Vegetation composition and diversity of Piluwa micro-watershed in Tinjure-Milke region, east Nepal

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Comparative study of vegetation structure and composition of two forests at Tamafok (TF) and Madimulkharka (MM) villages in the Piluwa micro-watershed was undertaken. A total of 20 tree species were reported, with more species in the non-degraded TF forest than in the degraded MM forest. *Rhododendron arboreum* and *Goldfussia penstemonoides* were the dominant species in the TF forest, whereas *Quercus semecarpifolia* and *Rhododendron arboreum* were dominant in the MM forest. The total density of trees in the TF forest (756 ha^{-1}) was higher than that at MM (346 ha^{-1}). Similarly, tree basal area in the TF forest (69.8 $m^2 \cdot ha^{-1}$) was greater than at MM (56.9 $m^2 \cdot ha^{-1}$). Shrub density was also higher in the TF forest than at MM. Diversity indices for both trees (2.61) and shrubs (0.915) in the TF forest showed higher values in comparison to MM (2.4, 0.854). Concentration of dominance of the tree species was stronger in the MM forest (0.266) as compared to TF (0.258). The regeneration potential was higher in the degraded MM forest than in the relatively undisturbed TF forest. Seedling-sapling density was lower in undisturbed and mature forest which had closed canopy.

Key words: Forest structure, degradation, species richness, dominance

Him J Sci 2(3): 29-32, 2004
Available online at: www.himjsci.com

Received: 18 Apr 2003
Accepted after revision: 15 Apr 2004

The species richness of the forests of eastern Nepal has been documented in a number of studies over the past 150 years, from Hooker's initial explorations (1854) to more recent works, including Schweinfurth (1957), Hara and William (1979), Stainton (1972), Dobremez and Shakya (1975), Numata (1980), Oshawa et al. (1986) and Shrestha (1989). Eastern Nepal is rich in floral and faunal diversity (Numata 1980, DNPWC 1995, Ali 1977, and Carpenter and Zomer 1996). Extensive forest stands at late succession stage with closed canopy are present throughout Makalu-Barun Conservation Area, especially above 2000 m asl. At lower elevations, spatially limited but ecologically significant stands are found within locally protected *raniban* forest and in corridors of near-tropical riparian forest within deep river valleys that penetrate a considerable distance into the conservation area.

Forests in the Himalaya are under pressure, from both internal (e.g. over exploitation of forest resources for livelihood) and external forces (e.g. over flow of tourists), with adverse impacts on the supply of forest resources such as fuelwood, fodder, timber and non-timber forest products as well as on forest-based government revenues (Eckholm 1982, Pandey and Singh 1984, Ramakrishnan 1992). The increasing flow of tourists has further increased pressure on forest resources (Ives 1988, Thapa and Weber 1990). Studies have shown that deforestation in the Himalaya has implications for agriculture not only in the adjoining hills and mountains, but also in the plains far below (Pandey and Singh 1984, Mahat et al. 1986, Virgo and Subba 1994).

The high rate of seedling survival in the shade of late successional species and the contrasting low rate of seedling survival in the shade of early successional species are related to these species' adaptation to different light regimes in the forest community (Ramakrishnan et al. 1982). In a forest ecosystem, if a disturbance is small, suitable microclimatic conditions may remain prevalent in scattered pockets, leading to germination and establishment of large number of species (Sundriyal and Sharma 1996).

In the present study, vegetation structure and composition of two forests lying at adjacent villages, Tamafok (TF) and Madimulkharka (MM) are compared. TF forest is characterized by low intensity degradation while MM forest by high intensity degradation. The study site falls within the Piluwa watershed of Tinjure-Milke region in eastern Nepal.

Methods

Study area

The study area (27°12' N, 87°27' E), covering 24.69 km^2, represents part of the Piluwa watershed and includes the two villages (Tamafok and Madimulkharka). The land use of the study area is 41.9% forest, 54.4% agriculture land, 2.3% grassland and others 1.4% (Koirala 2002). The altitude ranges from 2200 to 3100 m asl, with slopes of 15° to 45°. The soil is dark brown to black, acidic (pH 4.3 – 5.3), with a high proportion of sand and silt, and is podzolic (Koirala 2002). The study area has three distinct seasons: a short summer (April to June), monsoonic rainy season (July to October) and cold winter (November to March). Currently, this area is under consideration as a *Rhododendron* Conservation Area (HMG/MOPE 1998). This area leads to the Makalu-Barun National Park toward the northwest and Kanchenjunga Conservation Area to the northeast (Kanchenjunga Conservation Area is closer to Qomolonga Nature Reserve in Tibet, China). For this reason, the present study area is considered a critical habitat corridor for many rare and endangered wildlife species.

Sampling

Vegetation analysis of forests in various stages of degradation was undertaken using 30 quadrats in each forest. The standard quadrat sizes were 10 m x 10 m for trees, 5 m x 5 m for shrubs and 1 m x 1 m for herbs. Frequency, density, basal area and Importance Value Index (IVI) of each species were analyzed as suggested by Mishra (1968) and Kershaw (1973). Regeneration of tree species ➡

was calculated by counting seedlings (height = 20 cm) and saplings (height > 20 cm but diameter at breast height (dbh) < 10 cm) following Sundriyal and Sharma (1996). Diversity Index (H') was calculated following Shannon and Weaver (1949) and concentration of dominance (cd) of species was calculated following Simpson (1949). The field study was conducted during January – December 2000. Since the present findings are part of an integrated study, observations were carried out over a period of 12 calendar months, with a maximum lacuna of 4 weeks during the snowfall period. Identification of plant species was carried out following the standard literature (APROSC 1991, DFPR 1993). Nomenclature followed DPR (2001).

Results

Forest structure

A total of 20 tree species were found in the study area, with higher species richness and canopy cover (>70%) in the TF forest. Nine tree species were common in both forests (**Table 1**). Density and basal area were higher in the TF forest (756 ha^{-1} and 69.8 $m^2 \cdot ha^{-1}$) than in MM (346 ha^{-1} and 56.9 $m^2 \cdot ha^{-1}$). *Rhododendron arboreum* Smith, *Goldfussia pentastemonoides* Nees and *Lyonia ovalifolia* (Wall.) Drude were dominant tree species at TF, whereas *Quercus semecarpifolia* Sm., *R. arboreum* and *L. ovalifolia* were dominant at MM. *R. arboreum* has been conserved under the management of the local Laligurans (Nepali name for *R. arboreum*) Conservation Group. The mean volume of standing trees was similar in these two forests: TF = 373.08 ± 88.9 $m^3 \cdot ha^{-1}$, MM = 371.14 ± 65.5 $m^3 \cdot ha^{-1}$ (**Table 1**).

Five species of shrubs were recorded in both forests (**Table 2**). The density of shrubs was higher in the TF forest. *Rhamnus napalensis* (Wall.) Lawson, *Daphne bholua* Buch.-Ham. ex D. Don. and *Thamnocalamus spathiflorus* (Trin.) Munro were common and dominant in both forests but at higher densities at TF. *Desmodium microphyllum* (Thunb.) DC. and species A (unidentified) were present only in the MM forest, while *Calamus acanthospathus* Griff. as well as an unidentified species were present only in TF.

Species diversity and regeneration

The diversity index for both trees and shrubs was slightly higher in the TF forest (2.61 and 0.915) than in MM (2.4 and 0.854), although the concentration of dominance was stronger in MM (**Table 3**). The diversity index of tree species was almost three times that of shrubs in the same forest. The regeneration potential (density of seedlings and saplings) was higher in the MM forest than in TF (**Table 4**). However, a few tree species were represented only by large trees without any seedlings or saplings (e.g. *Ischaemum rugosum* Salisb. and *Quercus glauca* Thunb.). Seedling and sapling distribution did not correspond to mature tree distribution. *Berberis aristata* Roxb. ex Dc. and *Viburnum continifolium* D. Don were the dominant regenerating species in the TF forest, whereas *R. arboreum* and *Symplocos pyrifolia*

TABLE 1. Density (tree ha^{-1}), basal area (m^2 ha^{-1}) and Importance Value Indices (IVI) of tree species in Tamafok (TF) and Madimulkharka (MM) forests, Tinjure - Milke region, Nepal

Species	Local name	Tamafok (TF)			Madimulkharka (MM)		
		Density	Basal area	IVI	Density	Basal area	IVI
Berberis aristata DC.	Chutro	-	-	-	3	0.23	2.9
Castanopsis indica (Roxb.) Miq	Dhalne Katus	-	-	-	3	0.03	2.5
Goldfussia pentastemonoides Nees	Angare	117	6.7	46.6	23	3.3	33.4
Ischaemun rugosum Salisb	Mallido	13	0.8	3.3	-	-	-
Loranthus adoratus Wall.	Kandeliso	3	2.7	5.5	-	-	-
Lyonia ovalifolia (Wall.) Drude	Angeri	107	6.7	39.0	60	2.1	37.2
Osmanthus suavis King ex C.B. Clarke	Shillinge	70	3.8	21.0	3	0.03	2.5
Pilea symmeria Wedd.	Kamale	-	-	-	7	0.07	3.8
Quercus glauca Thunb.	Falat	10	0.7	4. 9	3	0.97	4.2
Quercus semecarpifolia Sm.	Khasru	20	7.6	20.0	147	37.3	140.3
Rhododendron arboreum Smith	Laliguras	340	35.1	116.1	77	12.4	58.6
Rhododendron grande Wight	Guras	7	0.2	3.8	-	-	-
Rhododendron hodgsonii Hook.f.	Guras	10	0.6	4.8	7	0.1	5.5
Symplocos pyrifolia Wall.	Kholme	10	0.3	4.2	7	0.23	4.1
Symplocos ramosissima Wall.	Kharane	23	1.5	12.8	3	0.07	2.6
Taxus baccata Linn.	Dhyangre sallo	3	1.1	3.2	-	-	-
Viburnum nervosum D. Don	Asare	13	0.5	7.5	-	-	-
Viburnum continifolium D. Don	Bakalpate	-	-	-	3	0.03	2.5
Miscellaneous (n = 2)		10	1.5	7.3	-	-	-
Total		**756**	**69.8**	**300**	**346**	**56.9**	**300**

Mean ± S.E. of volume of trees (m^3 ha^{-1}): TF = 373.08 ± 88.9; MM = 371.14 ± 65.5

TABLE 2. Density (number ha^{-1}) of shrub species in Tamafok (TF) and Madimulkharka (MM) forests, Tinjure - Milke region, Nepal

Species	Local name	TF	MM
Calamus acanthospathus Griff.	Betkanda	200	-
Daphne bholua Buch.-Ham. ex D.Don	Lokta	4066	3812
Desmodium microphyllum (Thunb.) DC.	Bakhreghas	-	67
Rhamnus napalensis (Wall.) Lawson	Chillikath	32632	20222
Thamnocalamus spathiflorus (Trin.) Munro	Malingo	3146	587
Species A (unidentified)	Musakane	-	160
Miscellaneous (n = 1)		40	
Total		**40084**	**24848**

TABLE 3. Diversity and dominance of tree species in Tamafok (TF) and Madimulkharka (MM) forests, Tinjure - Milke region, Nepal

Parameters		TF	MM
Diversity Index (H')	Trees	2.61	2.4
	Shrubs	0.915	0.854
Concentration of dominance (cd)		0.258	0.266

TABLE 4. Sapling-seedling density (number ha^{-1}) of tree species in Tamafok (TF) and Madimulkharka (MM) forests, Tinjure - Milke region, Nepal

Species	TF	MM
Berberis aristata DC.	4932	1346
Castanopsis sp.	-	27
Eurya cerasifolia (D.Don.) Kobuski	-	40
Ficus neriifolia Sm.	-	27
Garuga pinnata Roxb.	-	27
Goldfussia pentastemonoides Nees	533	693
Lyonia ovalifolia (Wall.) Drude	133	866
Helixanthera parasitica Lour	13	13
Mahonia acanthifolia G.Don	67	-
Osmanthus suavis King ex C.B. Clarke	147	67
Quercus semecarpifolia Sm.	360	1280
Rhododendron arboreum Smith	80	1626
Symplocos pyrifolia Wall.	587	1586
Symplocos ramosissima Wall.	1573	387
Viburnum continifolium D. Don	2399	1067
Viburnum nervosum D. Don	-	120
Miscellaneous (n=2)	200	2026
Total	**11024**	**11198**

Wall. were the dominant regenerating species in MM. The number of regenerating species and sapling–seedling density both were higher in the MM forest. *S. pyrifolia*. and *S. ramossima* Wall. had the highest sapling-seedling/tree ratio, indicative of the highest regeneration potential (**Table 5**). The ratio was 58.7 and 226.6 for *S. pyrifolia* in the TF and MM forests, respectively. Similarly, the ratio for *S. ramosissima* in the TF and MM forests was 68.4 and 129.0 respectively. The ratio for *R. arboreum* was low (0.24) in the TF forest but it was 21 in MM.

Discussion

Forest structure

The differences in the structure and composition of the two forests arise out of differences in their disturbance regimes and ecological niche of dominant species. Forest MM, which is closer to a settlement, experiences higher pressure in the form of fuelwood and fodder collection by local inhabitants. This pressure has reduced tree density and basal area. The higher density and basal area of *R. arboreum* in TF may also be due to conservation by local Laligurans Conservation Goup. It is the national flower of Nepal. Felling the trees of *R. arboreum* was not allowed in the study area. The differences in dominant species between the two forests can more readily be attributed to the ecological specificities of the species (aspect, photoperiodism, etc.) than to the disturbance regimes. The dominance of *Q. semecarpifolia* in the MM forest may be related to high moisture content of soil at lower elevation (Koirala 2002). On the other hand, *R. arboreum* occurs at higher elevations (Shrestha 1989, Sundriyal and Sharma 1996, Chaudhary 1998). This study site showed high tree species richness, a characteristic of the eastern Himalaya (Dobremez and Shakya 1975, Shrestha 1989, Sundriyal and Sharma 1996, Carpenter and Zomer 1996). Higher diversity indices of tree species compared to shrub species in both the TF and MM forests may be attributed to the ecological succession still in the process of stabilization in both ecosystems (Sundriyal and Sharma 1996, Carpenter and Zomer 1996).

Forest regeneration

Seedling germination and establishment are related to the availability of space created through perturbation and to adaptation to particular light regimes (Ramakrishnan et al. 1982). The regeneration potential of disturbed MM forest was higher than that of relatively undisturbed TF forest. An open canopy caused by mild disturbance to the forest allows the growth of seedlings and saplings, which ensures sustainable regeneration. However, in a mature forest with closed canopy, seedling establishment is constrained by lower light intensity on the ground surface. The fact that tree species are well-represented at the

TABLE 5. Number of sapling-seedling per tree in Tamafok (TF) and Madimulkharka (MM) forests, Tinjure - Milke region, Nepal

Species	TF	MM
Goldfussia pentastemonoides Nees	4.6	30.1
Lyonia ovalifolia (Wall.) Drude	1.24	14.43
Osmanthus suavis King ex C.B. Clarke	2.1	22.3
Quercus semecarpifolia Sm.	18.0	8.7
Rhododendron arboreum Smith	0.24	21.12
Symplocos pyrifolia Wall.	58.7	226.6
Symplocos ramosissima Wall.	68.4	129.0

adult stage but not as seedlings indicates a high light requirement (Borman and Likens 1979, Sundriyal and Sharma 1996). A very old and stable climax *Rhododendron* forest community with closed canopy might be the reason for a very low sapling-seedling/tree ratio for that species. Similarly, the higher sapling-seedling/tree ratio of *Symplocos* and *Quercus* indicates that these species may replace *Rhododendron* and become dominant in future.

Conclusion

The difference in structure and composition of the two forests studied arises out of differences in their disturbance regimes and microclimatic conditions. Forest MM, which is closer to a residential area, experienced higher pressure in the form of fuelwood and fodder collection, had lower density and basal area than the relatively undisturbed TF forest. However, due to the open canopy of MM forest, the seedling-sapling growth and regeneration potential were higher. Furthermore, the higher density and basal area of *Rhododendron arboreum* in TF may be due to conservation by society, as this is the national flower of Nepal. ■

Acknowledgements

The author acknowledges the financial assistance for this study provided by University Grants Commission, Nepal, and the creative comments of Eklabya Sharma, ICIMOD.

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