Chapter 8
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Effect of Elevation and Land Use Systems on Phytosociology of Shrub and Herbage Vegetation in Indian Central Himalayas

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ABSTRACT

Natural land use systems (LUS) are the backbone of people's livelihood and economy in Himalayas. The phytosociology of herbage and shrubs along the elevation gradient was investigated in the watershed (2B4D6). The watershed was grouped into five elevations i.e., <1100 m, 1101-1400 m, 1401-1700 m, 1701-2000 m and >2000 m. Six parcels of size, 10 m x 10 m (shrubs) and six quadrats of size 50 × 50 cm (herbage) were randomly laid out to study vegetation of LUS. In grasslands (Gr) herbage density (11.3%) and basal area (18.5%) was significantly higher compared to silvipasture (SP) LUS. Likewise, in Gr shrubs density (48.9%) and basal area (36.8%) was significantly higher as compared to SP LUS. Both density and basal area of shrubs and herbage decreased along the altitude in LUS. Herbage species dominance changed with elevation in Gr and SP LUS. In SP LUS compared to Gr and along altitude gradient the decrease in basal area and density herbs and shrubs can have relation to altered climate. The study could be worthwhile to understand the changes in the phytosociology in different LUS and along elevation.

Keywords: Elevation; grasslands; Himalayas; land use systems; silvipasture.

1. INTRODUCTION

Indian Himalayan Region (IHR) is divided into three parts, viz., western, central and eastern Himalaya and covers ~16.2% of Indian union's total geographical area. It is hilly and have a characteristic of vertical elevation zonation with steady alteration in climatic patterns [1] that lead to variations in biodiversity alongside altitude [2]. The IHR displays wide-ranging LUS and radical variations in the landscape biology in small detachments due to multifaceted uneven terrain [3]. The pattern of vegetation distribution, groups, and population are utmost important environmental features of any region [4].

The land use designates use to which the land is placed, whilst land-cover designates the characteristics of surface cover [5]. The trustworthy measureable evidence on prevailing use of land is important for added accurate, operative and unrelenting land resource and environment management. The flora and species distribution, production of biomass and carbon storage, water relations and soil improvement are indispensable study areas in the LUS [6-8]. Therefore, enough opportunity are available management and research of ecology in the background of worldwide climate change. Change of land use patterns to urban areas has become a major problem resulting from economic and population growth, especially in developing countries [9-14].

The study area has forest, scrub, grasslands and agriculture landscape [15] and the agrarian economy is completely reliant on these resources. Hence, this study was commenced to examine the LUS in detail that are key for rural economy. The natural LUS incorporating silvipasture and

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grasslands were studied with the objectives: i) measurement of phytosociology and ii) biomass estimation of ground vegetation along elevation.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted in 2B4D6-watershed (latitude 29°24' to 29°52' N and longitude 79°30' to 79°51' E) covers ~78,483 ha area with altitudinal range from 800 m to above 2250 meter (amsl) in Almora district of Uttarakhand state in India, Central Himalayas (Fig. 1). Climate in this watershed is sub-tropical in lower areas and wet-temperate in upper areas. The annual precipitation is ~1350 mm with major proportion (~60%) is received during rainy season and snowfall is a usual feature in areas above 1800 m. The meteorological data from 2001 to 2015 for Hawalbagh in Almora, a part of 2B4D6-watershedexhibited in Fig. 2. The watershed was grouped into five elevation zones as: E_1 = < 1100 m; E_2 = 1101-1400 m; E_3 = 1401-1700 m; E_4 = 1701-2000 m and E_5 = > 2000 m. Six study sites, each of around 1 km^2, were selected in each zone.

2.2 Phytosociology Analysis

In LUS two sub-plots of size, 10 m x 10 m were demarcated and density of each shrub species was determined. Stratified sampling of each shrub species was done by grouping it into - large, medium and small plants based on size and number of stems. Proportionate sampling in each group was done for measuring diameter with vernier caliper. Then the basal areas: $\Pi\ d^2/4$; Where, d = diameter of constituting stems was added to obtain basal area of a plant. Two line transacts were laid out across the each LUS and 6 quadrats of size 50 × 50 cm were randomly harvested from them at ground level at the time of peak growth of herbage in the month of September. The tillers of each species were counted and their basal area was determined. The individual species density and basal area were determined according to Mishra [16].

3. RESULTS AND DISCUSSION

3.1 Herbage

The density and basal area of herbage (Table 1) significantly differed in LUS. In chirpine silvipasture (SPCP), mixed-forest silvipasture (SPM) and banjoak silvipasture (SPBO) LUS herbage density (tillers/m^2) decreased significantly alongside elevation from 981.5, 966.4 and 861.7 (at E_1) to 832.2, 818.3 and 818.1 (at E_5), respectively. In SP and Gr LUS mean herbage density (tillers/m^2) was significantly high as 974.0 and 1072.8 (at E_1) which continuously decreased alongside elevation to 822.9 and 907.1 (at E_5), respectively (Table 1 & Fig. 3a). Herbage mean density (tillers/m^2) was significantly high in Gr (989.6) compared to SPCP (907.5) in SPM (890.8) and in SPBO (840.0) and from mean of SP (889.3 tillers/m^2) LUS. In SP herbage density decreased from 8.29 to 15.11% under trees (Table 1).

In SPCP, SPM and SPBO LUS herbage basal area (cm^2/m^2) decreased significantly alongside elevation from 53.5, 52.5 and 46.2 (at E_1) to 44.9, 43.9 and 44.4 (at E_5), respectively. In SP and Gr LUS mean herbage basal area (cm^2/m^2) was significantly high as 53.1 and 61.5 (at E_1) which continuously decreased alongside elevation to 44.4 and 52.9 (at E_5), respectively (Table 1 & Fig. 3b). Herbage mean basal area (cm^2/m^2) was significantly high in Gr (57.1) compared to SPCP (49.2) in SPM (48.3) and in SPBO (45.3) and from mean of SP LUS (48.2 cm^2/m^2). In SP herbage density decreased from 13.83 to 20.66% under trees (Table 1).

The herbage density and basal area in LUS reduced progressively with rise in elevations. The density and basal area of herbage ranged from 832.2 to 981.5, 818.2 to 966.4, 818.1 to 861.7 and 907.1 to 1072.8 tillers/m^2, and 44.9 to 53.5, 43.9 to 52.5, 44.5 to 46.2 and 52.9 to 61.5 cm^2/m^2 in SPCP, SPM, SPBO and Gr, respectively at different elevations (Table 1). The alterations in herbage density and basal area in LUS can be ascribed to differential growth of the constituent species due to variations in microclimatic situations along the altitude [17-19]. Along the altitude total atmospheric and partial pressure decreases [20], which may influence gas exchange in plants [1], precipitation [21] and moisture gradients [22] might increase or decrease depending on region, atmospheric temperature reduces [23] and radiation increases [24].

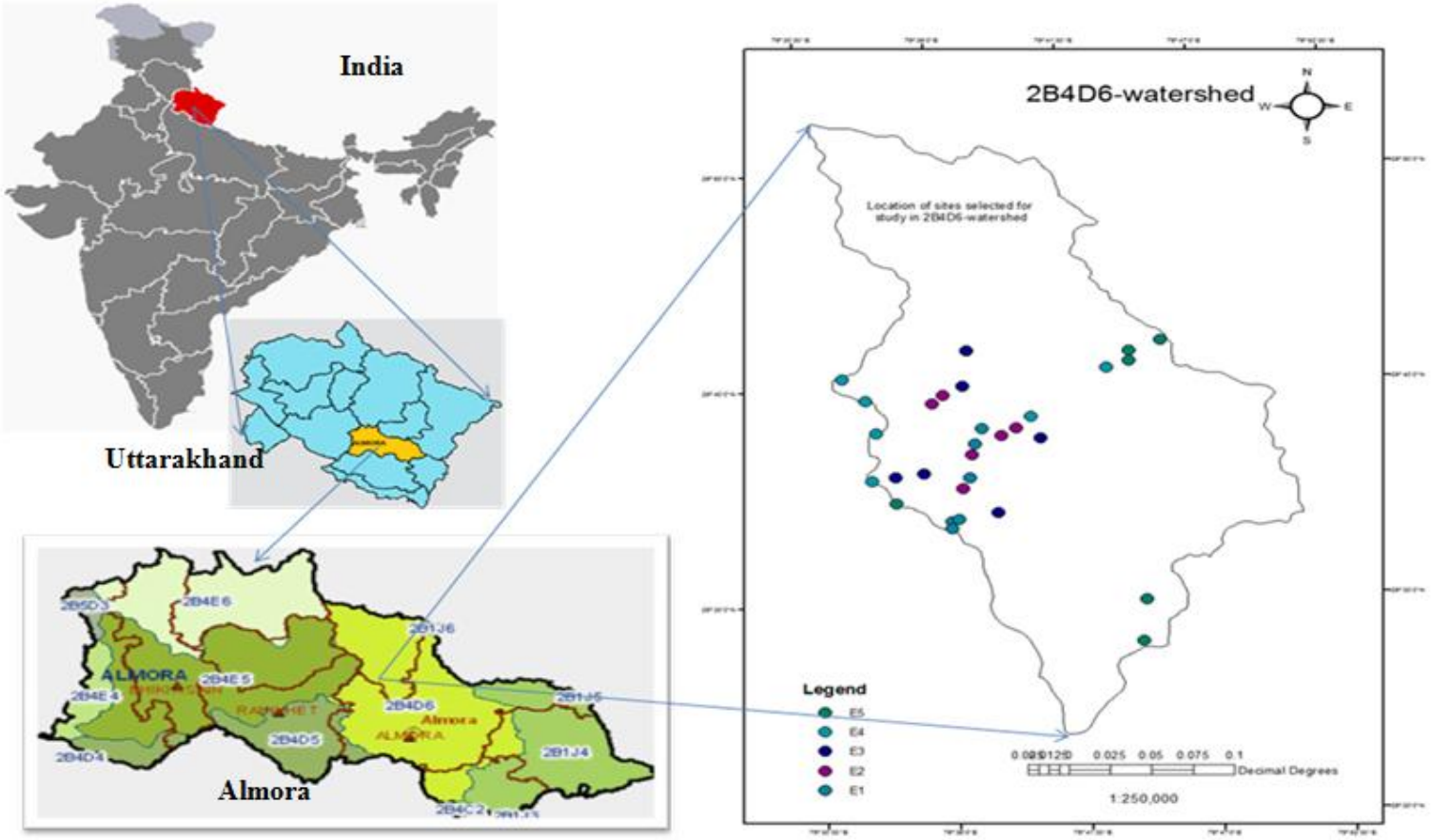

Fig. 1. Location of 2B4D6-watershed in Almora district of Uttarakhand

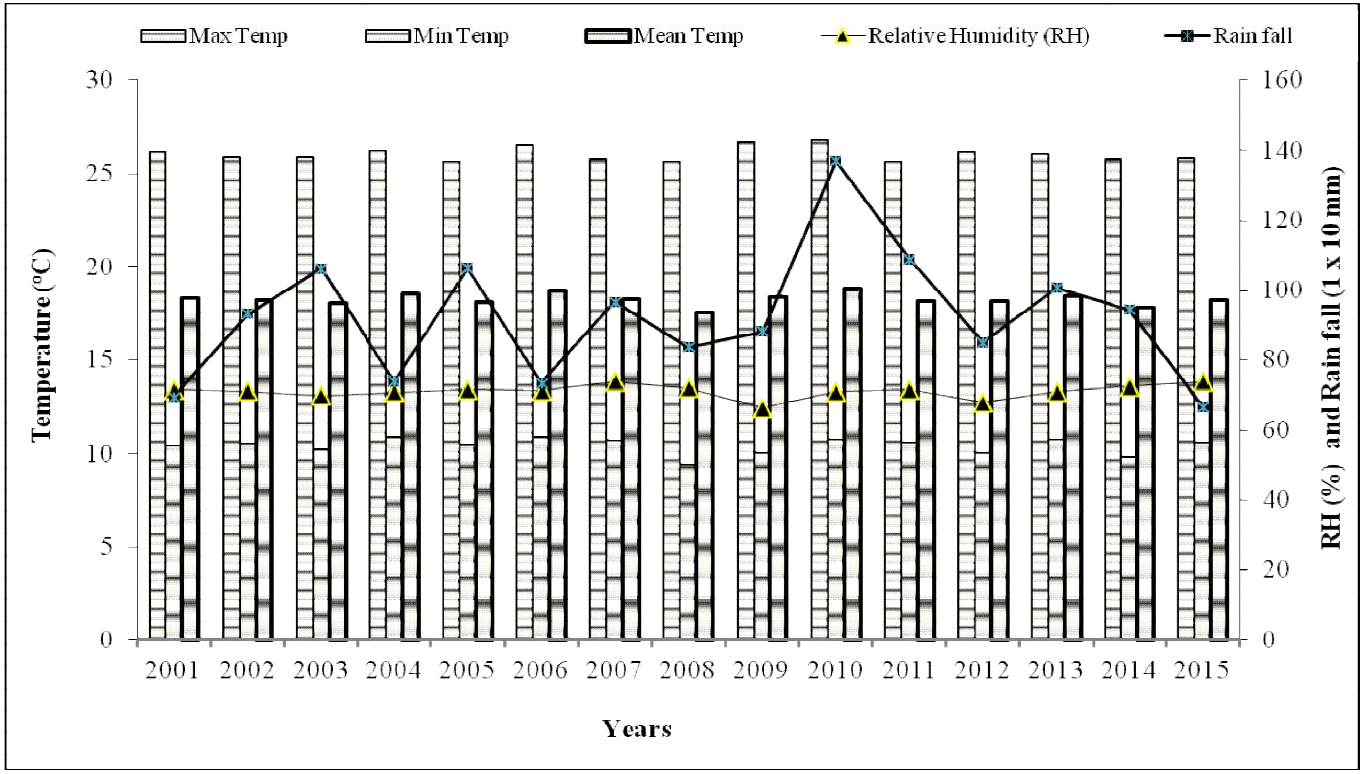

Fig. 2. Meteorological record of 2B4D6-watershed in Central Himalaya

Table 1. Herbage density (tillers/m^2) and basal area (cm^2/m^2) in LUS in 2B4D6-watershed

Land use systems (LUS)	Herbage density at different elevations (E)					Mean (LUS)
	E_1 (<1100 m)	E_2 (1101-1400 m)	E_3 (1401-1700 m)	E_4 (1701-2000 m)	E_5 (>2000 m)	
SPCP	981.5 a	948.0 b	908.4 c	867.4 d	832.2 e	907.5 b
SPM	966.4 a	924.4 b	887.7 c	857.5 d	818.3 e	890.8 b
SPBO	Not present	Not present	Not present	861.7 a	818.1 b	840.0 c
Mean	974.0 a	936.2 b	898.1 c	862.2 d	822.8 e	889.3 b
Gr	1072.8 a	1030.2 b	987.7 c	950.4 d	907.1 e	989.6 a
	Herbage basal area at different elevations (E)					
SPCP	53.5 a	51.6 b	48.5 c	47.1 d	44.9 e	49.2 b
SPM	52.5 a	51.3 b	47.6 c	46.0 d	43.9 e	48.3 b
SPBO	Not present	Not present	Not present	46.2 a	44.4 b	45.3 c
Mean	53.1 a	51.5 b	48.1 c	46.4 d	44.4 e	48.2 b
GR	61.5 a	59.1 b	57.0 c	54.9 d	52.9 e	57.1 a

Source: Yadav et al. (2018); Where,- Different successive letters suffixing the numbers in the columns for 'Mean (LUS)' and rows for 'SPCP, SPM, SPBO, Mean, Gr' denote significant difference

The herbage density under overstorey of different tree species forming in SP decreased by 9.22%, 9.12%, 9.08%, 9.28%, and 9.29% at elevations E_1, E_2, E_3, E_4 and E_5 and likewise the basal area also decreased by 13.72%, 12.90%, 15.68%, 15.42%, 16.10%, respectively as compared the values in the respective Gr at each elevation (Table 1). In Himalayan [17] have reported region decrease in density of herbage up to 77% and basal area up to 62% under trees in forests as compared to Gr. This is a manifestation of effect of overstorey on ground vegetation perhaps due curtailment of solar influx reaching ground [25]. Solar influx reduction by 48 to 79% under trees depending upon forest types [17]. Ruiz and Montes [26] and Jelaska et al. [19] recorded density of herbage ranging from 1993 to 2458 tillers/ha in forest of Garhwal Himalaya.

3.2 Shrubs

In LUS, the shrubs density and basal area (Table 2) differed. In SPCP, SPM and SPBO LUS shrub density (plants/ha) decreased significantly alongside elevation from 1883.3, 1788.8 and 1516.6 (at E_1) to 1516.6, 1416.6 and 1311.1 (at E_5), respectively. In SP and Gr LUS mean shrub density (plants/ha) was significantly high as 1836.1 and 2888.8 (at E_1) which continuously decreased alongside elevation to 1414.8 and 2027.7 (at E_5), respectively (Table 2 & Fig. 4a). Shrub mean density (plants/ha) was significantly high in Gr (2452.2) compared to SPCP (1707.8) in SPM (1608.9) and in SPBO (1413.9) and from mean of SP (1646.5 plants/ha) LUS (Table 2).

Table 2. Density (plants ha^{-1}) and basal area (m^2/ha) of shrubs in LUS in 2B4D6-watershed

Land use systems (LUS)	Shrubs density at different elevations (E)					Mean (LUS)
	E_1 (<1100 m)	E_2 (1101-1400 m)	E_3 (1401-1700 m)	E_4 (1701-2000 m)	E_5 (>2000 m)	
SPCP	1883.3 a	1855.5 a	1694.4 b	1588.8 c	1516.6 c	1707.8 b
SPM	1788.8 a	1755.5 a	1594.4 b	1488.8 c	1416.6 c	1608.9 b
SPBO	Not present	Not present	Not present	1516.6 a	1311.1 b	1413.9 c
Mean	1836.1 a	1805.5 a	1644.4 b	1531.5 c	1414.8 d	1646.5 b
Gr	2888.8 a	2638.8 b	2455.5 c	2250.0 d	2027.7 e	2452.2 a
	Shrubs basal area at different elevations (E)					
SPCP	0.45 a	0.44 a	0.40 b	0.38 c	0.34 d	0.40 b
SPM	0.45 a	0.43 b	0.38 c	0.36 d	0.33 e	0.39 b
SPBO	Not present	Not present	Not present	0.29 a	0.26 b	0.27 c
Mean	0.45 a	0.44 a	0.39 b	0.34 c	0.31 d	0.38 b
Gr	0.58 a	0.56 b	0.53 c	0.50 d	0.46 e	0.52 a

Source: Yadav et al. (2018); Where,- Different successive letters suffixing the numbers in the columns for 'Mean (LUS)' and rows for 'SPCP, SPM, SPBO, Mean, Gr' denote significant difference

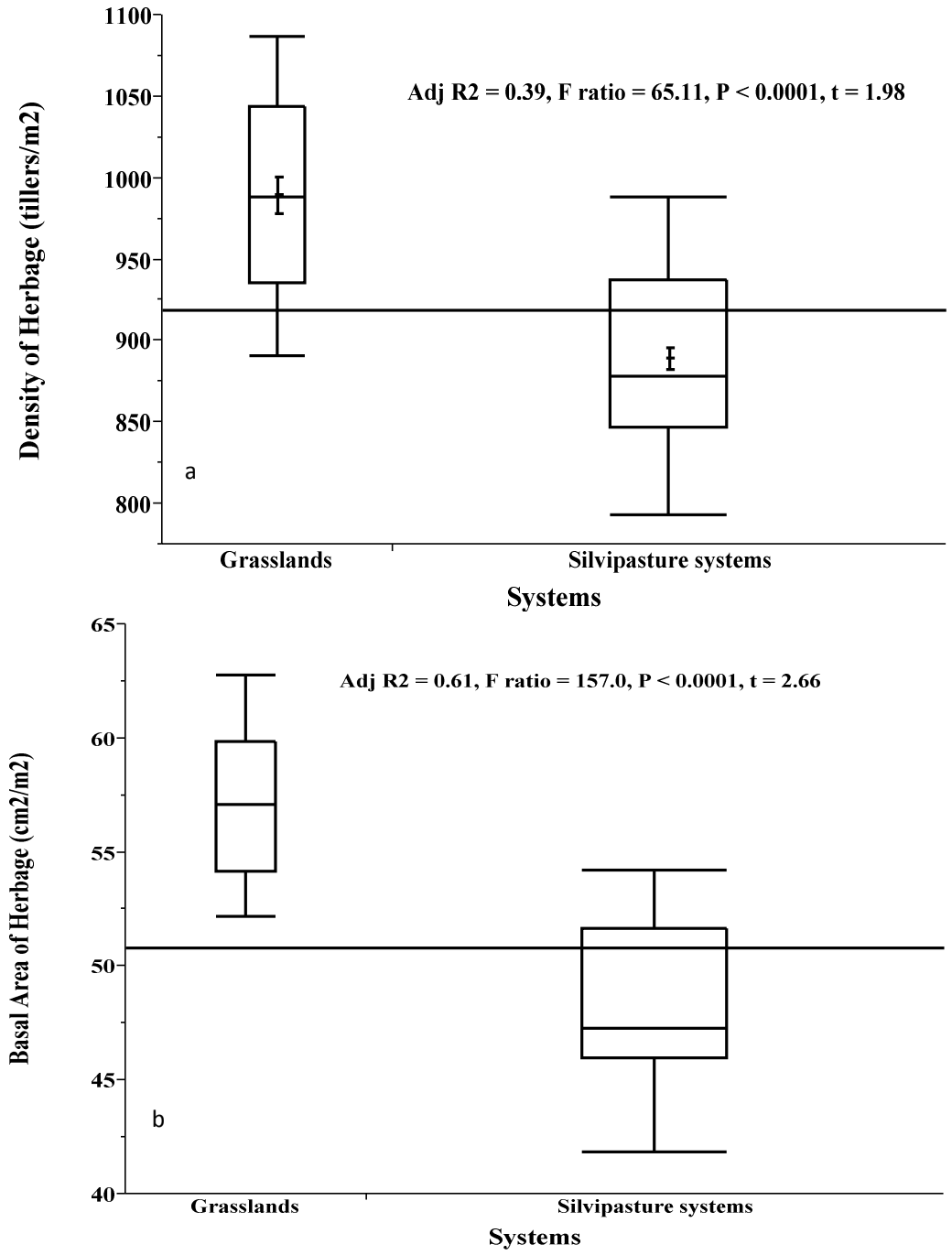

Fig. 3. Herbage density and basal area of LUS in 2B4D6-watershed (Source: Yadav et al. 2018)

In SPCP, SPM and SPBO LUS shrub basal area (m^2/ha) decreased significantly alongside elevation from 0.45, 0.45 and 0.29 (at E_1) to 0.34, 0.33 and 0.26 (at E_5), respectively. In SP and Gr LUS mean shrub basal area (m^2/ha) was significantly high as 0.45 and 0.58 (at E_1) which continuously decreased alongside elevation to 0.31 and 0.46 (at E_5), respectively (Table 2 & Fig. 4b). Shrub mean basal area (m^2/ha) was significantly high in Gr (0.52) compared to SPCP (0.40) in SPM (0.39) and in SPBO

(0.27) and from mean of SP (0.38 m^2/ha) LUS. In SP herbage density decreased from 13.83 to 20.66 % under trees (Table 2).

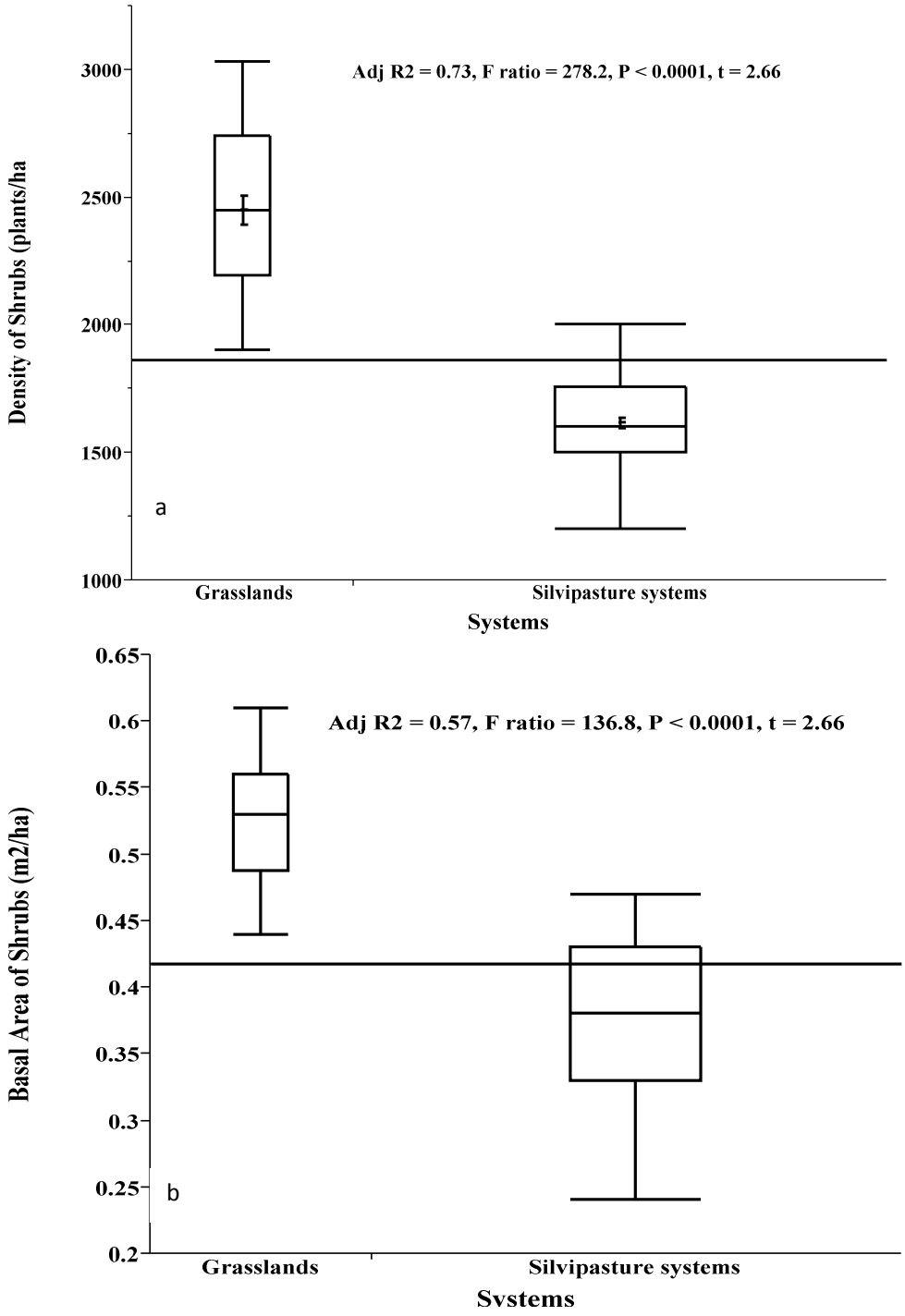

Fig. 4. Shrubs density and basal area of LUS in 2B4D6-watershed (Source: Yadav et al. 2018)

Along the altitude, shrubs density and basal area reduced in all LUS. It can be attributed to ecological changes alongside the altitude [17] that might have affected growth and development of shrubs. The

shrubs density under overstorey of different LUS decreased by 36.44 %, 31.58 %, 33.03 %, 31.93 %, and 30.23 % at elevations E_1, E_2, E_3, E_4 and E_5 and likewise the basal area also decreased by 22.41 %, 21.43 %, 26.42 %, 32.00 %, and 32.61 %, respectively compared to their values in the respective Gr at each elevation (Table 2). In central Himalaya has been reported similar effect of trees on density and basal area of shrubs [27].

In SP shrub density decreased by 30.35 to 42.34 % and basal area by 23.00 to 48.07 % compared to Gr, such decrease in shrubs growth under trees can be related to solar light reduction under trees [25,17]. The density of shrubs in SP (1646.5 plants/ha) was lower as compared to Gr (2452.3 plants/ha). The environmental variables like, altitude, moisture regime, aspect etc. are responsible for such differences [28,2]. Likewise, in banjoak forest shrub density as 820 plants/ha was recorded by Ningal et al. [27], 1880 plants/hectare by Beardsley et al. [29], 2064 plants/ha by Su et al. [30] and 1006 plants/hectare by Swangjang and Iamaram [31].

4. CONCLUSIONS

In SP and Gr, herbage density decreased from (981.5, 966.4, 861.7, 1072.8 tillers/m^2) at altitude E_5 to (832.2, 818.2, 818.2, 907.1 tillers/m^2) at altitude E_1 and basal area (53.5, 52.5, 46.2, 61.5 cm^2/m^2) at altitude E_5 to (44.91, 43.92, 44.48, 52.97 cm^2/m^2) at altitude E_1, respectively. In SP and Gr, shrubs density and basal area at different altitudes in the watershed ranged from 1566.6, 1416.6, 1311.1, 2027.7 to 1883.3, 1788.8, 1516.6, 2888.8 plant ha^{-1} and 0.34, 0.33, 0.20, 0.46 to 0.45, 0.44, 0.49, 0.58 m^2/ha, respectively.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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