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Diversity and Ecological Status of Major Lac Host Species in the Village Commons of the Periphery of Kuldiha Wildlife Sanctuary of Odisha

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Abstract: An ecological study was carried out in village commons of fringe forests (i.e. 05 Km) in the tropical deciduous forests of the periphery of Kuldiha Wildlife Sanctuary of Odisha during 2018-19. This paper has endeavoured to assess the diversity and distribution pattern of trees vis-à-vis major lac host species in the outer peripheral region of Kuldiha Wildlife Sanctuary in the Garadihi Gram Panchayat of Nilgiri Block, Balasore, Odisha. An attempt was made to present floral diversity in the study site and estimated diversity index using Simpson's Diversity Index were determined to draw a comparative inference. Stratified random samplings were laid in the field. A total of 44 tree species consisting of 31 genera and 17 families were recorded. Fabaceae was the most dominant family with 13 species. *Butea monosperma,* a major lac host species, recorded the highest tree density (120.00 individual's ha^{-1}) and the lowest tree density (10 individual's ha^{-1}) was observed for *Neolamarckia cadamba* and *Ficus religiosa*. *Shorea robusta* had the highest basal area ha^{-1} of 164.56. The Importance Value Index (IVI) of trees was the highest for *Shorea robusta* (20.74) followed by *Schleichera oleosa* which was also a major lac host species (16.15) and *Holarrhena antidysenterica* (15.07) while the lowest was for *Neolamarckia cadamba* (1.82). Species evenness for trees was (0.951). Abundance/ Frequency ratio (A/F) for trees of 44 species exhibited mostly random distribution patterns for 26 species, 13 species contagiously and 5 species were regularly distributed.

Keywords: Village commons, Lac hosts, Floral diversity, Diversity index, Distribution pattern, Conservation

Tropical forests are well known for the most species-diverse terrestrial ecosystems in the earth, which provides a wide range of goods and services to the forest dwellers (Gosain et al 2015). The biodiversity of these forests provide a variety of resources which help to sustain the livelihood of local communities. Forests are declining rapidly due over-exploitation resulting in one of the most significant environmental and economic obstacles all over the world (Walther et al 2002, Htun et al 2011). Shrinkage of forest areas in the study sites led to the ecological problem such as soil erosion, extinction of many ethnobotanical important species of plants and animals (Bora and Kumar 2003). Inventory of plant species providing information on diversity will play an important tool for strengthening ability of *in-situ* and *ex-situ* conservation of biodiversity as well as the socio-economic setup of local communities that occurred from depletion of forests (Baraloto et al 2013, Malik et al 2014, Malik and Bhatt 2016) . The know-how composition and diversity of tree species is vital to understand the structure of a forest community for formulation and implementation of conservation strategy of the forest ecosystem. A significant portion of diversity of the study site has already been lost due to the versatile issues like illicit felling, habitat loss, forest fire, timber and fuel wood collection, livestock grazing pressures etc.

Odisha is traditionally an agrarian state and well-known for its rich and abundant biodiversity in India and in Southeast Asia. It is endowed with vast natural resources, diversified agro-edaphic conditions, rich flora and fauna, wide range of cropping patterns, various socio-cultural groups and people with multiple economic strata. The wide ranges of topographic, edaphic and climatic conditions have led to consociation of a variety of vegetation on different landscapes of village commons in this hill range. Among species of much ecological and economic importance to the forest fringes in the surroundings of Kuldiha Wildlife Sanctuary are Kusum (*Schleichera oleosa*), Palash (*Butea monosperma*) and Ber (*Ziziphus mauritiana*). Kusum (*Schleichera oleosa*) is the best lac host species for production of Kusumi lac strain. Palash (*Butea monosperma*) plant is very suitable for production of Rangeeni lac strain within a period of 5-6 years of regeneration. Ber (*Ziziphus mauritiana*) is also suitable for Kusumi and Rangeeni strains of lac within a period of 4-5 years of regeneration. Therefore, lac cultivation is expected to result in disturbances in forest community which in turn may lead to change in population

structure of these species. Lac host species which not only provides livelihood to millions of lac growers but also helps in conserving vast stretches of village commons need priorities for conservation and protection and also required to be monitored. The information on distribution of plant communities are useful to understand the population dynamics of each species and how these major lac host species are distributed in relation to the other species in the same community are also studied.

Therefore, a necessity prevails to identify the vegetation composition and floristic status of upper storey and assess their diversity. A comprehensive phytosociological analysis of the forest ecosystem was done by incorporating parameters like relative density, abundance, relative frequency, relative basal area and Important Value Index, which will be applicable to plan for proper management intervention to enhance the sustainability development of forest biodiversity supporting livelihood through lac based activities in the study area.

MATERIAL AND METHODS

Study site: The present study was carried out in the Nilgiri block of Balasore district, Odisha, India by establishing ten numbers of randomly selected sites of Village Commons in Garadihi Gram Panchayat. All the sites are located on the undulating plain of Kuldiha foothill, blessed with rich floral and faunal diversity. It is located adjacent to Kuldiha Wildlife Sanctuary. Kuldiha Wildlife Sanctuary, a part of mega-habitat bounded by the tri-junction of Balasore, Mayurbhanj and Keonjhar districts, is covered with densely forested hill range spreading over 272.75 km^2. It is located in the South-western part of Balasore District under Nilgiri Civil Sub-Division in the State of Odisha and is declared as 'Kuldiha Wildlife Sanctuary' and lies between 21^0 20' to 21^0 30' North latitude & 86^0 26' to 86^0 45' East longitude. The area has a subtropical climate with three distinct seasons i.e. summer, monsoon and winter. The Sanctuary area is 272.75 sq km which includes Kuldiha, Devgiri and Tenda Reserve Forests and other Protected Forests. The periphery of the sanctuary is 150.5 kms. Kuldiha represents features of all the four Biotic Provinces such as Eastern Plateau, Chhotanagpur, Lower Gangetic Plain and Coastline. The mean annual rainfall is about 1630 mm. and enjoys a tropical climate. Because of its proximity to Bay of Bengal, climatically this tract is comparatively humid-hot. The mean maximum temperature is 38°C during April-May and minimum 8°C during November-January. The maximum temperature at times falls beyond 42°C. Forest type is mostly tropical deciduous forest type. Lac cultivation is also a subsidiary source of income of forest fringes. The lac host trees, namely Kusum (*Schleichera oleosa),* Palas (*Butea monosperma)* and Ber (*Ziziphus mauritiana*) are commercially exploited for lac cultivation which are known as common or major host plants or excellent host plants. Soil types vary from sandy to heavy red sandy loam found in the area.

Methodology: The primary data were collected from five major lac growing villages namely Tiakata, Garadihi, Chaindar, Balichua and Chekamara of Garadihi Gram Panchayat to survey all the possible habitats during 2018-19 from fringe forests (i.e. within 05 Km) around Kuldiha reserve forest of Balasore, Odisha. The study involves intensive field visits at regular intervals and careful investigations of the floral resources. The plants were collected, properly identified and when it was confusing to identify species in the field, the species were documented and herbarium specimens were prepared. The herbarium specimens were sent to College of Forestry, Odisha University of Agriculture and Technology (OUAT), Bhubaneswar, Odisha for proper identification. Standard field and herbarium methods given by Jain and Rao (1977), Bridson and Forman (1998) were followed for collection and preservation of plant samples. Herbarium specimens were prepared and the nomenclatures of the plant species were designated based on the regional floras like Flora of Presidency of Madras by Gamble and Fischer (1915-1935) and Flora of Odisha by Saxena and Brahmam (1994-1996). Each plant species recorded in the different quadrants in village commons were classified by family and genera.

Vegetation assessment: Phytosociological characteristics of tree species were studied by randomly laying out 10 quadrats of 10 x 10 m^2 sizes for trees (≥10 cm dbh) covering the entire study area. In the 100 m^2 quadrats the number of individuals of each tree species was counted and circumference at breast height (CBH at 1.37 m) from the ground was measured by using a girth tape. Buttressed trees were measured above the buttress. All the tree species in the quadrats were counted to estimate the diversity, frequency, density, abundance and Importance Value Index (IVI) of the woody vegetation. The size and the number of quadrats for study were determined following the principles of Kershaw (1973) and Mishra (1968). Floristic composition, density, diversity, dominance, distribution and tree population structure were studied according to Curtis and McIntosh (1950) and Mishra (1968). The importance value index (IVI) was calculated as reported by Curtis & McIntosh (1950), Mishra (1968) and Curtis (1953). It is used to identify the influence of each species in the community structure.

Abundance frequency ratio (A/F): Abundance to frequency ratio (A/F) has been computed following Whitford

(1949): WI = abundance/frequency (A/F Ratio) to assess the spatial distribution pattern of species and depending upon the ratios, distribution may be regular, random or contagious. A value of <0.025 would denote a regular distribution, values between 0.025-0.05 a random distribution and a value >0.05 would signify a contagious distribution. The data obtained were also used to enumerate community indices such as Shannon-Wiener's diversity index (Shannon and Wiener 1963) of species diversity of upper storey vegetation) and Pielou's evenness index (1966).

Shannon-wiener index (H): The diversity of the species was computed using the Shannon-Wiener index (H) as :

$H = \sum^{s} pi \ln pi \quad i=1$

Where s = Total number of species; pi = proportion of individuals in each species or abundance of the i-th species; and Ln is the natural logarithms to the base e.

All the collected data are put in the excel spreadsheet and according to the family of tree species the Simpson's formula has been worked out. Tree species whose numbers are more than 1, were assumed for calculating the Simpson diversity index as reported by Simpson (1949). Tree species whose numbers found were 1 or less was considered to have no diversity (Anandan et al 2014).

Simpson's species diversity index: Simpson's Diversity Index is a measure of diversity which takes into account the number of species present, as well as the relative abundance of each species. The formula for calculating D is presented as:

$$D = 1 - \left(\frac{\Sigma n(n-1)}{N(N-1)} \right)$$

Where n= the total number of individuals of each species, N=the total number of individuals of all species.

Pielou's index: Evenness Index was calculated using Pielou's index (D= -Σ pi2 / ln S), where S = species richness of the community, pi = proportion of individuals or abundance of the i^{th} species and ln is the natural logarithms to the base (Magurran 1988).

Association index: The inter-specific association was determined by association index which helps in assessing the main associates of an important species in the forest (Sukla et al 2015).

$$\text{Association Index of a Species (A)} = \frac{\text{Total no. of quadrats in which a species occurs along with another species (B) in the stand}}{\text{Total no. of quadrats in which a species occurs in that stand}} \times 100$$

RESULTS AND DISCUSSION

Floristic composition: The present study on the phytosociological analysis of trees recorded the presence of a total of 44 number of tree species under 31 genera belonging to 17 families (Table 1). The number of species per genus was higher than 1.4 and the number of species per family was about 2.6. Majority of families are represented by one or two species only. The foremost dominant family was Fabaceae which contained 13 species followed by Moraceae, Myrtacea. The total tree density across the study sites was 1750 individuals ha^{-1} and total basal area/ha of 1322.5. The tree density varied from 10 to 120 individuals ha^{-1} and the basal area ranged from 3.22 to 164.56 m^2 ha^{-1} (Table 1). *Butea monosperma* exhibited the highest density (120 plants/ha) followed by *Hollarhena antidyesenterica* and the lowest density was found at *Neolamarckia cadamba* (10 plants/ha) (Table 1). *Shorea robusta* occupied the highest basal area of 164.56 m^2 ha^{-1}, followed by *Holarrhena antidysenterica* and *Schleichera oleosa*. The lowest basal area was in *Melia azedarach* (3.22 m^2 ha^{-1}). The Importance Value Index (IVI) of tree species varied from 1.82 to 20.74 . This indicated that in the study area *Shorea robusta* and *Schleichera oleosa* were the most dominant species whereas *Neolamarckia cadamba* and *Melia azedarach* were least dominant species. The most dominant trees in descending order of IVI were *Shorea robusta* (20.74), *Schleichera oleosa, Madhuca indica* and *Butea monosperma.* The least dominant species in ascending order of IVI were *Neolamarckia cadamba* (1.82) and *Melia azedarach* (2.25), *Albizia lebbeck* (3.31), . Most of the recorded species revealed random distribution (26 species). Insignificant number of species indicated clumped *I*contagious (13 species) and regular distribution (5 species). The association index of species for lac host species such as *Schleichera oleosa*, *Butea monosperma* and *Ziziphus mauritiana* varied widely and the most important associates were *S. robusta*, *B. lanzana*, *S. cerasoides* and *S. cumin* in the study sites.

Species diversity: The Shannon-wiener's diversity index, Simpson's dominance and Species evenness was 3.599, 0.973 and 0.951 respectively. All the indices were calculated only for tree species. The flora of the study sites of village commons was characterized by a variety of plant species. The tree species richness of 44 species represents a moderate level of diversity of plants (Table 1). The results of the present work are in accordance with that of different ecosystems under tropical climates. A total of 65 species of 36 families was recorded by Pradhan and Rahaman (2015) from three tropical dry deciduous forests of Birbhum District, West Bengal. Vinayaka and Krishnamurthy (2016) reported a total of 231 plant species of 96 are trees, 53 herbs, 51 shrubs and 31 are climbers in Hulikal state forest, Karnataka. In Malappuram sacred grove of Kollengode, Tamilnadu, Sukumaran et al (2018) recorded 36 trees, 18 shrubs, 26

Table 1. Phytosociological attributes of trees in the village commons of Garadihi G.P

Scientific name	Local name	Family	Density ha^{-1}	Basal area ha^{-1} (m^2/ha)	Association index of lac host species			A/F	IVI
					Kusum	Palas	Barakoli		
Acacia auriculiformis	Acacia	Fabaceae	100	64.45	0.17	0.25	0.50	1.00	11.45
Acacia leucophloea	Dhalaguhira	Fabaceae	20	37.10	0.33	0.05	1.00	0.05	5.67
Acacia nilotica	Babul	Fabaceae	50	24.66	0.33	0.13	1.00	0.13	6.45
Adina cordifolia	Kurum	Rubiaceae	30	11.78	0.50	0.08	1.50	0.03	5.19
Aegle marmelos	Bela	Rutaceae	20	13.05	0.33	0.05	1.00	0.05	3.85
Albizia lebbeck	Sirisha	Fabaceae	20	5.89	0.33	0.05	1.00	0.05	3.31
Albizia procera	Dhalasiris	Fabaceae	30	19.41	0.50	0.08	1.50	0.03	5.77
Alstonia scholaris	Chhatiyana	Apocynaceae	20	15.38	0.33	0.05	1.00	0.05	4.03
Anogeissus acuminata	Phasi	Combretaceae	40	20.95	0.67	0.10	2.00	0.03	7.32
Neolamarckia cadamba	Kadambo	Rubiaceae	10	5.09	0.17	0.03	0.50	0.10	1.82
Azadirachta indica	Nimba	Meliaceae	30	19.89	0.50	0.08	1.50	0.03	5.80
Bombax ceiba	Simili	Bombacaceae	40	36.08	0.67	0.10	2.00	0.03	8.46
Borassus flabellifer	Tala	Arecaceae	20	16.81	0.33	0.05	1.00	0.05	4.14
Buchanania lanzan	Char	Anacardiaceae	50	11.32	0.50	0.13	1.50	0.06	6.30
Butea monosperma	Palaso	Fabaceae	120	55.86	0.67	0.30	2.00	0.08	14.53
Cassia fistula	Sunari	Fabaceae	30	4.54	0.50	0.08	1.50	0.03	4.64
Cassia siamea	Sana chakunda	Fabaceae	50	35.37	0.67	0.13	2.00	0.03	8.98
Dalbergia lanceolaria	Sajanapati	Fabaceae	20	6.16	0.33	0.05	1.00	0.05	3.33
Dalbergia latifolia	Kala Sishu	Fabaceae	20	16.81	0.33	0.05	1.00	0.05	4.14
Dalbergia sissoo	Sishu	Fabaceae	30	9.91	0.33	0.08	1.00	0.08	4.19
Diospyros malabarica	Kala Kendu/Maakada kendu	Ebenaceae	30	44.34	0.50	0.08	1.50	0.03	7.65
Diospyros melanoxylon	Kendu	Ebenaceae	40	34.65	0.67	0.10	2.00	0.03	8.35
Eucalyptus tereticornis	Eucalyptus	Myrtaceae	80	70.18	0.17	0.20	0.50	0.80	10.74
Feronia elephantum	Kaitha	Rutaceae	40	27.89	0.50	0.10	1.50	0.04	6.98
Ficus benghalensis	Bara	Moraceae	20	34.45	0.33	0.05	1.00	0.05	5.47
Ficus cuspidifera	Dimiri	Moraceae	30	17.21	0.50	0.08	1.50	0.03	5.60
Ficus hispida	Baidimiri	Moraceae	30	11.22	0.50	0.08	1.50	0.03	5.15
Ficus racemosa	Dimiri / Lowa	Moraceae	20	6.70	0.33	0.05	1.00	0.05	3.37
Ficus religiosa	Aswastha	Moraceae	10	28.72	0.17	0.03	0.50	0.10	3.61
Holarrhena antidysenterica	Kulchi/Kurei	Apocynaceae	110	93.31	0.33	0.28	1.00	0.28	15.07
Madhuca indica	Mahula	Sapotaceae	40	33.86	0.50	0.10	1.50	0.04	7.43
Melia azedarach	Bilatinimba	Meliaceae	20	3.22	0.17	0.05	0.50	0.20	2.25
Phoenix sylvestris	Khajuri	Arecaceae	30	29.00	0.33	0.08	1.00	0.08	5.63
Protium serratum	Rimuli	Burseraceae	20	10.18	0.33	0.05	1.00	0.05	3.64
Pterocarpus marsupium	Bijasal/ Piasal	Fabaceae	40	10.20	0.67	0.10	2.00	0.03	6.51
Schleichera oleosa	Kusum	Sapindaceae	90	77.26	1.00	0.23	3.00	0.03	16.16
Semecarpus anacardium	Bhalia	Anacardiaceae	30	10.73	0.50	0.08	1.50	0.03	5.11
Shorea robusta	Sal	Dipterocarpaceae	100	164.56	0.50	0.25	1.50	0.11	20.74
Syzygium cerasoides	Poijamu/ Kaduaiamu	Myrataccae	60	36.97	0.50	0.15	1.50	0.07	8.81
Syzygium cumini	Jamu	Myrataccae	40	45.59	0.50	0.10	1.50	0.04	8.32
Tamarindus indica	Tentuli	Fabaceae	30	36.86	0.50	0.08	1.50	0.03	7.09
Terminalia tomentosa	Asana	Combretaceae	40	39.78	0.50	0.10	1.50	0.04	7.88
Ziziphus mauritiana	Barakoli	Rhamnaceae	20	14.40	0.33	0.05	1.00	0.05	3.96
Ziziphus xylopyrus	Gonti/Khataber	Rhamnaceae	30	10.73	0.50	0.08	1.50	0.03	5.11
Total			1750	1322.5					300

A/F= Abundance to Frequency Ratio; IVI- Importance Value Index

herbs and 22 climbers. Composition of the forest and hence its type depend on aggregation of various species. Various factors, like seed dispersal, microclimate and other biotic factors promote the distribution of the species in an ecosystem. Tree species richness of study site was lower as compared to species recorded in Similipal biosphere reserve (Reddy et al 2007) which may be attributed to anthropogenic pressure and/ or low rainfall. The Fabaceae were exhibited to be the most dominant for their ability to produce numerous seeds, quick germination and symbiotic characters which might have promoted species of the plant family to easily establish within habitat types. However, the studies were similar with the works of Deka et al (2012), Pausas and Austin (2001) reported on species richness in relation to environment i.e. suitable habitat and an environmental condition promotes pollination, dispersal of seeds and ensuring establishment of species. Some families have characterised due to the presence of the least dominant species as being associated with unsuitable climatic conditions, diseases and trampling by herbivores which resulted in poor growth and establishment. Egbe et al (2012) reported similar activities affecting growth and distribution of species.

Plant diversity of an area is measured by density, abundance and distribution of individual species. The stand density of 1750 stems/ ha in the study site is comparable with the stem density in other tropical forests of different ecosystems e.g., 516.23 stems ha^{-1} for Nayagarh Forest Division, Odisha (Sahoo and Panda 2015, Sahoo et al 2017), 352 stems ha^{-1} in Northern Eastern Ghats (Panda et al 2013), 443 stems ha^{-1} in Malyagiri hills of Odisha (Sahu et al 2012), 298 stems ha^{-1} at Mudumalai Forest Reserve, India and 689 stems ha^{-1} at Sinharaja, Sri Lanka (Condit 2000). Mishra et al (2008) reported a tree density 650 - 970 individuals/ ha in Simlipal Biosphere Reserve which was lesser than the stem density recorded in this study. Importance value index of different plants in the present study area is compared with report of various other workers. In Similipal Biosphere Reserve, Mishra et al (2012) found that *Shorea robusta* was the most dominant species having IVI of 77.67 followed by *Terminalia alata* (16.13) and *Anogeissus latifolia* (13.43). *Wendlandia sp.* was the rarest species of the reserve forest with an IVI of 0.25. Most of the species in the present investigation showed less IVI values and occupied low ecological status of the ecosystem suggesting positive interactions among the tree species (Mishra et al 2012*).* Higher IVI values of plants depend on their good regeneration ability, more adaptability to specific site and environmental conditions. In the present investigation *Shorea robusta, Schleichera oleosa* and *Butea monosperma* showed wide association and good regenerating ability in the different sites of village commons. Moreover, adequate knowledge on IVI would play an important role for deciding the conservation practices of specific host plant populations of lac insects that are facing the vulnerability of extirpation by forest dependants in and the surroundings of this village commons. Tree species like *Schleichera oleosa, Butea monosperma. Ziziphus mauritiana, Shorea robusta, Buchanania lanzan, Madhuca indica, Dalbergia sissoo, Dalbergia latifolia, Pterocarpus marsupium* have local economic importance. Similarly, plant species like *Acacia nilotica, Azadirachta indica, Aegle marmelos, Alstonia scholaris* etc. have been used by the tribal population since time immemorial for medicinal purposes. Similar uses of studied species have been reported by various researchers (Mehra et al 2014, Bajpai et al 2016, Rout et al 2018). These plant species need to be conserved on priority basis against the factors like illicit harvesting, grazing by domestic animals and many other anthropogenic activities (WP, 2008-2017). Most of the upper storey vegetation showed a generally random type of distribution in the present study (Table 1). The abundance frequency ratio (A/F) for trees and shrubs indicates that forest seedlings grow close to the mother plant in the natural vegetation. Similar observations were also recorded by earlier researchers (Al-Amin et al 2004. Giliba et al 2011, Sobuj and Rahman 2011, Deka et al 2012) .

Adaptation of the species influences the species diversity which increases with the stability of the community. Shannon-Weiner (H′) index varied from 0.0295 to 0.184 with a total diversity value 3.599 of the trees. The findings were comparable with the report of earlier researchers (Sundarapandian and Swamy 2000, Kumar et al 2010, Panda et al 2013) in tropical forests of Indian sub-continent which falls within the range of 0.67 to 4.86. These findings suggest that the village commons represent a species diverse system. Maximum species diversity of 0.184 was in *Butea monosperma* while the minimum of 0.0511 was in many species of the study area indicating that over storey vegetation of the site had higher diversity. The dominance (Simpson's index) in the present study was 0.0273 have been compared with the reports in other forests (Lalfakawma et al 2009, Sahu et al 2012). This indicates that influence of anthropogenic and ecological factors brings about declining vegetation of the ecosystem.

CONCLUSION

Tropical forest in the periphery of Kuldiha Wildlife Sanctuary of Balasore district acts as one of the richest reservoirs of floral genetic diversity harbouring a number of

indigenous forest plants, medicinal herbs, underutilized fruits and wild tubers. The study area reveals 44 species mostly showing random distribution. Out of the documented tree species, 3 species viz *Schleichera oleosa*, *Butea monosperma* and *Ziziphus mauritiana* were used as lac hosts of which *B. monosperama* was recorded with the highest stem density/ha and *S. oleosa* showed the maximum IVI. *S. robusta*, *B. lanzan*, *S. cerasoides* and *S. cumin* were found to be the most associated species of the of major lac host trees in the study site. Adequate conservation and management practices of these plant species not only maintain the forest biodiversity but also meet the basic needs of tribal population living in the peripheral areas of the village commons. The documentation of the tree diversity in the present study provides a base line input in understanding the threats of tropical forests, a suitable long term management intervention and conserving the phytodiversity of the forest ecosystem that would ensure sustained supply of goods and services for communities in the study area.

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