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Floristic composition and diversity in Upper Manaslu Conservation Area, Central Nepal

Rita Chhetri[1*] and Prakash Bhattarai[2]

[1]*National Herbarium and Plant Laboratories, Lalitpur, Nepal*
[2]*Central Department of Botany, Tribhuvan University, Kirtipur, Nepal*

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ABSTRACT

This study presents the floristic composition pattern of Manaslu Conservation Area (MCA), Central Nepal. We recorded a total of 161 species from 70 different sampling plots within an altitudinal range of 1400 m between 3000-4400 m. The study area has found to be dominated by the family Asteraceae with 12 genera and 20 species followed by Ranunculaceae with 5 genera and 13 species. The frequency distribution of *Potentilla cuneata* and *Viola biflora* were found the highest among all those recorded species, and the most dominant species. Detrended Correspondence Analysis (DCA) was used to analyse the distribution and composition patterns of species. A unimodal relationship of the species composition was found with altitude.

Key words: DCA diagram, eigen value, altitudinal gradient, unimodal relationship

INTRODUCTION

Nepal comprises 0.09 % of global land area that possesses disproportionately a huge diversity of flora and fauna (HMG/MFSC 2002). This diversity is manifested by the tropical forests in the Terai, the deciduous and coniferous forests in the subtropical and temperate regions and the meadows and grasslands at the high altitude subalpine and alpine regions of Nepal. The subalpine and alpine regions of the Nepalese Himalayas are rich in floristic diversity. Therefore, subalpine and alpine regions are considered as an ideal place to carry out further scientific researches (Korner, 2000).

Altitude increases/changes as one ascends up from tropical to the subalpine and alpine regions. This affects physiographical, topographical and environmental factors that influence the floristic composition and diversity of that area (Ellu and Obua, 2005). Diversity of life-forms i.e., floristic composition usually changes with change in altitude and remains one or two life-forms at extreme altitudes (Pavon, *et al.,* 2000). Floristic diversity varies with life-forms or functional groups of plants such as woody and herbaceous, monocots and dicots (Peet, 1978; Bhattarai and Veetas, 2003), pteridophyte (Jacobsen and Jacobsen, 1989; Bhattarai, *et al.,* 2004a; Kluge *et al.,* 2006), bryophytes (Grau *et al.,*2007), lichens (Baniya *et al.,* 2010) and orchids (Acharya *et al.,*2011).

Floristic diversity and composition along the altitudinal gradient had been a subject of ecosystem. Various researches had been carried out in different parts of the country to explore the floristic composition including all the vegetation and habitat types. Bhattarai and Vetaas (2003) studied the floristic composition and richness along the subtropical altitudinal gradient from east Nepal, Streade *et al.*(2002) from Royal Chitwan Natioanl Park including the natural and community forest, Subedi and Shakya (1993) in Oak Forest of Rasuwa district. Grytnes and Vetaas (2002), Panthi *et al.*(2007), Bhatt and Lekhak (2009), Baniya (2010) had also carried out the similar work in the subalpine and alpine areas. Recently, Joshi and Khadka (2013) had studied the floristic compostion and species diversity on lowlands of Siwalik and Churia regions. Similarly, Bhattarai and Vetaas (2013) had focussed their study on the herbaceous species composition and diversity in different land types of Eastern Nepal.

Manaslu Conservation Area is one of the remote conservation areas in Nepal. This area declared as conservation area in 1998, since then scientific researches on this area are emerging. King Mahendra Trust for Nature Conservation (1998) carried out the feasibility study of this area during the declaration as the conservation area that estimated an occurrence of about 1500- 2000 plant species. The main objective of this study is to document the floristic composition patterns of species encountered between 3000-4400 m in Manaslu Conservation Area, Central Nepal especially at two VDCs, Samagaun and Lho.

MATERIALS AND METHODS

STUDY AREA

This study was conducted at areas belonged to two Village Development Committees (VDCs), namely Samagaun and Lho of Manaslu Conservation Area, Gorkha District of Central Nepal (Figure 1). Both VDCs lie at the northern part of this district and fall under the subalpine and alpine vegetation zones of Nepal.

*Corresponding Author's E-mail: ritachhetrinhpl@gmail.com

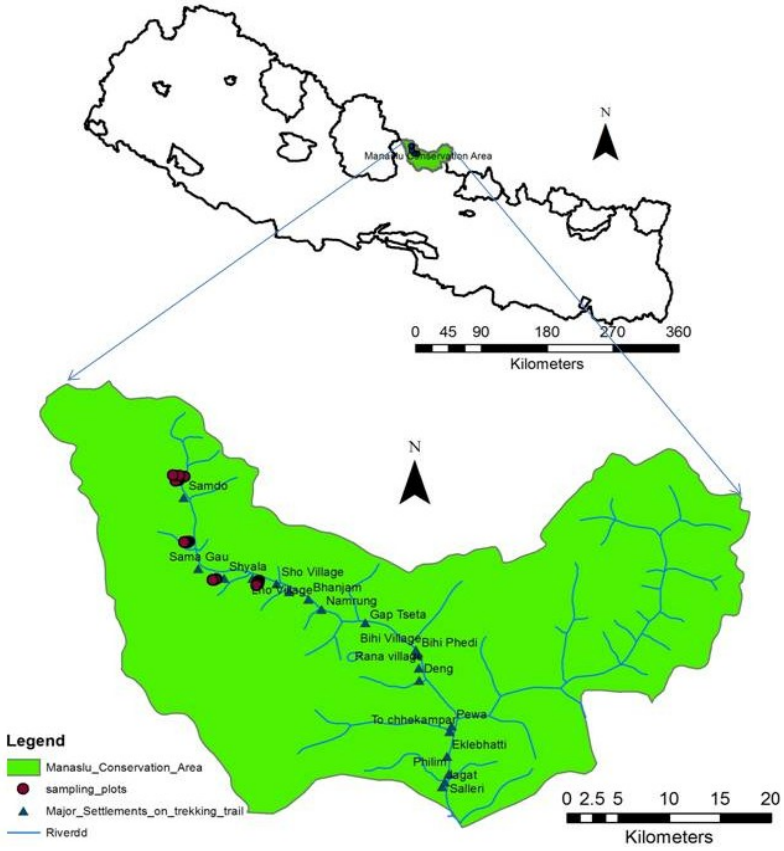

Figure 1. Location Map of the study area with black dots representing studied areas.

Manaslu Conservation Area (MCA) represents an ideal place for the diverse flora and fauna, their scenic beauties and vegetation due to their sharp altitudinal difference and abundance of different topographies and microclimatic conditions. The KMTNC (1998) categorized the flora of MCA into 19 different forest types and about 1500-2000 species of flowering plants species. This study area is dominated by conifer forests. The Buri Gandaki Valley at Lho is also well known as the Land of Conifer Diversity (KMTNC, 1998). Some other species of this vegetation zone are *Picea smithiana*, *Larix himalaica*, *Tsuga dumosa*, *Abies spectabilis*, *Pinus wallichiana* and *Juniper* species. This area also harbors several species of *Rhododendron*, *Betula utilis* forest, alpine meadows and grasslands.

DATA COLLECTION

Preliminary study of finding study sites, selecting sampling areas and some basic information of local flora were carried out during December 12-30, 2009. Second visit was conducted during October 15-30, 2010 and all the necessary data were collected.

A semi-systematic representative sampling method was applied to collect the floristic diversity in all the possible habitats and vegetation types ranging from 3000 - 4000 m altitude. Abundance of each species quantified at 10 × 10 m² quadrat laid at an interval of 100 m elevation and a total of 5 times at a single elevational band. The species presence data were recorded and plant specimens were collected. A total of 70 sampling plots were laid to cover the whole study area. Latitude, Longitude, altitude, slope and aspect of each sampling plots were recorded. Correct identification of all collected specimens was done by comparing each herbarium specimens deposited at Tribhuvan University Central Herbarium, Kirtipur (TUCH), and National Herbarium and Plant Laboratories, Godavari (KATH). The plants were also identified after consulting relevant literature such as: Polunin and Stainton (1984), Stainton (1997), Grierson and Long (1983-2001), Noltie (1994, 2000 and 2002), etc. The nomenclature of each species was validated after using the latest taxonomic literature (Press *et al.,* 2000).

Further, frequency of each individual species and their dominance were calculated. All collected species were classified as dicot, monocot and gymnosperms. Besides that the dominant families and their broad life-form categories: trees, shrubs and herbs were also categorized. Floristic composition of the whole study area was analyzed through the Detrended Correspondence Analysis (DCA; Hill and Gouch 1980). DCA is an explorative weightage average technique (Jongman *et al.,* 1995). Each sample and species disperse in their space based upon their weightage average. CANACO version 4.5 (ter Braak, 2002) and its graphical program CANOCO DRAW (Šmilauer, 2002) were used to analyze the compositional pattern from the data set.

RESULTS

A total of 161 species (Table 1) were recorded from 70 different sampling plots of the study. Altogether, this study represented 44 families, 93 genus and 161 species. Among them the most dominant family was the Asteraceae (12 genera, 20 species), followed by

Table 1. List of recorded Plant species with their family, habit, frequency and geographical location.

Sl No.	Plant Species	Family	Habit	Life-forms	Abbrev.	Fre-quency	Latitude (°)	Longitude (°)
1	*Abies spectabilis* (D.Don) Mirb.	Pinaceae	Tree	Gymno-sperm	*Abi spe*	42.857	28.6076	84.6366
2	*Acer acuminatum* Wall. ex D. Don	Aceraceae	Tree	Dicot	*Ace acu*	4.285	28.5702	84.7064
3	*Acer campbelli* Hook. F. and Thomson ex Hiern	Aceraceae	Tree	Dicot	*Ace cam*	4.285	28.5702	84.7064
4	*Aconitum bishma* (Buch.-Ham.) Rapaics	Ranunculaceae	Herb	Dicot	*Aco bis*	18.571	28.6075	84.6338
5	*Aconitum dhowjii* Lauener	Ranunculaceae	Herb	Dicot	*Aco dho*	7.142	28.6687	84.6234
6	*Aconitum ferox* Wall. ex Ser.	Ranunculaceae	Herb	Dicot	*Aco fer*	21.428	28.6072	84.6358
7	*Aconitum nepalense* Lauener	Ranunculaceae	Herb	Dicot	*Aco nep*	15.714	28.6687	84.6234
8	*Aconitum spicatum* (Bruhl) Stapf	Ranunculaceae	Herb	Dicot	*Aco spi*	15.714	28.6072	84.6358
9	*Aconogonon molle* (D. Don) H. Hara	Polygonaceae	Herb	Dicot	*Aco mol*	31.428	28.568	84.7056
10	*Actaea spicata* (Wall. ex Royle) H. Hara	Ranunculaceae	Herb	Dicot	*Act spi*	20	28.568	84.7056
11	*Allium przewalskianum* Regel	Amaryllidaceae	Herb	Monocot	*All prz*	22.857	28.6687	84.6234
12	*Allium wallichi* Kunth	Amaryllidaceae	Herb	Monocot	*All wal*	20	28.6076	84.6366
13	*Anaphalis contorta* (D. Don) Hook.f.	Asteraceae	Herb	Dicot	*Ana con*	37.142	28.6078	84.6352
14	*Anaphalis subumbellata* C.B. Clarke	Asteraceae	Herb	Dicot	*Ana sub*	8.571	28.6687	84.6234
15	*Anaphalis triplinervis* (DC.) Airy Shaw	Asteraceae	Herb	Dicot	*Ana tri*	44.285	28.6677	84.6334
16	*Andropogan munroi* C. B. Clarke	Poaceae	Herb	Monocot	*And mun*	20	28.6687	84.6234
17	*Androsace lehmannii* Wall. ex Duby	Primulacea	Herb	Dicot	*And leh*	35.714	28.6645	84.6276
18	*Androsace sarmentosa* Wall.	Primulacea	Herb	Dicot	*And sar*	25.714	28.6072	84.6358
19	*Androsace strigillosa* Franch.	Primulacea	Herb	Dicot	*And str*	27.142	28.6645	84.6276
20	*Arisaema jacquemontii* Blume	Araceae	Herb	Monocot	*Ari jac*	5.714	28.6072	84.6358
21	*Artemisia dubia* Wall. ex Besser	Asteraceae	Herb	Dicot	*Art dub*	5.714	28.5919	84.7275
22	*Artemisia gmelinii* Weber ex Stechm.	Asteraceae	Herb	Dicot	*Art gme*	30	28.568	84.7056
23	*Arundinella hookerii* Munro ex Keng	Poaceae	Herb	Monocot	*Aru gme*	12.857	28.5689	84.7065
24	*Aster albescens* (DC.) Hand.-Mazz.	Asteraceae	Herb	Dicot	*Ast alb*	28.571	28.6076	84.6363
25	*Aster sikkimensis* Hook.	Asteraceae	Herb	Dicot	*Ast sik*	10	28.5708	84.7070
26	*Aster himalaicus* C.B. Clarke	Asteraceae	Herb	Dicot	*Ast him*	18.571	28.6076	84.6366
27	*Astilbe rivularis* Buch.-Ham. ex D. Don	Saxifragaceae	Herb	Dicot	*Ast riv*	22.857	28.5708	84.7070
28	*Astragalus melanostachys* Benth. ex Bunge	Fabaceae	Herb	Dicot	*Ast mel*	42.857	28.6687	84.6234
29	*Astragalus floridus* Benth. ex Bunge	Fabaceae	Herb	Dicot	*Ast flo*	20	28.5725	84.6607
30	*Berberis aristata* DC.	Berberidaceae	Shrub	Dicot	*Ber ari*	2.857	28.5919	84.7275
31	*Berberis erythroclada* Ahrendt	Berberidaceae	Shrub	Dicot	*Ber ery*	31.428	28.6076	84.6338
32	*Berberis mucrifolia* Ahrendt	Berberidaceae	Shrub	Dicot	*Bet muc*	34.285	28.6076	84.6338
33	*Betula utilis* D. Don	Betulaceae	Tree	Dicot	*Bet uti*	38.571	28.6645	84.6276
34	*Bistorta affinis* (D. Don) Greene	Polygonaceae	Herb	Dicot	*Bis aff*	20	28.6076	84.6338
35	*Bistorta amplexicaulis* (D. Don) Gree-ne	Polygonaceae	Herb	Dicot	*Bis amp*	21.428	28.5678	84.7053
36	*Bistorta emodi* (Meisn.) H. Hara	Polygonaceae	Herb	Dicot	*Bis emo*	14.285	28.6677	84.6334
37	*Bistorta macrophylla* (D. Don) Sojak	Polygonaceae	Herb	Dicot	*Bis mac*	12.857	28.6677	84.6334

38	*Bistorta vaccinifolia* (Wall. ex Meisn.) Greene	Polygonaceae	Herb	Dicot	*Bis vac*	21.428	28.6686	84.6248
39	*Cassiope fastigiata* (Wall.) D.Don	Ericaceae	Shrub	Dicot	*Cas fas*	14.285	28.6645	84.6276
40	*Caragana brevispina* Royle	Fabaceae	Shrub	Dicot	*Car bre*	5.714	28.5919	84.7275
41	*Caragana gerardiana* Royle	Fabaceae	Shrub	Dicot	*Car ger*	50	28.5919	84.7275
42	*Caragana sukiensis* C.K. Schneid.	Fabaceae	Shrub	Dicot	*Car suk*	14.285	28.5919	84.7275
43	*Carex atrofusca* (Boott) T. Koyama	Cyperaceae	Herb	Monocot	*Car atr*	15.714	28.6656	84.6266
44	*Carex cruenta* Nees	Cyperaceae	Herb	Monocot	*Car cru*	10	28.6656	84.6266
45	*Carex filicina* Nees	Cyperaceae	Herb	Monocot	*Car fil*	67.142	28.6075	84.6326
46	*Carex gracilenta* Bott ex Strachey	Cyperaceae	Herb	Monocot	*Car gra*	12.857	28.5734	84.6645
47	*Ceropegia pubescens* Wall.	Asclepiadaceae	Herb climber	Dicot	*Cer pub*	14.285	28.5919	84.7275
48	*Cirsium falconeri* (Hook.f.) Petr.	Asteraceae	Herb	Dicot	*Cir fal*	25.714	28.6656	84.6266
49	*Clematis barbellata* Edgew.	Ranunculaceae	Woody climber	Dicot	*Cle bar*	10	28.5702	84.7036
50	*Clematis montana* Buch.-Ham. ex DC.	Ranunculaceae	Woody climber	Dicot	*Cle mon*	17.142	28.5689	84.7065
51	*Codonopsis rotundifolia* Benth.	Campanulaceae	Herb	Dicot	*Cod rot*	8.571	28.5689	84.7065
52	*Coeloglossum viride* (L.) hartm.	Orchidaceae	Herb	Monocot	*Coe vir*	34.285	28.5689	84.7065
53	*Corydalis flaccida* Hook. f. and Thomson	Papaveraceae	Herb	Dicot	*Cor fla*	7.142	28.5678	84.7053
54	*Corydalis juncea* Wall.	Papaveraceae	Herb	Dicot	*Cor jun*	17.142	28.6686	84.6236
55	*Cotoneaster frigidus* Wall. ex Lindl.	Rosaceae	Shrub	Dicot	*Cot fri*	7.142	28.5919	84.7275
56	*Cotoneaster microphyllus* Wall. ex Lindl.	Rosaceae	Shrub	Dicot	*Cot mic*	47.142	28.6686	84.6236
57	*Cremanthodium nepalense* Kitam.	Asteraceae	Herb	Dicot	*Cre nep*	4.285	28.5919	84.7275
58	*Cremanthodium oblongatum* C.B. Clarke	Asteraceae	Herb	Dicot	*Cre obl*	18.571	28.6978	84.6352
59	*Cremanthodium purpureifolium* Kitam.	Asteraceae	Herb	Dicot	*Cre pur*	21.428	28.6978	84.6352
60	*Cremanthodium reniforme* (DC.) Benth.	Asteraceae	Herb	Dicot	*Cre ren*	21.428	28.6978	84.6352
61	*Crepis himalaica* Kitam.	Asteraceae	Herb	Dicot	*Cre him*	18.571	28.6645	84.6276
62	*Cyathula capitata* Moq.	Amaranthaceae	Shrub	Dicot	*Cya cap*	4.285	28.5919	84.7275
63	*Cynanthus lobatus* Wall. ex Benth	Campanulaceae	Herb	Dicot	*Cyn lob*	30	28.6645	84.6276
64	*Dactylorhiza hatagirea* (D. Don) Soo	Orchidaceae	Herb	Monocot	*Dac hat*	11.428	28.6076	84.6366
65	*Delphinium denudatum* Wall. ex Hook.f.	Ranunculaceae	Herb	Dicot	*Del den*	5.714	28.5730	84.6639
66	*Delphinium himalayai* Munz	Ranunculaceae	Herb	Dicot	*Del him*	45.714	28.6076	84.6366
67	*Ephedra gerardiana* Wall. ex Stapf	Ephedraceae	Shrub	Gymnosperm	*Eph ger*	14.285	28.6645	84.6276
68	*Epilobium latifolium* P. H. Raven	Onagraceae	Herb	Dicot	*Epi lat*	15.714	28.6078	84.6358
69	*Euphorbia stracheyi* Boiss.	Euphorbiaceae	Herb	Dicot	*Eup str*	22.857	28.5919	84.7275
70	*Fragaria nubicola* Lindl. ex Lacaita	Rosaceae	Herb	Dicot	*Fra nub*	94.285	28.5919	84.7275
71	*Fritillaria cirrhosa* D. Don	Lilaceae	Herb	Monocot	*Fri cir*	34.285	28.5717	84.7071
72	*Galium paradoxum* Maxim.	Rubiaceae	Herb	Dicot	*Gal par*	32.857	28.5734	84.6645
73	*Gentiana depressa* D. Don	Gentianaceae	Herb	Dicot	*Gen dep*	94.285	28.6076	84.6366
74	*Gentiana ornata* (G. Don) Griseb.	Gentianaceae	Herb	Dicot	*Gen orn*	67.142	28.6645	84.6276
75	*Geranium nepalense L.*	Geraniaceae	Herb	Dicot	*Ger nep*	50	28.5919	84.7275

76	*Geranium pratense* L.	Geraniaceae	Herb	Dicot	*Ger pra*	50	28.6978	84.6352
77	*Gerbera nivea* (DC.) Sch. Bip.	Asteraceae	Herb	Dicot	*Ger niv*	91.428	28.6687	84.6239
78	*Hedysarum kumaonense* Benth. ex Baker	Fabaceae	Herb	Dicot	*Hed kum*	35.714	28.5679	84.7055
79	*Heracleum lallii* C. Norman	Apiaceae	Herb	Dicot	*Her lal*	32.857	28.5687	84.7059
80	*Hippophae salicifolia* D. Don	Elaeagnaceae	Tree or shrub	Dicot	*Hip sal*	12.857	28.5679	84.7055
81	*Hippophae tibetana* Schltdl.	Elaeagnaceae	Tree or shrub	Dicot	*Hip tib*	14.285	28.6645	84.6276
82	*Hypericum elodioides* Choisy	Guttiferae	Shrub	Dicot	*Hyp elo*	18.571	28.5734	84.6645
83	*Inula hookeri* C.B. Clarke	Asteraceae	Herb	Dicot	*Inu hoo*	45.714	28.5919	84.7275
84	*Iris clarkei* Baker ex Hook. f.	Iridaceae	Herb	Monocot	*Iri cla*	41.428	28.5919	84.7275
85	*Iris stantonii* H. Hara	Iridaceae	Herb	Monocot	*Iri sta*	15.714	28.5734	84.6645
86	*Iris kemaonensis* D. Don ex Royle	Iridaceae	Herb	Monocot	*Iri kem*	48.571	28.5734	84.6645
87	*Juniperus communis* L.	Cupressaceae	Shrub	Gymno-sperm	*Jun com*	77.142	28.5687	84.7059
88	*Juniperus indica* Bertol.	Cupressaceae	Shrub	Gymno-sperm	*Jun ind*	11.428	28.6078	84.6358
89	*Juniperus macropoda* Boiss.	Cupressaceae	Tree	Gymno-sperm	*Jun mac*	4.2857	28.6078	84.6358
90	*Juniperus recurva* Buch.- Ham. ex D. Don	Cupressaceae	Shrub	Gymno-sperm	*Jun rec*	54.285	28.6078	84.6358
91	*Juniperus squamata* Buch.- Ham. ex D. Don	Cupressaceae	Shrub	Gymno-sperm	*Jun squ*	77.142	28.5919	84.7275
92	*Kobresia duthiei* C.B. Clarke in Hook.f.	Cyperaceae	Herb	Monocot	*Kob dut*	57.142	28.6078	84.6358
93	*Kobresia fragilis* C.B. Clarke	Cyperaceae	Herb	Monocot	*Kob fra*	57.142	28.5687	84.7059
94	*Kobresia laxa* Nees	Cyperaceae	Herb	Monocot	*Kob lax*	41.428	28.5687	84.7059
95	*Kobresia nepalensis* (Nees) Kuk.	Cyperaceae	Herb	Monocot	*Kob nep*	30	28.6677	84.6334
96	*Larix himalaica* W.C. Cheng and L.K. Fu	Pinaceae	Tree	Gymno-sperm	*Lar him*	41.428	28.5708	84.7070
97	*Leontopodium jacotianum* Beauverd	Asteraceae	Herb	Dicot	*Leo jac*	27.142	28.6645	84.6276
98	*Ligularia fischeri* (Ledeb.) Turcz.	Asteraceae	Herb	Dicot	*Lig fis*	95.714	28.5708	84.7070
99	*Lilium nepalense* D. Don	Lilaceae	Herb	Monocot	*Lil nep*	18.571	28.5708	84.7070
100	*Lomatogonium carinthiacum* (Wulfen) Rchb.	Gentianaceae	Herb	Dicot	*Lom car*	54.285	28.5679	84.7055
101	*Lonicera angustifolia* Wall. ex DC.	Caprifoilaceae	Tree	Dicot	*Lon ang*	31.428	28.5708	84.7070
102	*Lonicera lanceolata* Wall.	Caprifoilaceae	Shrub	Dicot	*Lon lan*	12.857	28.6079	84.6355
103	*Lonicera obovata* Royle ex Hook. f. and Thomson	Caprifoilaceae	Shrub	Dicot	*Lon obo*	21.428	28.6079	84.6355
104	*Meconopsis regia* G. Taylor	Papaveraceae	Herb	Dicot	*Mec reg*	28.571	28.6645	84.6276
105	*Morina polyphylla* Wall. ex DC.	Dipsacaceae	Herb	Dicot	*Mor pol*	55.714	28.6686	84.6326
106	*Nardostachys grandiflora* DC.	Valerianaceae	Herb	Dicot	*Nar gra*	44.285	28.6685	84.6254
107	*Neopicrorhiza scrophulariiflora* (Pennell) Hong	Scrophulari-aceae	Herb	Dicot	*Neo scr*	28.571	28.6685	84.6254
108	*Nepeta lamiopsis* Benth. ex Hook. f.	Lamiaceae	Herb	Dicot	*Nep lam*	48.571	28.5708	84.7070
109	*Origanum vulgare* L.	Lamiaceae	Herb	Dicot	*Ori vul*	44.285	28.5708	84.7070
110	*Oxytropis microphylla* (Pall.) DC.	Fabaceae	Herb	Dicot	*Oxy mic*	50	28.5676	84.7050
111	*Parnassia nubicola* Wall. ex Royle	Paranassi-aceae	Herb	Dicot	*Par nub*	54.285	28.5679	84.7055
112	*Pedicularis poluninii* Tsoong	Scrophulari-aceae	Herb	Dicot	*Ped pol*	21.428	28.5676	84.7050
113	*Pedicularis pseudoregeliana* P.C. Tsoong	Scrophulari-aceae	Herb	Dicot	*Ped pse*	28.571	28.6684	84.6252
114	*Pedicularis siphonantha* D. Don	Scrophulari-aceae	Herb	Dicot	*Ped sip*	41.428	28.6686	84.6248

115	*Pedicularis wallichii* Bunge	Scrophulari-aceae	Herb	Dicot	*Ped wal*	25.714	28.6677	84.6261
116	*Pinus wallichiana* A.B. Jacks.	Pinaceae	Tree	Gymno-sperm	*Pin wal*	24.285	28.5919	84.7275
117	*Plantago erosa* Wall.	Plantaginaceae	Herb	Dicot	*Pla ero*	71.428	28.5919	84.7275
118	*Podophyllum hexandraum* Royle	Berberidaceae	Herb	Dicot	*Pod hex*	32.857	28.5919	84.7275
119	*Polygonatum cirrhifolium* (Wall.) Royle	Lilaceae	Herb	Monocot	*Pol cir*	34.285	28.5714	84.7071
120	*Polygonatum hookeri* Baker	Lilaceae	Herb	Monocot	*Pol hoo*	34.285	28.6655	84.6362
121	*Polygonatum verticillatum* (L.) All.	Lilaceae	Herb	Monocot	*Pol ver*	31.428	28.5919	84.7275
122	*Potentilla biflora* Wild. ex Schltdl	Rosaceae	Herb	Dicot	*Pot bif*	24.285	28.6677	84.6261
123	*Potentilla cuneata* Wall. ex Lehm.	Rosaceae	Herb	Dicot	*Pot cun*	98.571	28.5919	84.7275
124	*Potentilla fruticosa* Lindl. ex Lehm.	Rosaceae	Shrub	Dicot	*Pot fru*	44.285	28.6076	84.6366
125	*Primula concinna* Watt	Primulacea	Herb	Dicot	*Pri con*	2.857	28.6077	84.6363
126	*Primula denticulata* Sm.	Primulacea	Herb	Dicot	*Pri den*	57.142	28.6077	84.6363
127	*Primula rotundifolia* Wall.	Primulacea	Herb	Dicot	*Pri rot*	4.285	28.6684	84.6252
128	*Primula wigramiana* W.W. Sm.	Primulacea	Herb	Dicot	*Pri wig*	11.428	28.6684	84.6252
129	*Ranunculus diffuses* DC.	Ranunculaceae	Herb	Dicot	*Ran dif*	44.285	28.5708	84.7070
130	*Rheum australe* D. Don	Polygonaceae	Herb	Dicot	*Rhe aus*	27.142	28.6080	84.6375
131	*Rheum moorcroftianum* Royle	Polygonaceae	Herb	Dicot	*Rhe moo*	28.571	28.6684	84.6252
132	*Rhodendron anthopogon* D. Don	Ericaceae	Shrub	Dicot	*Rho ant*	47.142	28.6080	84.6375
133	*Rhododendron arboreum* Sm.	Ericaceae	Tree	Dicot	*Rho arb*	17.142	28.5708	84.7070
134	*Rhododendron barbatum* Wall. ex G. Don	Ericaceae	Tree	Dicot	*Rho bar*	18.571	28.5708	84.7070
135	*Rhododendron campanulatum* D. Don	Ericaceae	Shrub	Dicot	*Rho cam*	41.428	28.5708	84.7070
136	*Rhododendron lepidotum* Wall. ex G. Don	Ericaceae	Shrub	Dicot	*Rho lep*	38.571	28.5708	84.7070
137	*Rhododendron nivale* Hook. f.	Ericaceae	Shrub	Dicot	*Rho niv*	20	28.6687	84.6246
138	*Rosa macrophylla* Lindl.	Rosaceae	Shrub	Dicot	*Ros mac*	40	28.5708	84.7070
139	*Rosa sericea* Lindl.	Rosaceae	Shrub	Dicot	*Ros ser*	27.142	28.5708	84.7070
140	*Rubia manjith* Roxb. ex Fleming	Rubiaceae	Herb climber	Dicot	*Rub man*	8.571	28.5708	84.7070
141	*Rumex nepalensis* Spreng	Polygonaceae	Herb	Dicot	*Rum nep*	40	28.5708	84.7070
142	*Salix calyculata* Hook. f. ex Andersson	Salicaceae	Shrub	Dicot	*Sal cal*	14.285	28.6080	84.6375
143	*Salix daltoniana* Andersson	Salicaceae	Shrub	Dicot	*Sal dal*	21.428	28.6080	84.6375
144	*Salix sikkimensis* Andersson	Salicaceae	Shrub	Dicot	*Sal sik*	20	28.6687	84.6246
145	*Saxifraga poluninana* H. Sm.	Saxifragaceae	Herb	Dicot	*Sax pol*	10	28.5687	84.7059
146	*Selinum candollei* DC.	Apiaceae	Herb	Dicot	*Sel can*	34.285	28.5705	84.7066
147	*Senecio wallichi* DC.	Asteraceae	Herb	Dicot	*Sel wal*	14.285	28.6687	84.6246
148	*Sibbaldia cuneata* Hornem. ex Kuntze	Rosaceae	Herb	Dicot	*Sib cun*	21.428	28.6075	84.6333
149	*Silene indica* Roxb. ex Otth	Caryophylla-ceae	Herb	Dicot	*Sil ind*	31.428	28.5708	84.7070
150	*Smilax menispermoidea* A. DC.	Lilaceae	Woody climber	Dicot	*Smi men*	12.857	28.5708	84.7070
151	*Sorbus foliolosa* (Wall.) Spach	Rosaceae	Tree	Dicot	*Sor fol*	18.571	28.5714	84.7071
152	*Sorbus lanata* (D. Don) Schauer	Rosaceae	Tree	Dicot	*Sor lan*	18.571	28.5714	84.7071
153	*Swertia angustifolia* Buch.-Ham. ex D. Don	Gentianaceae	Herb	Dicot	*Swe ang*	5.714	28.5714	84.7071
154	*Swertia paniculata* Wall.	Gentianaceae	Herb	Dicot	*Swe pan*	28.571	28.5725	84.6607
155	*Tanacetum tibeticum* Hook.f. and Thomson ex C.B. Clarke	Asteraceae	Herb	Dicot	*Tan tib*	21.428	28.6656	84.6266

156	*Thalictrum alpinum* L.	Ranunculaceae	Herb	Dicot	*Tha alp*	25.714	28.6658	84.6260
157	*Thalictrum foliosum* DC.	Ranunculaceae	Herb	Dicot	*Tha fol*	18.571	28.5714	84.7071
158	*Tsuga dumosa* (D. Don) Eichler	Pinaceae	Tree	Gymno-sperm	*Tsu dum*	15.714	28.5714	84.7071
159	*Valeriana hardwickii* Wall.	Valerianaceae	Herb	Dicot	*Val har*	15.714	28.5919	84.7275
160	*Viburnum erubescens* Wall. ex DC.	Sambucaceae	Tree	Dicot	*Vib eru*	4.285	28.5919	84.7275
161	*Viola biflora* L.	Violaceae	Herb	Dicot	*Vio bif*	98.571	28.6690	84.6218

Ranunculaceae (5 genera, 13 species), Rosaceae (6 genera, 11 species), Polygonaceae (9 species) and Cyperaceae (8 species). Other families like Primulaceae, Ericaceae, Fabaceae were represented by 7 species, Cupressaceae, Gentianaceae and Scrophulariaceae were represented by 5 species each, and Berberidaceae and Pinaceae with 4 species each. The plant species were further classified into their own functional groups and life-forms. The total numbers of dicots, monocots and gymnosperms were 127, 24 and 10 respectively. Dicots were found dominant over the monocots representing 127 species and 24 species respectively. Similarly, the herbaceous flora was higher than shrubs and trees. The study area was represented by 13 tree species.

Among all recorded species, *Potentilla cuneata* and *Viola biflora* were found the most dominant with frequency 98.57%. Similarly, other most frequently occurring species were *Gentiana depressa, Gerbera nivea, Ligularia fischeri* etc. The plant species were further categorized into different life-forms and functional groups. Among them *Abies spectabilis* was found most dominant tree with frequency 42.85% followed by *Larix himalaica* 41.42% and *Betula utilis* 38.57%. *Juniperus communis* (77.14%), *Juniperus squamata* (77.14%) were the most frequently occurring gymnosperm and shrub species in the study area. Among the monocots, *Carex filicina* (67.14%) was found dominant. Other dominant monocot species were *Fritillaria cirrhosa*, *Polygonatum cirrhifolium*, and *Polygonatum hoookeri*.

Detrended correspondence analysis (DCA) on the species data showed strong gradient in species composition (Fig. 2). The first axis eigen value significantly expressed that altitude was the main underlying gradient which also hold true for the sampling method adopted in the study. The DCA axis first showed the gradient length of 3.33 SD unit and eigen value of 0.559 (Table 2). This showed that species composition along the first axis was more heterogeneous in comparison with second and third and complete turnover of species occurred there. The DCA diagram showed the dispersion of species in first two axes. Most of the species showed high abundance towards the positive end of the both axes.

DISCUSSIONS

This study addresses the floristic diversity and life-forms patterns across a range of subalpine to alpine zones of per humid range, Central Nepal especially at Upper Manaslu Conservation Area. This study agreed the general finding of dominancy of Asteraceae in Nepal Himalayas, Tibet, Western Himalayas and elsewhere. Dominancy of Asteraceae found by Paudel (2010) from Sagarmatha National Park, Eastern Nepal, Klime and Dickore (2005) from Ladhak, Western Himalayas, Baniya (2010) from Tibet are similar at family rank but differed at their composition. This similarity exists not only at direct field data of direct observation but also on the data from herbarium specimens (Baniya, 2010). This similarity may suggest commonness of this family conservative to almost similar habitat range. Frequent occurrences of *Potentilla cuneata, Viola biflora, Gentiana ornata,* G*erbera nivea* species further support that the present study area offered the most suitable subalpine to alpine habitat for their growth and development.

Diversity of Gymnosperms as of the total 34 species reported from Nepal (Press *et al.,* 2000), 29 % of them (10 species) are found within the short geographical range of this study. Luxuriant growth with pure stands of *Tsuga* forest met in this MCA may one of the unique locations so far reported until from Nepal. Likewise, pure growth of *Larix himalaica* in this study area showed another rich habitat as previously reported from Langtang.

Researches on species distribution and composition have often been used to determine the ecological drivers and the mechanism within the ecosystem. The length of gradient 3.33 (>2.5) indirectly supports the unimodal relationship of species with altitude (Okansen, 1996). Most species were occurred at the altitudes 3400-3600m, and their abundance are decreasing towards the lower and upper gradients thus predicting the patterns of species composition and richness as unimodal. This unimodal relationship of species with altitude resembled in many other studies in several mountain ranges (Grytnes, 2003; Oomen and Shanker, 2005; Grytnes and Vetaas, 2002). The woody species like *Abies spectabilis, Larix himalaica, Rhododendron campanulatum, Berberis* spp., etc are abundant more towards the lower altitudes which suggested their decreasing trend of the woody species composition and richness with altitude. The study done by Carpenter (2005) in Eastern Nepal, Aiba and Kitayama (1999) in Mount Kinabalu have also shown the similarity in species composition with the present study.

The DCA analysis has also revealed the range of species distributional along altitude, for example, *Kobresia laxa* (3000-3500m) and *Kobresia nepalensis* (3900-4400m) are visible distinctly on the figure, the former are seen at the left and the latter at right side, which may suggest that there are species that has their own distributional range though belonging to the same genus. Abundance of plants like *Morina polyphylla*,

Plate-1: Some photographs of plant species of the study

Bistorta vaccinifolia (Wall.ex meisn.) Greene

Podophyllum hexandrum Royle

\ *Neopicrorhiza scrophulariifolia* (Pennell) Hong

Rhododendron lepidotum Wall.ex G. Don

Ephedra gerardiana Wall. ex Stapf

Viola biflora L.

Table 2. DCA Summary

	Axis 1	Axis 2	Axis 3	Axis 4	Total inertia
Eigen values	0.559	0.058	0.046	0.037	2.077
Lengh of gradient	3.33	1.536	1.059	1.205	
Cummulative % variance of species data	26.9	29.7	31.9	33.7	

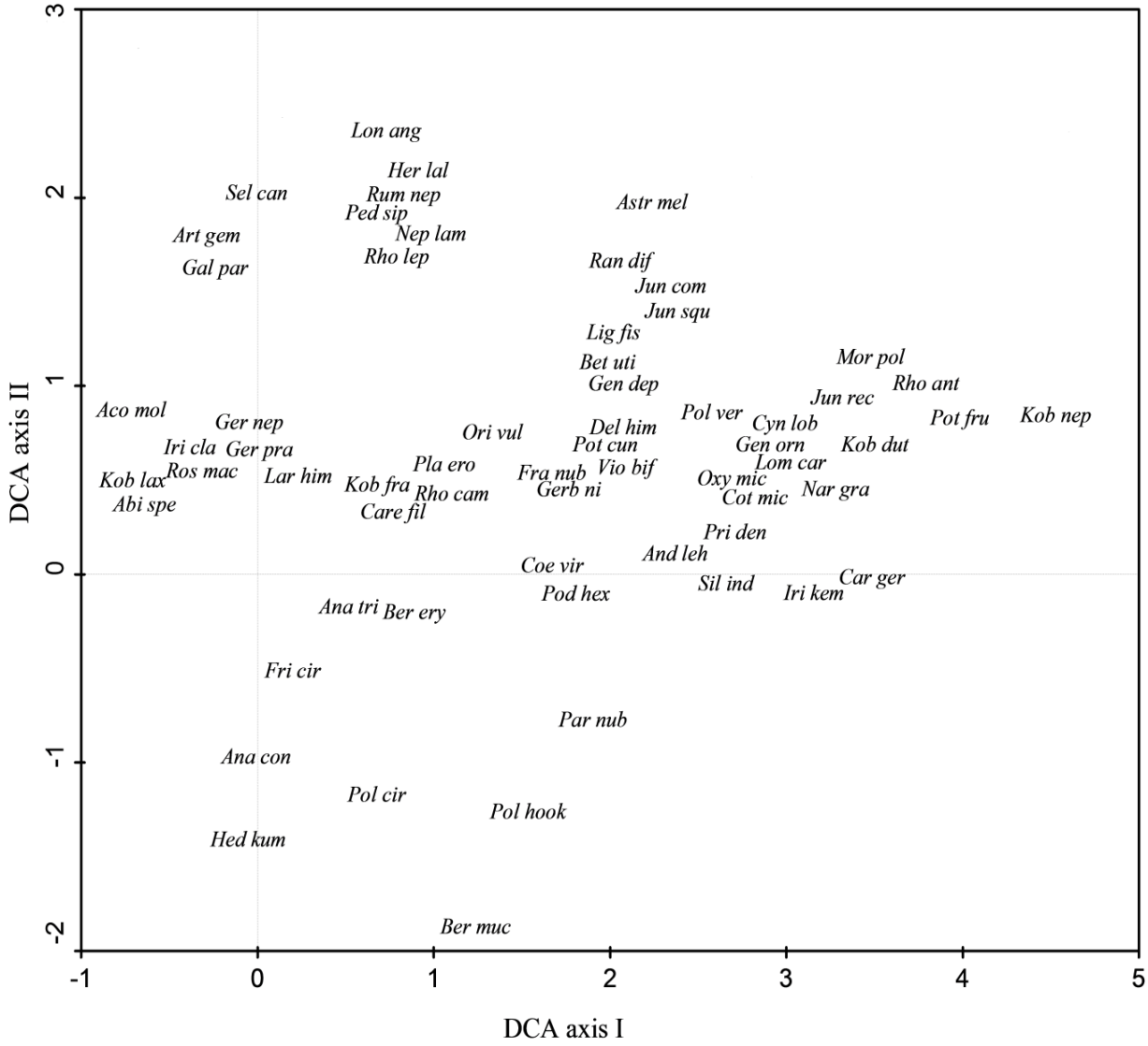

Figure 2. DCA diagram for species distribution. Species are labelled by the first three letters of generic and species name. Abbreviations are given in Table 1.

Primula spp., *Polygonatum spp*., *Nardostachys grandiflora*, etc towards the positive end of the DCA I axis in the figure well explained the range of these species as well as distribution and composition of plants at higher altitudes. However, there are few species distributed towards the lower and upper end of the figure not showing significant relationship with altitude. Such type of distribution may be due to the other influencing factors like soil moisture, pH or others which collectively interact with altitude to determine the species distribution and composition.

CONCLUSIONS

Present paper had documented the floristic composition and diversity at upper MCA area of Central Nepal and helped to explore the flora and species diversity patterns of that particular area. The study had documented the 161 plant species from that area with the dominancy of family Asteraceae and species like *Potentilla cuneata* and *Viola biflora*. The area was well represented by the herbaceous flora as compared to the tree and shrubs which is the characteristic of the

subalpine and alpine flora. The DCA analysis of the floristic composition of the area showed the unimodal Relationship with altitude representing more species abundance at the mid-altitudes. Thus, the present study suggested that the study area was rich in terms of flora and more studies are required to document the overall flora and patterns of species composition of Manaslu Conservation Area.

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