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Successional changes in Shrub community composition in an age series of restored mined sites and natural forest in Uttarakhand, India

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ABSTRACT

The present study was carried out to understand the successional changes, which take place in shrubby vegetation in an age series of 23, 22, 21 and 20 years old mine restored sites at Dehradun district in Uttarakhand, India and an adjoining natural forest was also studied for comparison of composition of shrubs species community in all sites. Phytosociological survey was conducted in all the restored sites and the natural forest for composition of shrubs species community by using quadrat method. The critical examination of the data shows that although some of the planted species like *Agave sisalana, Dodonea viscosa* and *Rumex hastatus* are still present but their density has declined considerably through the entire years of successional development. The results reveal that higher successional species had invaded the area and some of the shrub species which were planted in the initial phase of restoration had declined in their density and some species have vanished from the area altogether. The results confirms the fact that as the age of succession increases, the restored area gets occupied by the higher successional species and also an ecologically sound restructured system forms which is an indication of the efficacy of the restoration programme leading to a self sustaining system.

Keywords: Age series, Phytosociological survey, Quadrat method, Restoration, Successional development, Succession, Species

1. Introduction

Opencast mining is practiced for commercial exploitation of minerals. In this process, overburden materials, i.e. the overlying soil layer with existing vegetation are removed and deposited in another fresh area. Thus, the deposition of million tons of overburdens in the forms of rocks, shale, course tailing results in barren, biologically inert overburden dumps, called mine spoils. Restoration of these mine spoils is essential for conservation of environment, biodiversity and to make the land productive. The use of native and indigenous plant species have been emphasized in restoration programs with a view to maintain essential processes and life support system, preservation of genetic diversity and to ensure sustainable utilization of species and ecosystem (Banerjee et al. 1996 and Soni et al. 1989). Plant species also emerge naturally on the barren mined land after certain intervals of time from the initiation of dump, but succession of plant species under such situation proceeds at a much slower rate (Bradshaw and Chadwick 1980; and Roberts et al. 1981). Therefore, it is essential to understand the structure and function of an ecosystem with its primary and secondary succession patterns for a successful revegetation programs (Gibson et al. 1985). Present study is an effort to show the succession in shrub species in an age series of restored mine lands.

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2. Materials and Method

2.1 Study Area

The present study has been undertaken in restored area of rock phosphate mine at Maldeota in Doon Valley that has an elevation ranging from 650m to about 1050m above mean sea level (MSL). It is situated in the north east of Dehradun at a distance of about 18km on the west bank of perennial river Bandal. The area affected by open cast mining was about 15 hectares till 1982 when ecorestoration was initiated. Ecological restoration of this mine site has been done by using integrated technical and biological measures. (Soni and Vasistha,1985). Present study was done in the year 2005 and 2006 and data was collected during post monsoon seasons during both the years.

2.2 Materials properties

A comparative study of shrubby vegetation has been done between a 23 years old restored site (site1), 22 years old restored site (site 2), 21 years old restored site (site3) and 20 years old restored site (site 4). For comparison an adjoining natural forest (site 5) has also been studied.

For the present investigation, the restored areas of different ages were selected, besides the adjoining natural forest (undisturbed by mining) as control site for comparing the impact of restoration and successional changes in shrubs in all age series of restoration. Five quadrat of 5x5 meter was laid in the selected sites according to quadrat method (Misra, 1968). Importance Value Index (IVI) was calculated separately for each species of the community. . Bhatt (1990) has reported that shrub species *Eriophorum comosum, Pennisetum purpureum* and *Saccharum spontaneum* were planted in the initial phase of restoration. Importance Value Index (IVI) was calculated by the summation of relative values of frequency, density and dominance (Curtis and McIntosh, 1950; Curtis and Cottam, 1956; Phillips, 1959).

The formulae used for the various calculations were: -

$$\text{Density} = \frac{\text{Total number of individual of a species}}{\text{Total number of quadrats studied}}$$

$$\text{Frequency\%} = \frac{\text{Number of quadrats of occurrence of a species}}{\text{Total number of quadrats studied}} \times 100$$

$$\text{Abundance} = \frac{\text{Total no. of individuals of a species}}{\text{Number of quadrats of occurrence}}$$

3. Results

A perusal on the data of floristic diversity shows that *Lantana camara* (95.23 and100.13) showed the maximum IVI in site 1 during both the years while lowest IVI was calculated for *Pogestemon benghalense* (7.22) during first year of study and *Celtis australis* (4.76) showed the lowest IVI during the second year of study (Table 1). In site 2, the maximum IVI was recorded for *Lantana camara* with highest IVI values with 67.26 and 115.22 during both the years of study while *Artemisia vulgaris* showed the lowest IVI value (4.67) during the first year of study while lowest IVI value was recorded for *Jasminum officinale* (5.89) during the second year of study (Table 2).

Table 1: Floristic composition of shrubs in 23 years old restored site (site 1)

Shrub species	**Frequency**		**Density ha^{-1}**		**Abundance**		**IVI**	
Years	**Ist**	**IInd**	**Ist**	**IInd**	**Ist**	**IInd**	**Ist**	**IInd**
Adhatoda zeylanica Nees.	80.00	100.00	1280	640	4.00	1.60	39.48	27.38
Adina cordifolia Hook f.	-	20.00	-	160	-	2.00	-	6.30
Agave sisalana Perrine	40.00	-	480	-	3.00	-	18.91	-
Artemisia vulgaris Linn.	20.00	-	80	-	1.00	-	4.87	-
Desmodium gangeticum Linn.	20.00	-	80	-	1.00	-	6.07	-
Boehmeria platyphylla D.Don	40.00	100.00	160	960	1.00	2.40	12.37	37.88
Casearia tomentosa Roxb.	-	20.00	-	320	-	4.00	-	12.76
Colebrookea oppositifolia Smith	60.00	-	400	-	1.67	-	21.01	-
Ehretia laevis Roxb.	20.00	20.00	240	160	3.00	2.00	20.43	9.75
Eupatorium glandulosum Michx.	40.00	-	160	-	1.00	-	16.54	-
Flacourtia cataphracta Roxb.	-	20.00	-	160	-	2.00	-	8.95
Grewia optiva J. R. Drumm. ex Burret.	20.00	20.00	80	160	1.00	2.00	10.38	11.07
Holarrhena antidysenterica Wall.	-	20.00	-	160	-	2.00	-	8.99
Jasminum officinale Linn.	-	20.00	-	160	-	2.00	-	5.89
Lantana camara L.	100.00	100.00	1440	3680	3.60	9.20	67.26	115.22
Mallotus philippensis (Lam.) Muell.-Arg.	20.00	20.00	160	160	2.00	2.00	9.81	7.28
Millettia auriculata Baker.	-	40.00	-	320	-	2.00	-	16.62
Murraya koenigii Spreng.	100.00	40.00	1040	320	2.60	2.00	52.08	13.62
Nyctanthes arbor-tristis Linn.	-	20.00	-	160	-	2.00	-	10.22
Pogostemon benghalense (Burm.F.) O.Kuntz.	-	20.00	-	320	-	4.00	-	8.08
Syzygium cumini (L.) Skeels	20.00	-	160	-	2.00	-	6.30	-
Terminalia tomentosa W.& A.	20.00	-	80	-	1.00	-	6.07	-
Woodfordia fruticosa Kurz.	20.00	-	80	-	1.00	-	8.42	-

Table 2: Floristic composition of shrubs in 22 years old restored site (site 2)

Shrub species	Frequency		Density ha^{-1}		Abundance		IVI	
Year	I st	II nd	I st	II nd	I st	II nd	I st	II nd
Adhatoda zeylanica Nees.	-	40.00	-	480	-	3.00	-	14.95
Adina cordifolia Hook f.	-	40.00	-	240	-	1.50	-	10.86
Artemisia vulgaris Linn.	60.00	40.00	80	320	1.00	2.00	24.60	12.10
Bidens pilosa L.	-	60.00	-	1040	-	4.33	-	39.20
Boehmeria platyphylla D.Don	100.00	40.00	80	160	3.00	1.00	87.44	9.66
Carissa opaca Stapf.	-	20.00	-	80	-	1.00	-	4.84
Celtis australis Linn.	-	20.00	-	80	-	1.00	-	4.76
Colebrookea oppositifolia Smith.	40.00	20.00	80	80	1.00	1.00	12.86	5.29
Ficus palmata Forsk.	-	40.00	-	160	-	1.00	-	10.57
Lantana camara L.	100.00	100.00	880	2240	5.20	5.60	95.23	100.13
Leucaena leucocephala (Lam) De Wit	-	40.00	-	240	-	1.50	-	10.73
Mallotus philippensis (Lam.) Muell.-Arg.	20.00	-	160	-	1.00		11.42	-
Murraya koenigii Spreng.	60.00	60.00	80	720	2.00	3.00	31.60	37.94
Ricinus communis Linn.	--	40.00	-	240	-	1.50	-	10.72
Pogostemon benghalense (Burm.F.) O.Kuntz.	20.00	-	2400	-	1.00	-	7.22	-
Solanum torvum Swartz.	20.00	-	80	-	1.00	-	11.31	-
Tithonia diversifolia Gray.	40.00	20.00	80	80	1.00	1.00	18.32	5.99
Toona ciliata M.Reem.	-	20.00	-	80	-	1.00	-	7.09
Woodfordia fruticosa Kurz.	-	20.00	-	160	-	2.00	-	15.16

Table 3: Floristic composition of shrubs in 21 years old restored site (site 3)

Shrub species	Frequency		Density ha^{-1}		Abundance		IVI	
Year	Ist	IInd	Ist	IInd	Ist	IInd	Ist	IInd
Acacia catechu (L.f.) Willd.	-	40.00	-	160	-	1.00	-	21.65
Achyranthes aspera L.	20.00	-	240	-	3.00	-	11.65	-
Adhatoda zeylanica Nees.	20.00	40.00	240	320	3.00	2.00	10.63	12.63
Adina cordifolia Hook f.	-	20.00	-	80	-	1.00	-	10.97
Anthocephalus cadamba (Roxb.)	20.00	-	80	-	1.00	-	8.32	-
Boehmeria platyphylla D.Don	100.00	60.00	1120	800	2.80	3.33	49.49	25.24
Boehmeria rugulosa Wedd.	-	20.00	-	80	-	1.00	-	5.63
Callicarpa macrophylla Vahl.	-	40.00	-	160	-	1.00	-	9.86
Cassia fistula Linn.	20.00	-	80	-	1.00	-	6.31	-
Casearia tomentosa (Roxb.)	-	20.00	-	80		1.00	-	4.65
Carissa opaca Stapf.	20.00	20.00	80	160	1.00	2.00	6.25	8.40
Colebrookea oppositifolia Smith	20.00	-	80	-	1.00	-	5.63	-
Flacourtia cataphracta Roxb.	20.00	-	80	-	1.00	-	6.46	-
Lantana camara L.	100.00	100.00	1280	2800	3.20	7.00	61.14	82.76
Mallotus philippensis (Lam.) Muell.-Arg.	40.00	20.00	320	80	2.00	1.00	23.52	5.69
Melia composita Willd. leaf.	20.00	-	80	-	1.00	-	6.38	-
Pinus roxburghii Sargent	80.00	100.00	880	1040	2.75	2.60	60.57	52.21
Toona ciliata M.Reem.	-	20.00	-	80	-	1.00	-	4.95
Tithonia diversifolia Gray.	-	20.00	-	160	-	2.00	-	5.84
Urtica dioica L.	-	40.00	-	240	-	1.50	-	11.46
Vallaris solanacea (Roth) Kuntze, Revis.	20.00	40.00	160	160	2.00	1.00	7.51	9.93
Vitex negundo Linn.	-	20.00	-	80	-	1.00	-	4.33
Wendlandia exerta DC.	-	20.00	-	80	-	1.00	-	4.52
Woodfordia fruticosa Kurz.	40.00	60.00	800	240	5.00	1.00	36.13	19.29

Table 4: Floristic composition of shrubs in 20 years old restored site (site 4)

Shrub species	**Frequency**		**Density ha^{-1}**		**Abundance**		**IVI**	
Year	**Ist**	**IInd**	**Ist**	**IInd**	**Ist**	**IInd**	**Ist**	**IInd**
Adhatoda zeylanica Nees.	20.00	20.00	240	1600	3.00	4.00	11.23	13.11
Agave sisalana Perrine	20.00	-	80	-	1.00	-	6.55	-
Ageratum conyzoides Linn.	20.00	-	80	-	1.00	-	5.23	-
Artemisia vulgaris Linn	20.00	-	80	-	1.00	-	5.50	-
Bidens pilosa L.	20.00	20.00	400	1200	5.00	3.00	11.73	10.79
Boehmeria platyphylla D.Don	40.00	20.00	240	800	1.50	2.00	12.94	10.57
Boehmeria rugulosa Wedd.	20.00	-	240	-	3.00	-	9.61	-
Colebrookea oppositifolia Smith.	20.00	-	80	-	1.00	-	5.94	-
Deutzia staminea R. Br. ex. Wall.	40.00	-	320	-	2.00	-	14.51	-
Eupatorium glandulosum Michx.	20.00	-	160	-	2.00	-	7.44	-
Grewia optiva J. R. Drumm. ex Burret.	20.00	-	80	-	1.00	-	5.97	-
Lantana camara L.	100.00	100.00	1280	2640	3.20	9.80	88.75	156.18
Leucaena leucocephala (Lam.) De Wit	20.00	-	80	-	1.00	-	5.95	-
*Mallotus philippensis (*Lam.) Muell.-Arg.	20.00	40.00	80	600	1.00	1.50	6.65	16.15
Murraya koenigii Spreng.	100.00	100.00	1520	2240	3.80	5.60	84.03	76.93
Murraya paniculata (L) Jacq.	20.00	-	80	-	1.00	-	6.67	-
Syzygium cumini (L.) Skeels	20.00	20.00	80	800	1.00	2.00	5.32	8.75
Vallaris solanacea (Roth) Kuntze, Revis.	-	20.00	-	400	-	1.00	-	7.53
Vitex negundo Linn.	20.00	-	80	-	1.00	-	5.97	-

Table 5: Floristic composition of shrubs in natural forest (site 5)

Shrub species	Frequency		Density ha^{-1}		Abundance		IVI	
Year	Ist	IInd	Ist	IInd	Ist	IInd	Ist	IInd
Adhatoda zeylanica Nees.	100.00	100.00	1280	1680	3.20	4.20	59.84	62.83
Adina cordifolia Hook f.	40.00	20.00	160	80	1.00	1.00	12.28	5.42
Bauhinia variegata L.	40.00	20.00	160	160	1.00	1.00	11.66	10.34
Bauhinia vahlii W. & A.	40.00	-	160	-	1.00	-	12.45	-
Boehmeria platyphylla D.Don	80.00	-	400	-	1.25	-	20.45	-
Bridelia retusa Spreng	20.00	20.00	80	80	1.00	1.00	5.11	4.59
Callicarpa macrophylla Vahl.	40.00	40.00	160	160	1.00	1.00	9.14	8.32
Casearia tomentosa Roxb.	-	40.00	-	160	-	1.00	-	8.81
Cassia fistula Linn.	-	80.00	-	320	-	1.00	-	24.27
Ehretia laevis Roxb.	20.00	-	80	-	1.00	-	8.07	-
Erythrina indica Lam.	60.00	40.00	240	160	1.00	1.00	19.15	11.23
Eupatorium glandulosum Michx.	20.00	60.00	160	240	2.00	1.00	7.79	13.72
Flacourtia cataphracta Roxb.	60.00	40.00	240	160	1.00	1.00	17.57	10.38
Grewia optiva J. R. Drumm. ex Burret.	-	40.00	-	160	-	1.00	-	9.79
Holarrhena antidysenterica Wall.	20.00	20.00	80	80	1.00	1.00	6.95	6.07
Lantana camara L.	40.00	80.00	640	1680	4.00	5.25	27.35	57.55
Mallotus philippensis (Lam.) Muell.-Arg.	40.00	40.00	160	160	1.00	1.00	9.34	8.48
Millettia auriculata Baker.	40.00	40.00	160	160	1.00	1.00	11.29	10.05
Murraya koenigii Spreng.	40.00	60.00	640	800	4.00	3.33	26.98	29.64
Nyctanthes arbor-tristis Linn.	20.00	40.00	80	160	1.00	1.00	5.20	9.34
Pogostemon benghalense (Burm.F.) O.Kuntz.	20.00	-	80	-	1.00	-	4.85	-
Sapium insigne Royle	40.00	-	160	-	1.00	-	8.46	-
Randia dumetorum Lamk.	40.00	40.00	160	160	1.00	1.00	10.21	9.17
Mimosa himalayana Gamble	20.00	-	80	-	1.00	-	5.84	-

In site 3, again maximum IVI values were recorded for *Lantana camara* (61.41 and 82.76) during both the years of study (Table 3). In site 4, highest IVI was recorded for *Lantana camara* (88.75 and 156.18) during both the periods of study while lowest IVI was recorded for *Ageratum conyzoides* (5.23) in the first year of study while *Vallaris solanacea* has the lowest IVI value during the second year of study (Table 4). In the natural forest *Adhatoda zeylanica* showed the maximum IVI (59.84 and 63.83) during both the study period while *Pogestemon benghalense* showed minimum IVI (4.85) during the first year of study while *Adina cordifolia* showed the lowest IVI (5.42) during second year of study (Table 5).

4. Discussion

The examination of data recorded indicates that the pattern of frequency is more even in the restored sites which are also similar to the adjoining natural forest. Among shrub vegetation *Lantana camara* remained the dominant species. *Lantana camara* has invaded the area and in restored sites it has gained the maximum IVI. Bhatt (1990) has reported the presence of planted species like *Eriophorum comosum, Pennisetum purpureum* and *Saccharum spontaneum* after 8 years of restoration in the same area but after 23 years of succession these species has been replaced by higher successional species. The critical examination of the data shows that although some of the planted species like *Agave sisalana, Dodonea viscosa* and *Rumex hastatus* are still present but their density has declined considerably through the entire year of successional development. The widespread dominance of natural invaders like *Eupatorium glandulosum, Desmodium gangeticum Artemisia vulgaris, Boehmeria platyphylla, Woodfordia fruticosa* and *Lantana camara* indicates that the restored site is proceeding towards similar characteristics of the adjacent natural forest. It is interesting to note that while natural invaders recorded an increase in the percentage contribution to overall density, the species introduced initially showed an increasing mortality. These findings support the earlier studies which show that planted species do not persist because local species required less maintenance and provide compatibility with surrounding sites (Luken, 1990).

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