants per ha)
1	<i>Dendrocalamus strictus</i> (Roxb.) Nees	1458
2	<i>Holarrhena pubescens</i> Wall. ex G. Don	1388
3	<i>Ventilago calyculata</i> Tul.	1042
4	<i>Syzygium cumini</i> (L.) skeels	992
5	<i>Pterocarpus marsupium</i> Roxb.	949
6	<i>Emblica officinalis</i> Gaertn	741
7	<i>Diospyros melanoxylon</i> Roxb.	740
8	<i>Kydia calycina</i> Roxb.	533
9	<i>Cassia fistula</i> L.	526
10	<i>Ougeinia dalbergioides</i> Benth.	502
11	<i>Celastrus paniculatus</i> Willd.	500
12	<i>Milium tomentosum</i> (Roxb.) Sinclair	451
13	<i>Mallotus philippensis</i> (Lam.) Muell.	432
14	<i>Bauhinia vahlii</i> Wight. & Arn.	347
15	<i>Bauhinia variegata</i> L.	332

S.N.	Name of Species	Av. established regeneration (plants per ha)
16	<i>Casearia graveolens</i> Dalz.	312
17	<i>Lagerstroemia parviflora</i> Roxb.	295
18	<i>Sterespermum chelonoides</i> (L.f.) DC.	289
19	<i>Dalbergia paniculata</i> Roxb.	255
20	<i>Schleichera oleosa</i> (Lour.) Oken.	250
21	<i>Buchanania lanzan</i> Spreng.	243
22	<i>Terminalia chebula</i> Retz.	243
23	<i>Ziziphus rugosus</i> Lamk.	241
24	<i>Bridelia retusa</i> (L.) Spreng.	231
25	<i>Ehretia laevis</i> Roxb	208
26	<i>Grewia tiliaefolia</i> Vahl	208
27	<i>Randia dumetorum</i> Lam.	208
28	<i>Terminalia tomentosa</i> (Roxb.ex DC.)	191
29	<i>Careya arborea</i> Roxb.	139
30	<i>Flacourtia indica</i> (Burm.f.) Merr.	104
31	<i>Anogeissus latifolia</i> (Roxb.ex DC.) Wall.ex Bedd.	69
32	<i>Butea monosperma</i> (Lam.) Taub.	69
33	<i>Cordia dichotoma</i> G. forster	69
34	<i>Woodfordia fruticosa</i> (L.) Kurz	69
35	<i>Ziziphus xylopyrus</i> (Retz.) willd.	69

3.2. Buffer Zone of Kanha Tiger Reserve

3.2.1. Population Structure of Standing Crop in Buffer Zone: The status of standing crop of sal and its associates, pertaining to crop composition, density of standing trees per ha, percent composition of sal and its associates in different girth classes, current status of borer infestation etc. In buffer zone (Khatiya, Sijhora, Garhi, Khapa ranges) of Kanha Tiger Reserve is described in Table-5. The growth phase of sal showed uninterrupted trend of regeneration from saplings to mature stage. Other associates like *Terminalia tomentosa*, *Mitragyna parviflora*, *Ziziphus xylopyrus*, *Terminalia chebula*, *Terminalia belerica*, *Schleichera oleosa*, *Catunaregam nilotica*, *Miliusa tomentosa*, *Lannea coromandelica*, *Lagerstroemia parviflora*, *Emblica officinalis*, *Diospyros melanoxylon* and *Casearia graveolens* also showed uninterrupted trend of regeneration from sapling to mature stage. This is the good indication of establishment and development of sal and other associates. Besides these species, other species (Table -5) showed interrupted trend of growth and need conservation strategies for development of their population structure in the ecosystem. These species require detailed study on reproductive biology and eco-silvicultural requirements at different growth stages.

Table 5. Population Structure of Different Trees Species in Various Girth Classes with Percent Density in Buffer Zone of Kanha Tiger Reserve (KTR)

S. No.	Species	Trees per ha in different girth classes (cm) / (Percent Density)									
		>10- 20	> 20 - 40	>40- 60	>60- 80	>80- 100	>100- 120	>120- 140	>140- 160	>160- 180	>180 - 200 and above
1	<i>Adina cordifolia</i> (Roxb.) Hook.f.ex Brandis	2.5 (14)	5 (29)	5 (29)	-	2.5 (14)	-	-	2.5 (14)	-	-
2	<i>Anogeissus latifolia</i> (Roxb.ex DC.) Wall.ex Bedd.	45 (43)	43.33 (41)	13.33 (13)	3.33 (3)	-	-	-	-	-	-
3	<i>Bridelia retusa</i> (L.) Spreng.	-	10 (40)	5 (20)	10 (40)	-	-	-	-	-	-
4	<i>Buchanania lanzan</i> Spreng.	6.25 (22)	10 (36)	8.13 (29)	1.25 (4)	2.5 (9)	-	-	-	-	-
5	<i>Butea monosperma</i> (Lam.) Taub.	3.33 (17)	6.67 (33)	10 (50)	-	-	-	-	-	-	-
6	<i>Careya arborea</i> Roxb.	-	10 (100)	-	-	-	-	-	-	-	-
7	<i>Carissa opaca</i> Stapfex Haines	-	10 (100)	-	-	-	-	-	-	-	-
8	<i>Casearia graveolens</i> Dalz.	17.5 (58)	11.25 (38)	1.25 (4)	-	-	-	-	-	-	-
9	<i>Cassia fistula</i> L.	3.33 (25)	10 (75)	-	-	-	-	-	-	-	-
10	<i>Catunaregam nilotica</i> (Stapf) Tirvengadam	9.17 (35)	3.33 (13)	5 (19)	5 (19)	3.33 (13)	-	-	-	-	-
11	<i>Dendrocalamus strictus</i> (Roxb.) Nees	20 (67)	-	5 (17)	-	-	5 (17)	-	-	-	-
12	<i>Diospyros melanoxylon</i> Roxb.	15.45 (74)	3.64 (17)	1.82 (9)	-	-	-	-	-	-	-
13	<i>Embllica officinalis</i> Gaertn	20.91 (47)	12.73 (29)	7.27 (16)	3.64 (8)	-	-	-	-	-	-
14	<i>Erythrina indica</i> Lamk.	-	-	-	10 (100)	-	-	-	-	-	-
15	<i>Gmelina arborea</i> Roxb.	-	10 (100)	-	-	-	-	-	-	-	-
16	<i>Grewia tiliaefolia</i> Vahl	-	-	-	5 (50)	-	5 (50)	-	-	-	-
17	<i>Lagerstroemia parviflora</i> Roxb.	18.89 (27)	38.89 (55)	10 (14)	3.33 (5)	-	-	-	-	-	-
18	<i>Lannea coromandelica</i> (Houtt.)Merr.	-	-	-	-	10 (100)	-	-	-	-	-
19	<i>Lannea coromandelica</i> (Houtt.)Merr.	8 (21)	13 (33)	8 (21)	1 (3)	5 (13)	2 (5)	-	-	2 (5)	-
20	<i>Mallotus philippensis</i> (Lam.) Muell.	-	10 (100)	-	-	-	-	-	-	-	-
21	<i>Mangifera indica</i> L.	10 (50)	10 (50)	-	-	-	-	-	-	-	-
22	<i>Miluisa tomentosa</i> (Roxb.)Sinclair	15 (43)	5 (14)	6.67 (19)	3.33 (10)	5 (14)	-	-	-	-	-
23	<i>Mitragyna parviflora</i> (Roxb.) Korth	2.5 (17)	2.5 (17)	2.5 (17)	2.5 (17)	2.5 (17)	2.5 (17)	-	-	-	-

S. No.	Species	Trees per ha in different girth classes (cm) / (Percent Density)									
		>10- 20	> 20 - 40	>40- 60	>60- 80	>80- 100	>100- 120	>120- 140	>140- 160	>160- 180	>180 - 200 and above
24	<i>Pterocarpus marsupium</i> Roxb.	-	5 (33)	2.5 (17)	2.5 (17)	2.5 (17)	-	2.5 (17)	-	-	-
25	<i>Schleichera oleosa</i> (Lour.) Oken.	8 (57)	2 (14)	4 (29)	-	-	-	-	-	-	-
26	<i>Semecarpus anacardium</i> L.f.	-	10 (43)	10 (43)	3.33 (14)	-	-	-	-	-	-
27	<i>Shorea robusta</i> Gaertn. f.	52.31 (18)	57.69 (20)	40 (14)	37.69 (13)	26.92 (9)	23.85 (8)	17.69 (6)	10.77 (4)	8.46 (3)	8.46 (3)
28	<i>Terminalia bellerica</i> (Gaertn.) Roxb.	2.5 (17)	5 (33)	2.5 (17)	-	-	-	2.5 (17)	2.5 (17)	-	-
29	<i>Terminalia chebula</i> Retz.	10 (38)	12.5 (48)	1.25 (5)	1.25 (5)	-	1.25 (5)	-	-	-	-
30	<i>Terminalia tomentosa</i> (Roxb.ex DC.)	11.43 (14)	27.14 (33)	14.29 (17)	15 (18)	3.57 (4)	5 (6)	1.43 (2)	2.86 (3)	0.71 (1)	0.71 (1)
31	<i>Ziziphus rugosus</i> Lamk.	30 (100)	-	-	-	-	-	-	-	-	-
32	<i>Ziziphus xylopyrus</i> (Retz.) willd.	5 (7)	20 (30)	22.5 (33)	20 (30)	-	-	-	-	-	-

Note: The values in parentheses are the percent plant density in various girth classes

3.2.2. Regeneration Status of sal and its Associates in Buffer Zone: On perusal of the compartment wise details summarized in Table-6, it reveals that the regeneration of sal (seedlings per ha) varied from 28 to 13208. The average number of regeneration per ha at division level worked out to be 3446 which is quite adequate as per the standard norms of code of working plans. Besides this adequate regeneration of sal, the distribution pattern of individuals of sal trees in different girth classes was also seemed to be uninterrupted in most of the stands studied (Table-5). This trend of uninterrupted distribution of sal in different growth phases with plenty of established regeneration is the healthy sign of establishment and growth of sal crop in the past in this area. Though in some cases interrupted/gap phase of regeneration also occurred which may indicate that one are more climatic and/or bioedaphic sectors inhibited the regeneration completely for certain periods of time and with the return of favourable conditions, the species was able to regenerate again. No indication of any disease/ borer infestation was found in the study area. The presence of healthy sal trees in all age groups suggests the sustainable development of the sal crop and its associates in this area.

Among other associates of sal, maximum established regeneration was found in *Holarrhena pubescens* followed by *Dendrocalamus strictus*, *Lagerstroemia parviflora*, *Bauhinia vahlii*, *Celastrus paniculatus*, *Terminalia tomentosa*, *Chloroxylon swietenia*, *Schleichera oleosa*, *Diospyros melanoxylon*, *Randia dumetorum*, *Smilax macrophylla*, *Buchanania lanzan*, *Syzygium cumini*, *Bauhinia variegata*, *Casearia graveolens*, *Sterospermum chelonoides*, *Terminalia chebula*, *Bauhinia vahlii*, *Cassia fistula*, *Embllica officinalis*, *Anogeissus latifolia*, *Bridelia retusa*, *Kydia calycina*, *Mitragyna parviflora*, *Careya arborea*, *Grewia tiliaefolia*, *Madhuca indica*, *Ventilago calyculata*, *Ziziphus xylopyrus*, *Ougeinia dalbergioides*, *Pterocarpus marsupium* and *Adina cordifolia* (Table-7).

Table 6. Population Structure in Terms of Plant Density of Sal Crop in Different Girth Classes (growth phases) in Different Compartments Studied in Kanha Tiger Reserve (Buffer Zone)

S. No.	Comptt. No./ Site quality	Plant density per ha in different girth classes (cm)										
		Established regeneration per ha	10-20 (saplings)	> 20-40	>40-60	>60-80	>80-100	>100-120	>120-140	>140-160	>160-180	>180-200 and above
1	335 (MP II&III)	Nil										
2	339 (MP II)	3431	10	50	60	80	30			10		
3	346 (MP IVa & IVb)	28				10						
4	352 (MP III)	9819	10		10	50	10	20	30	10	10	10
5	770 (MP III)	Nil	Nil									
6	823 (MP IVa)	819		40	50	70	60	10	20			20
7	828 (MP IVb)	6000	130	200	40	20		20	10	10		
8	838 (MP IVa)	5542	70	130	140	160	60	70	130	20	10	
9	848 (MP IVb)	8042					20	10		10		10
10	862 (MP IVa)	611	20	10	30	10	30	50	40	30	10	
11	870 (MP IVb)	4903	70	60	20	10	10	30	10		20	10
12	1087 (MP IVa)	13208	70	110	30	30	60	30	30	30		10
13	1094 (MP IVa)	4000	290	160	100	10	10					10
14	1114 (MP IVa)	1569			30	40	40	40	30			
15	1122 (MP IVa)	111			10		20	30	30	20	60	40
Average		3446.54										

Table 7. Average Established Regeneration of Different Tree Species in Kanha Tiger Reserve (Buffer Zone)

S.N.	Name of Species	Av. established regeneration (plants per ha)
1	<i>Holarrhena pubescens</i> Wall. ex G. Don	3472
2	<i>Dendrocalamus strictus</i> (Roxb.) Nees	2327
3	<i>Lagerstroemia parviflora</i> Roxb.	836
4	<i>Bauhinia vahlii</i> Wight. & Arn.	833
5	<i>Celastrus paniculatus</i> Willd.	526
6	<i>Terminalia tomentosa</i> (Roxb.ex DC.)	497
7	<i>Chloroxylon swietenia</i> DC.	375
8	<i>Schleichera oleosa</i> (Lour.) Oken.	322
9	<i>Diospyros melanoxylon</i> Roxb.	319
10	<i>Randia dumetorum</i> (Retz.)Poir.	313
11	<i>Smilax macrophylla</i> Roxb.	306
12	<i>Buchanania lanzan</i> Spreng.	304
13	<i>Syzygium cumini</i> (L.) skeels	304
14	<i>Bauhinia variegata</i> L.	278
15	<i>Casearia graveolens</i> Dalz.	269
16	<i>Sterospermum chelonoides</i> (L.f.) DC.	268
17	<i>Terminalia chebula</i> Retz.	264
18	<i>Bauhinia vahlii</i> Wight. & Arn.	208
19	<i>Cassia fistula</i> L.	180
20	<i>Emblica officinalis</i> Gaertn	174

S.N.	Name of Species	Av. established regeneration (plants per ha)
21	<i>Anogeissus latifolia</i> (Roxb.ex DC.) Wall.ex Bedd.	172
22	<i>Bridelia retusa</i> (L.) Spreng.	162
23	<i>Kydia calycina</i> Roxb.	139
24	<i>Mitragyna parviflora</i> (Roxb.) Korth	139
25	<i>Careya arborea</i> Roxb.	118
26	<i>Grewia tiliaefolia</i> Vahl	69
27	<i>Madhuca indica</i> J.F. Gimelin	69
28	<i>Ventilago calyculata</i> Tulasne	69
29	<i>Ziziphus xylopyrus</i> (Retz.) willd.	69
30	<i>Ougeinia dalbergioides</i> Benth.	56
31	<i>Pterocarpus marsupium</i> Roxb.	38
32	<i>Adina cordifolia</i> (Roxb.) Hook.f.ex Brandis	28

3.3. Phen Wild Life Sanctuary Range of Kanha Tiger Reserve

3.3.1. Population Structure of Standing Crop in phen Wild Life Sanctuary Range:

The status of standing crop of sal and its associates, pertaining to crop composition, density of standing trees per ha, percent composition of sal and its associates in different girth classes, health status of crop, biotic pressure, current status of borer infestation etc. in the compartments studied in different ranges of Kanha Tiger Reserve is described in Table-8. The growth phase of sal showed uninterrupted trend of regeneration from saplings to mature stage. Other associates like *Terminalia tomentosa*, *Miliusa tomentosa*, *Buchanania lanzan*, *Casearia graveolens*, *Embllica officinalis*, *Madhuca indica*, *Ougeinia dalbergioides*, *Schleichera oleosa*, *Terminalia chebula* and *Syzygium cumini* also showed uninterrupted trend of regeneration from sapling to mature stage. This is the good indication of establishment and development of sal and other associates. Besides these species, other species (Table-8) showed interrupted trend of growth and need conservation strategies for development of their population structure in the ecosystem. These species require detailed study on reproductive biology and eco-silvicultural requirements at different growth stages.

Table 8. Population Structure of Different Trees Species in Various Girth Classes with Percent Density in Phen Wild Life Sanctuary in Kanha Tiger Reserve (KTR)

S. No.	Species	Trees per ha in different girth classes (cm)									
		>10-20	>20-40	>40-60	>60-80	>80-100	>100-120	>120-140	>140-160	>160-180	>180-200 and above
1	<i>Anogeissus latifolia</i> (Roxb.ex DC.) Wall.ex Bedd.	10 (14)	-	10 (14)	5 (7)	15 (21)	25 (36)	-	5 (7)	-	-
2	<i>Bauhinia variegata</i> L.	-	20 (100)	-	-	-	-	-	-	-	-
3	<i>Boswellia serrata</i> Roxb.	-	-	5 (50)	-	-	-	5 (50)	-	-	-
4	<i>Bridelia retusa</i> (L.) Spreng.	-	10 (100)	-	-	-	-	-	-	-	-
5	<i>Buchanania lanzan</i> Spreng.	30 (67)	12.5 (28)	-	2.5 (6)	-	-	-	-	-	-
6	<i>Butea monosperma</i> (Lam.) Taub.	-	10 (100)	-	-	-	-	-	-	-	-
7	<i>Careya arborea</i> Roxb.	-	10 (100)	-	-	-	-	-	-	-	-

S. No.	Species	Trees per ha in different girth classes (cm)									
		>10-20	> 20 - 40	>40-60	>60-80	>80-100	>100-120	>120-140	>140-160	>160-180	>180 - 200 and above
8	<i>Casearia elliptica</i> Willd.	10 (100)	-	-	-	-	-	-	-	-	-
9	<i>Casearia graveolens</i> Dalz.	70 (78)	-	10 (11)	10 (11)	-	-	-	-	-	-
10	<i>Cassia fistula</i> L.	13.33 (80)	3.33 (20)	-	-	-	-	-	-	-	-
11	<i>Chloroxylon swietenia</i> DC.	-	10 (100)	-	-	-	-	-	-	-	-
12	<i>Diospyros melanoxylon</i> Roxb.	75 (86)	5 (6)	-	-	-	5 (6)	-	-	-	-
13	<i>Emblica officinalis</i> Gaertn	22.5 (39)	32.5 (57)	-	2.5 (4)	-	-	-	-	-	-
14	<i>Ficus religiosa</i> L.	-	10 (100)	-	-	-	-	-	-	-	-
15	<i>Grewia tiliaefolia</i> Vahl	10 (67)	-	-	5 (33)	-	-	-	-	-	-
16	<i>Lagerstroemia parviflora</i> Roxb.	-	10 (75)	3.33 (25)	-	-	-	-	-	-	-
17	<i>Madhuca indica</i> J.F. Gimelin	3.33 (20)	6.67 (40)	-	6.67 (40)	-	-	-	-	-	-
18	<i>Milium tomentosum</i> (Roxb.) Sinclair	10 (43)	6.67 (29)	3.33 (14)	-	-	-	-	-	3.33 (14)	-
19	<i>Mitragyna parviflora</i> (Roxb.) Korth	-	-	10 (100)	-	-	-	-	-	-	-
20	<i>Ougeinia dalbergioides</i> Benth.	10 (60)	3.33 (20)	-	-	3.33 (20)	-	-	-	-	-
21	<i>Pterocarpus marsupium</i> Roxb.	-	-	-	-	-	10 (75)	3.33 (25)	-	-	-
22	<i>Schleichera oleosa</i> (Lour.) Oken.	5 (50)	5 (50)	-	-	-	-	-	-	-	-
23	<i>Shorea robusta</i> Gaertn. f.	36 (12)	56 (19)	38 (13)	40 (13)	52 (17)	36 (12)	22 (7)	14 (5)	2 (1)	6 (2)
24	<i>Syzygium cumini</i> (L.) skeels	-	10 (25)	10 (25)	-	-	20 (50)	-	-	-	-
25	<i>Terminalia belerica</i> (Gaertn.) Roxb.	10 (100)	-	-	-	-	-	-	-	-	-
26	<i>Terminalia chebula</i> Retz.	10 (60)	3.33 (20)	-	3.33 (20)	-	-	-	-	-	-
27	<i>Terminalia tomentosa</i> (Roxb.ex DC.)	90 (38)	112 (47)	16 (7)	8 (3)	4 (2)	4 (2)	2 (1)	-	-	-
28	<i>Ziziphus xylopyrus</i> (Retz.) willd.	-	7.5 (60)	-	5 (40)	-	-	-	-	-	-

Note: The values in parentheses are the percent plant density in various girth classes

3.3.2. Regeneration Status of sal and its Associates in phen Wild Life Sanctuary: On perusal of the compartment wise details summarized in Table-9, it reveals that the regeneration of sal (seedlings per ha) varied from 1333 to 15139. The average number of regeneration per ha at division level worked out to be 7137 which is quite adequate as per the standard norms of code of working plans. Besides this adequate regeneration of sal, the distribution pattern of individuals of sal trees in different girth classes was also seemed to be uninterrupted in most of the stands studied (Table-8). This trend of uninterrupted distribution of sal in different growth phases with plenty of established

regeneration is the healthy sign of establishment and growth of sal crop in the past in this area. Though, in some cases interrupted/gap phase of regeneration also occurred which may indicate that one are more climatic and/or bio-edaphic sectors inhibited the regeneration completely for certain periods of time and with the return of favorable conditions, the species was able to regenerate again. No indication of any disease/ borer infestation was found in the study area. The presence of healthy sal trees in all age groups suggests that the sal seed collection would not hamper the sustainable development of the sal crop and its associates in this area.

Among other associates of sal, maximum established regeneration was found in *Terminalia tomentosa* followed by *Ougeinia dalbergioides*, *Miliusa tomentosa*, *Randia dumetorum*, *Terminalia chebula*, *Careya arborea*, *Casearia graveolens*, *Mitragyna parviflora*, *Pterocarpus marsupium*, *Buchanania lanzan*, *Diospyros melanoxylon*, *Cassia fistula*, *Anogeissus latifolia*, *Emblica officinalis*, *Bridelia retusa*, *Syzygium cumini*, *Butea monosperma*, *Elaeodendron glaucum*, *Ficus religiosa* and *Ziziphus xylopyrus* (Table-10).

Table 9. Population Structure in Terms of Plant Density of Sal Crop in Different Girth Classes (Growth Phases) in Different Compartments Studied in Phen Wild Life Sanctuary in Kanha Tiger Reserve

S. No.	Comptt. No./ Site quality	Plant density per ha in different girth classes (cm)										
		Established regeneration per ha	10-20 (saplings)	> 20-40	>40-60	>60-80	>80-100	>100-120	>120-140	>140-160	>160-180	>180-200 and above
1.	447 (MP III)	4597	30			50	50	10	10	10		
2.	489 (MP III)	9139	30	80	60	50	30	30	10	20		10
3.	501 (MP III)	15139	30	140	70		20	30	40			
4.	508 (MP III)	5486	30	30	30	90	100	70	10	10		10
5.	521 (MP III)	1333	60	30	30	10	60	40	40	30	10	10
Average		7137										

Table 10. Average Established Regeneration of Different Tree Species in Phen Wild life Sanctuary Range of KTR

S.N.	Name of Species	Av. established regeneration (plants per ha)
1	<i>Terminalia tomentosa</i> (Roxb.ex DC.)	1795
2	<i>Ougeinia dalbergioides</i> Benth.	1146
3	<i>Miliusa tomentosa</i> (Roxb.)Sinclair	1111
4	<i>Randia dumetorum</i> (Retz.)Poir.	541
5	<i>Terminalia chebula</i> Retz.	382
6	<i>Careya arborea</i> Roxb.	278
7	<i>Casearia graveolens</i> Dalz.	278
8	<i>Mitragyna parviflora</i> (Roxb.) Korth	278
9	<i>Pterocarpus marsupium</i> Roxb.	271
10	<i>Buchanania lanzan</i> Spreng.	188
11	<i>Diospyros melanoxylon</i> Roxb.	188
12	<i>Cassia fistula</i> L.	180
13	<i>Anogeissus latifolia</i> (Roxb.ex DC.) Wall.ex Bedd.	174
14	<i>Emblica officinalis</i> Gaertn	163
15	<i>Bridelia retusa</i> (L.) Spreng.	125
16	<i>Syzygium cumini</i> (L.) skeels	77
17	<i>Butea monosperma</i> (Lam.) Taub.	69
18	<i>Elaeodendron glaucum</i> Pers.	69

S.N.	Name of Species	Av. established regeneration (plants per ha)
19	<i>Ficus religiosa</i> L.	69
20	<i>Ziziphus xylopyrus</i> (Retz.) willd.	69

4. Discussions

The population structures of various tree species showed three types of growth pattern. One pattern of population structure is represented by D,E,F,H, with a greater proportion of individuals in lower girth classes compared to larger girth classes, indicating frequent regeneration (Knight, 1975). Another pattern showed most of the individuals in higher girth classes with the absence of seedling and saplings. Benton and Werner (1976) stated that if such a trend continues, the population of these species is on the way to extinction. The population structure of certain species is characterized by gap phase type regeneration (interrupted). Interrupted regeneration of species may indicate that one or more climatic and/or bio-edaphic factors inhibited the regeneration completely for certain periods of time, and with the return of favorable conditions, the species was able to regenerate again. There is another pattern which consists of individuals in lower and middle girth classes but absence of seedlings. The last pattern is consisting of seedlings with absence of some intermediate classes.

5. Conclusion

Keeping the status of standing crop and regeneration of *Shorea robusta* in particular and its associates in general, it is concluded that The crop condition is quite good and regeneration is adequate, yet for the sustainable development, biotic influences, fire and other hazards should be strictly controlled in different management zones of Kanha Tiger Reserve.

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