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Understanding the Patch Dynamics of a few Homogenous and Heterogenous Vegetational Patches

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ABSTRACT

Variations in size and shape distinguish vegetation patches across different ecosystems. Nonetheless, recent research highlights notable parallels in the dynamics of these patches and the mechanisms governing their formation and persistence. Two primary types, banded and spotted vegetation, characterized by their patch shapes, stem from shared mechanisms, albeit each type is predominantly influenced by a distinct driver. Banded vegetation emerges when water primarily facilitates the redistribution of materials and propagules, whereas spotted vegetation arises when wind serves as the primary redistributing force. Overall, the analysis underscores how patchy vegetation structures bolster primary production. According to Patch Dynamics theory, vegetation can be categorized into homogeneous and heterogeneous patches, with seasonal conditions playing a pivotal role in the coexistence of various vegetation types. Understanding mechanisms of coexistence necessitates a thorough grasp of the ecophysiological responses of dominant species to different patch types. Consequently, this study aimed to discern the ecophysiological reactions of species to two distinct patch categories. Throughout the examination of Patch Dynamics, both patch species exhibited the highest photosynthetic capacity within their respective patches. Parameters such as Leaf Area Index (LAI), the number of individuals (N), biomass, height (h), weight, and others manifested changes across patch types. Notably, species within the banded patch exhibited heightened sensitivity and more substantial fluctuations in their values compared to those in the spotted patch. These differential responses to distinct patches offer insights into potential mechanisms facilitating species coexistence.

INTRODUCTION

In contemporary ecology, recognizing spatial heterogeneity as a core aspect of natural systems is essential. Ecologists and wildlife biologists have primarily focused on broader scale patterns such as elevational gradients and climatic zones (Wiens 1989). Patch dynamics, investigating spatial configurations and processes within landscapes, explores how patches evolve over time (Pickett & White 1985). These patches, differing from adjacent areas, can be found in various ecosystems like forests, where stands of trees form patches (Turner et al. 2001). Understanding patch dynamics is crucial for grasping the interplay among pattern, process, and scale in ecology, forming the basis of landscape ecology, disturbance ecology, and population ecology's spatial components (Forman & Godron 1986). Despite the dynamic nature of patch dynamics, it contributes to the concept of the shifting mosaic steady state (Levin & Paine 1974). Integrating patch dynamics with hierarchy theory addresses disparities across spatial scales, crucial for biodiversity conservation and resource management. Patch dynamics intersects with key ecological concepts like island biogeography theory (MacArthur & Wilson 1967), Metapopulation Theory (Hanski 1999), succession, and disturbance ecology, providing a vital framework for understanding and preserving complex natural systems.

Foundation Work

The history of patch dynamics can be divided into two main phases. Initially, from the 1930s to the late 1970s, researchers explored spatial change and patchiness, particularly in ecosystems like rocky shores and forests. The concept expanded with seminal works like Watt's 1947 paper, hinting at its relevance in various ecosystems (Watt 1947). The 1980s witnessed the maturation of patch dynamics, coinciding with the rise of landscape ecology and spatial ecology. This period saw an expanded application of patch dynamics across diverse ecosystems (Forman 1995). Patch dynamics highlights the importance of diverse habitat patches, shaped by natural disturbances, for maintaining ecological diversity. A patch refers to a discrete area utilized by species for breeding or resources, while mosaics encompass landscape patterns like forest stands or highways. This perspective views ecological systems as mosaics of patches, varying in size, shape, composition, and history. Patch dynamics originated in the study of vegetation structure and dynamics in the 1940s, later evolving into a predominant theme in ecology from the late 1970s to the 1990s. This framework emphasizes the dynamic interplay between heterogeneity and homogeneity within ecosystems. Patches transition between potential, active, and degraded states, influenced by colonization, abandonment, and recovery processes. Human activities like logging and farming can alter patch shape and composition, impacting nutrient cycling and species migration. Despite spatial separation, patches remain interconnected, sustaining populations and facilitating species spread (Corrado et al. 2014). Understanding patch dynamics is crucial for effective conservation. Conservation efforts involve managing patch dynamics, predicting responses to external forces, and monitoring biodiversity changes. Analysis of patch dynamics aids in predicting biodiversity fluctuations, with alterations in external conditions serving as early indicators of biodiversity collapse (Saravia & Momo 2017). The research aims to identify and monitor patches within a university campus, analyzing vegetation cover spatially and temporally. Utilizing remote sensing and field surveys, the study will assess changes in species numbers and vegetation cover, providing insights into campus ecosystem dynamics for effective conservation and management strategies.

MATERIALS AND METHODS

Study Area

The study is conducted within the campus of The Maharaja Sayajirao University of Baroda, situated in the Sayajigunj ward of Vadodara city of Gujarat (Fig. 1). The campus features a variety of vegetational patches comprising both herbs and trees. Additionally, a small river traverses the campus, hosting diverse patches of trees and annual herbs. These patches are significantly influenced by a multitude of biotic and abiotic factors, which exert considerable impact on their growth and development.

Two types of vegetation patches were identified for the study

1. **Homogeneous patch:** Characterized by uniform structure with minimal variation within the population.
2. **Heterogeneous patch:** Comprising a diverse population where individuals exhibit dissimilar characteristics.

Twenty patches, including 10 homogeneous and 10 heterogeneous, were randomly selected, encompassing various vegetation types such as herbs and trees. Special attention was paid to ensure that the patches chosen for the study were naturally grown. Monthly observations were conducted to analyze the changes occurring in different patches in response to environmental conditions and anthropogenic activities. Field visits were conducted three times during December, January, and February. The minimum patch size considered was 1×1 m^2, while the maximum patch size was 10×10 m^2. Various parameters, including the number of individuals, mean patch area, height, biomass, leaf area index (LAI), diameter at breast height (DBH), and moisture content, were measured for each patch. The detailed methodology for measuring these parameters is elaborated in the following sections. Fig. 2 shows the experimental design of the study.

Number of Patches (NP): The total number of patches for both communities was computed using GIS for the three time periods.

Fig. 1: The study area.

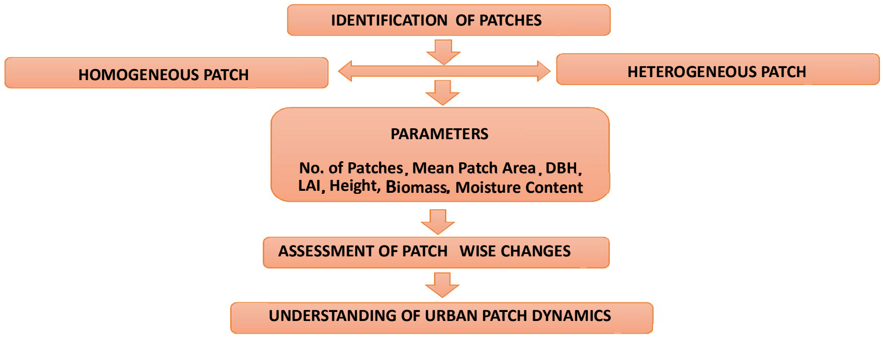

Fig. 2: Flowchart showing the experimental design of the study.

Mean Patch Area (MPA): The area of each patch within a landscape mosaic is a crucial piece of information. It is calculated as the sum of the areas (in square meters) of all patches divided by the number of patches of the same type per unit area.

Biomass: Biomass refers to the total mass of living material measured over a specific area. Since living organisms contain water, biomass is typically calculated as dry mass. To compute the Quadratic Stand Density (QSD), the basal area of the diameter class is divided by the number of trees in the class to determine the basal area of the average tree. The Harvest method is commonly used for measuring biomass: the biomass is harvested, dried in an oven to remove moisture, and then weighed to obtain the dry weight, which provides a more stable measure of biomass compared to fresh weight.

Diameter at Breast Height (DBH): Diameter at Breast Height (DBH) is a standard measure used to express the diameter of a tree trunk or bole. It is one of the most common dendrometry measurements. Electronic calipers are often utilized to measure DBH, with the measured data transmitted online via Bluetooth to a field computer. DBH is typically measured at 1.3 meters above ground level, although previous conventions varied. Some suggest using Dx instead of DBH to denote the exact height above the floor at which the diameter is measured. Instruments such as girthing tapes and calipers are commonly used to measure DBH, with girthing tapes calibrated in divisions of π centimeters. In many countries, the diameter has been measured usually at 1.3 meters above ground (Brack 2009). Previously 4.5 ft (1.37 m) was used. (Paul 2017) The height can make a substantial difference to the measured diameter (Russell & Barbara 1990). Ornamental trees are usually measured at 1.5 meters above ground. However, some authors (Brokaw & Thompson 2000) maintain that the term DBH should be abolished precisely because the heights at which the diameter is measured are so variable and because it may strongly influence forestry calculations such as biomass. Instead, Dx was proposed whereby the x denotes the exact height above the floor (and along the stem) at which the diameter is measured.

Leaf Area Index (LAI): Leaf Area Index (LAI) is a dimensionless quantity used to characterize plant canopies. It represents the one-sided green leaf area per unit ground surface area (LAI = leaf area/ground area) in broadleaf canopies (Krebs 1999).

RESULTS AND DISCUSSION

The concept of patch dynamics stems from recognizing ecosystems as spatially heterogeneous, containing diverse mixtures of organisms and resources distributed unevenly across time and space. Ecological disturbances like floods, fires, and disease outbreaks drive much of this spatial heterogeneity by disrupting biological communities, creating patches of varying sizes, shapes, compositions, and histories. University campus studies revealed influences of environmental factors on both homogeneous and heterogeneous herb patches, with significant changes observed across all measured parameters. These studies identified 10 homogeneous patches hosting 10 herb species (Table 2, Fig. 3) and 10 heterogeneous patches hosting 55 herb species. (Table 1, Fig. 4) Population size correlated significantly with patch area, indicating that larger patches had a higher probability of supporting sustainable plant populations compared to smaller patches (Jacquemin 2002).

In Homogenous herb patches, high quantities of *Alternanthera ficoidea*, *Acalypha indica*, and *Synedrella nodiflora* were observed (79, 40, and 42 individuals, respectively). The patch occupancy of *Alternanthera ficoidea* and *Acalypha indica* was influenced by habitat and patch characteristics, with moisture content and number of individuals decreasing as patch area decreased, while height and leaf area increased (Honnay et al. 1999). *Sida acuta* occurred in the largest patch (15.2 m), experiencing a rapid

Table 1: Heterogeneous Patches.

Patch No.	Patch species	Family
1.	*Alternanthera ficoidea* (L.) P.Beauv.	Amaranthaceae
	Acalypha indica L.	Euphorbiaceae
	Elephantopus tomentosus L.	Asteraceae
2.	*Sida acuta* Burm.f.	Malvaceae
	Alternanthera ficoidea (L.) P.Beauv.	Amaranthaceae
	Cyanthillium cinereum (L.) H.Rob.	Asteraceae
	Acalypha indica L.	Euphorbiaceae
3.	*Alternanthera ficoidea* (L.) P.Beauv.	Amaranthaceae
	Cyanthillium cinereum (L.) H.Rob.	Asteraceae
	Echinochloa colona (L.) Link	Poaceae
	Tridax procumbens L.	Asteraceae
	Ziziphus mauritiana Lam.	Rhamnaceae
4.	*Sida acuta* Burm.f.	*Malvaceae*
	Alternanthera ficoidea (L.) P.Beauv.	Amaranthaceae
	Achyranthes aspera L.	Amaranthaceae
	Antigonon leptopus Hook. & Arn.	Polygonaceae
	Zinnia elegans Jacq.	Asteraceae
	Trifolium repens L.	Fabaceae
	Tephrosia purpurea (L.) Pers.	Fabaceae
5.	*Alternanthera ficoidea* (L.) P.Beauv.	Amaranthaceae
	Acalypha indica L.	Euphorbiaceae
	Eragrostis gangetica (Roxb.) Steud.	Poaceae
	Phyllanthus amarus Schumach. & Thonn.	Phyllanthaceae
	Amaranthus viridis L.	Amaranthaceae
	Cyanthillium cinereum (L.) H.Rob.	Asteraceae
	Launaea intybacea (Jacq.) Beauverd	Asteraceae
	Actinidia chinensis Planch.	Actinidiaceae
6.	*Alternanthera ficoidea* (L.) P.Beauv.	Amaranthaceae
	Parthenium hysterophorus L.	Asteraceae
	Trifolium repens L.	Fabaceae
	Sida acuta Burm.f.	*Malvaceae*
	Senna tora (L.) Roxb.	Fabaceae
7.	*Lantana camara* L.	Verbenaceae
	Acalypha indica L.	Euphorbiaceae
	Alternanthera ficoidea (L.) P.Beauv.	Amaranthaceae
	Tephrosia purpurea (L.) Pers.	Fabaceae
8.	*Synedrella nodiflora* Gaertn.	Asteraceae
	Acalypha indica L.	Euphorbiaceae
	Alternanthera ficoidea (L.) P.Beauv.	Amaranthaceae
	Phyllanthus niruri L.	Phyllanthaceae
	Sida acuta Burm.f.	*Malvaceae*
	Cyanthillium cinereum (L.) H.Rob.	Asteraceae
9.	*Phyllanthus niruri* L.	Phyllanthaceae
	Tephrosia purpurea (L.) Pers.	Fabaceae
	Synedrella nodiflora Gaertn.	Asteraceae
	Alternanthera ficoidea (L.) P.Beauv.	Amaranthaceae
	Acalypha indica L.	Euphorbiaceae
	Achyranthes aspera L.	Amaranthaceae
	Dicliptera paniculata (Forssk.) I.Darbysh.	Acanthaceae
10.	*Ocimum tenuiflorum* L.	Laminaceae
	Tephrosia purpurea (L.) Pers.	Fabaceae
	Ligustrum lucidum W.T.Aiton	Oleaceae
	Alternanthera ficoidea (L.) P.Beauv.	Amaranthaceae
	Acalypha indica L.	Euphorbiaceae
	Heliotropium indicum L.	Boraginaceae

Fig. 3: Homogeneous Patches.

Table 2: Homogeneous Patches.

Patch No.	Patch species	Family
1.	*Acalypha indica* L.	Euphorbiaceae
2.	*Sida acuta* Burm.f.	Malvaceae
3.	*Achyranthes aspera* L.	Amaranthaceae
4.	*Phyllanthus reticulatus* Poir.	Phyllanthaceae
5.	*Tephrosia purpurea* (L.) Pers.	Fabaceae
6.	*Alternanthera ficoidea* (L.) P.Beauv.	Amaranthaceae
7.	*Indigofera tinctoria* L.	Fabaceae
8.	*Synedrella nodiflora* Gaertn.	Asteraceae
9.	*Ficus hispida* L.f.	Moraceae
10.	*Barleria prionitis* L.	Acanthaceae

Fig. 4: Heterogeneous Patches.

reduction in patch area (4.99 m) and a decrease in species number from 28 to 13. *Phyllanthus reticulatus* occurred in the smallest patch (1.96 m), with a decrease in species number from 29 to 15 (Table 3).

In Heterogeneous herb patches, species like *Alternanthera ficoidea*, *Acalypha indica*, *Synedrella nodiflora*, and *Sida acuta* were commonly found across patches. Moisture content and number of individuals varied across patches with changes in patch area, while some herb species showed an increase in height and leaf area as patch area decreased (Honnay et al. 1999). Patch No. 8 and 9 exhibited the largest patch sizes (9.3 m and 14.9 m, respectively) with rapid reductions in patch area (6.69 m and 10.74 m, respectively), resulting in both increased and decreased species numbers. Patch No. 3 had the smallest patch area (1.45 m) with similar fluctuations in species numbers across patches (Table 4). The findings from the heterogeneous patches underscored the significant role of the patch area, affirming its importance in

Table 3: Homogeneous Patches.

Patch No.	Patch Species	No. of Individuals (n)			LAI			Moisture Content (%)			Area Covered by Patch (sq. m)			Height (m)		
		DEC	JAN	FEB	DEC	JAN	FEB	DEC	JAN	FEB	DEC	JAN	FEB	DEC	JAN	FEB
1	*Acalypha indica* L.	40	35	30	0.62	0.70	1.48	2.2	7.07	7.32	8.97	5.76	3.14	0.4	0.8	1
2	*Sida acuta* Burm.f.	28	20	13	0.15	0.16	0.27	12.8	4.05	2.96	10.8	7.88	3.8	1	1.4	1.6
3	*Achyranthes aspera* L.	25	12	10	0.42	0.53	0.88	47.1	38.7	19.18	15.2	10.28	4.99	1.2	1.6	1.8
4	*Phyllanthus reticulatus* Poir.	29	18	15	0.71	0.78	1.2	36.3	10.7	5.92	1.96	1.67	1	1.5	1.7	1.8
5	*Tephrosia purpurea* (L.) Pers.	38	30	25	0.27	0.32	0.80	22.8	22.4	19.72	4.15	2.95	1.09	0.8	1	1.2
6	*Alternanthera ficoidea* (L.) P.Beauv.	79	74	69	0.48	0.57	0.72	13.1	10.4	10.14	4.15	3.45	2.54	0.45	0.6	0.8
7	*Indigofera tinctoria* L.	32	20	14	0.27	0.62	1.36	28.5	16.2	15.48	4.91	2.39	1.21	1.8	2	2.4
8	*Synedrella nodiflora* Gaertn.	42	34	28	0.48	0.81	1.19	12.4	6.78	1.44	5.55	3.15	2.11	0.5	0.8	1
9	*Ficus hispida* L.f.	25	12	10	19.6	20.7	25.1	24.3	9.22	6.95	2.54	2.1	1.5	0.4	0.5	0.6
10	*Barleria prionitis* L.	33	25	19	2.64	3.41	4.04	4.64	4.7	3.88	3.14	2.11	1.56	2	2.2	2.4

explaining the formation of plant patches and patch dynamics. Heterogeneous herb species exhibited greater sensitivity to decreases in patch area compared to homogeneous herb species, which showed lower sensitivity. Interestingly, tree species appeared to be less affected or unaffected by changes in patch area. In both homogeneous and heterogeneous tree patches, tree species were consistently present across all observed patches, with minimal changes detected. There was a slight increase observed in the number of tree species, as well as an increase in height and diameter at breast height (DBH) with an increase in height.

Species Area Curves: Species-area curves are employed to estimate the rate of decrease in species number, illustrating the positive relationship between the area of a region and the number of biological species found within it. These curves have been extensively discussed in conservation biology, particularly concerning their utility in designing optimal nature reserves and predicting the loss of species richness in regions experiencing area reduction (Higgs 1981). By utilizing species-area curves, patch sizes corresponding to approximately 90%, 75%, 50%, and 25% of the total species were interpolated to evaluate the potential impact of patch size reduction on species richness. It is crucial to delineate the chosen slope for calculation. Several parameters must be considered: firstly, the relationship between species and area can follow either a linear or power function. Secondly, the slope of the species-area curve should remain constant across spatial scales encompassing the area reduction over which species loss is estimated. Lastly, it must be determined whether the reduced area better represents an isolated entity (a true island) or merely a subsample of the original area (Connor & McCoy 2001). In homogeneous patches, the mean patch area exhibited a more pronounced decrease compared to heterogeneous patches (Fig. 5).

Eco-physiological Responses of Patches

Ecophysiology is a biological discipline that studies the adaptation of an organism's physiology to environmental conditions. It is closely related to Comparative Physiology and Evolutionary Physiology (Schulte et al. 2011). Light plays a pivotal role in the survival, growth, and development of higher plants, as highlighted by various studies (Valladares 2003, Walters & Reich 2000, Durand & Goldstein 2001, Hitsuma 2012). During patch dynamics, the light environment undergoes diurnal variations and differs by patch type. Consequently, individual plants fine-tune their physiological traits to optimize carbon gain under varying environmental conditions. Leaves serve as a prime example of a plant's ability to respond to changes in light and the environment (Poorter & Bongers 2006). Plants belonging to

Table 4: Heterogenous patches.

Patch No.	Patch species	No. of Individuals			LAI			Moisture Content (%)			Area covered by patch (sq. m)			Height (m)		
		DEC	JAN	FEB	DEC	JAN	FEB	DEC	JAN	FEB	DEC	JAN	FEB	DEC.	JAN.	FEB.
1	*Alternanthera ficoidea* (L.) P.Beauv.	28	20	15	0.86	1.09	1.34	3.52	4.88	5.02	2.07	1.32	0.97	0.2	0.4	0.6
	Acalypha indica L.	6	5	3	5.92	6.06	6.48	2.62	3.02	3.31				1	1.2	1.6
	Elephantopus tomentosus L.	3	4	5	11.15	10.9	9.02	4.76	5.98	6.74				0.2	0.3	0.5
2	*Sida acuta* Burm.f.	8	5	4	0.55	0.54	0.53	25.4	18.4	12.2	5.6	4.3	3.79	1	1.3	1.5
	Alternanthera ficoidea (L.) P.Beauv.	32	25	12	0.74	0.69	0.55	5.8	4.1	3.6				0.1	0.2	0.4
	Cyanthillium cinereum (L.) H.Rob.	5	3	2	0.68	0.83	1.00	10.9	7.1	3.88				0.4	0.5	0.8
	Acalypha indica L.	4	5	7	1.25	1.93	2.09	5.86	5.71	5.62				0.1	0.2	0.6
3	*Alternanthera ficoidea* (L.) P.Beauv.	16	10	8	3.14	2.79	2.32	2.06	2.53	3.26	1.45	0.72	0.56	0.3	0.5	0.6
	Cyanthillium cinereum (L.) H.Rob.	2	3	4	7.52	8.05	9.55	7.35	7.67	7.94				0.3	0.4	0.7
	Echinochloa colona (L.) Link	26	21	10	1.98	2.22	4.73	0.18	0.29	0.51				0.2	0.4	0.5
	Tridax procumbens L.	5	6	7	4.36	3.95	3.35	6.05	4.19	2.15				0.1	0.2	0.4
	Ziziphus mauritiana Lam.	8	4	3	9.53	9.72	9.85	6	6.13	6.39				1.8	2	2.2
4	*Sida acuta* Burm.f.	36	30	23	0.28	0.25	0.21	35.4	15.6	6.59	8.2	6.3	4.74	1.3	1.5	1.6
	Alternanthera ficoidea (L.) P.Beauv.	64	58	19	0.34	0.31	0.29	3.39	3.34	3.27				0.06	0.1	0.3
	Achyranthes aspera L.	7	5	5	1.42	1.11	0.98	43.1	21.2	10.0				0.5	0.6	0.8
	Antigonon leptopus Hook. & Arn.	29	23	16	0.26	0.95	1.36	3.1	2.65	2.51				4.9	5.2	5.6
	Zinnia elegans Jacq.	3	2	1	0.43	0.45	0.46	12.8	9.09	7.6				1	0.6	0.4
	Trifolium repens L.	42	45	48	0.38	0.31	0.25	1.15	1.21	1.54				6.1	6.3	6.6
	Tephrosia purpurea (L.) Pers.	2	1	1	0.4	0.31	0.21	21.8	18.4	17.6				0.4	0.5	0.7
5	*Alternanthera ficoidea* (L.) P.Beauv.	18	12	10	0.37	0.79	1.27	2.2	2.13	1.83	4.8	2.54	1.41	0.2	0.3	0.5
	Acalypha indica L.	6	8	9	1.69	2.75	4.39	9.35	7.72	5.99				0.8	1	1.3
	Eragrostis gangetica (Roxb.) Steud.	9	3	0	0.10	0.20	0	0.01	0.17	0				0.08	0.1	0
	Phyllanthus amarus Schumach. & Thonn.	9	5	2	0.12	0.39	1.20	4.64	3.96	3.62				0.3	0.4	0.6
	Amaranthus viridis L.	4	6	8	1.79	2.5	4.23	68.6	36.0	24.8				1	1.2	1.4
	Cyanthillium cinereum (L.) H.Rob.	2	2	3	2.01	3.93	6.80	1.98	2.12	3.24				0.8	0.7	0.5
	Launaea intybacea (Jacq.) Beauverd	4	5	6	5.46	8.58	15.2	40.0	14.4	5.52				1.2	1.4	1.6
	Actinidia chinensis Planch.	1	1	2	1.63	2.87	4.48	0.58	0.74	0.84				0.1	0.2	0.4

Table Cont....

Patch No.	Patch species	No. of Individuals			LAI			Moisture Content (%)			Area covered by patch (sq. m)			Height (m)		
		DEC	JAN	FEB	DEC	JAN	FEB	DEC	JAN	FEB	DEC	JAN	FEB	DEC.	JAN.	FEB.
6	*Alternanthera ficoidea* (L.) P.Beauv.	36	28	21	0.61	0.46	0.43	7.1	4.12	2.72	5.2	4.52	3.2	0.8	0.6	0.4
	Parthenium hysterophorus L.	3	3	4	2.94	3.28	3.83	14.5	15.1	16.7				0.4	0.5	0.8
	Trifolium repens L.	84	76	38	0.52	0.68	0.75	2.4	1.93	1.32				0.1	0.2	0.4
	Sida acuta Burm.f.	6	5	4	0.48	0.34	0.13	7.25	7.11	7.01				1.2	1.3	1.5
	Senna tora (L.) Roxb.	2	1	1	0.48	0.45	0.44	9.4	7.28	5.7				0.6	0.5	0.3
7	*Lantana camara* L.	12	7	0	8.54	6.34	0	57.6	49.3	0	3	2.26	1.32	0.8	0.4	0
	Acalypha indica L.	10	8	7	1.36	2.45	3.47	4.76	3.55	3.54				0.4	0.6	0.8
	Alternanthera ficoidea (L.) P.Beauv.	37	34	28	1.27	1.32	1.47	5.82	4.13	2.31				0.8	1	1.2
	Tephrosia purpurea (L.) Pers.	40	38	6	0.18	0.52	0.93	6.06	3.62	2.58				0.4	0.6	0.7
8	*Synedrella nodiflora* Gaertn.	18	15	4	1.29	0.70	0.68	33.2	24.3	16.5	9.3	8.48	6.69	1	1.2	1.4
	Acalypha indica L.	14	10	7	0.82	0.94	1.23	22.4	14.0	8.29				0.8	1	1.2
	Alternanthera ficoidea (L.) P.Beauv.	26	23	9	0.35	0.33	0.32	4.9	4.67	3.37				0.9	0.7	0.4
	Phyllanthus niruri L.	3	3	4	0.13	0.26	0.33	3.4	4.24	6.5				0.8	0.6	0.7
	Sida acuta Burm.f.	8	6	11	0.22	0.18	0.13	22.8	19.4	15.2				0.6	0.8	1
	Cyanthillium cinereum (L.) H.Rob.	1	2	2	0.52	0.54	0.55	6.9	5.38	4.27				0.4	0.5	0.7
9	*Phyllanthus niruri* L.	1	1	2	0.17	0.12	0.07	29.5	18.3	9.47	14.9	11.2	10.74	0.2	0.3	0.4
	Tephrosia purpurea (L.) Pers.	1	2	0	0.20	0.13	0	27.2	19.4	0				0.7	0.5	0
	Synedrella nodiflora Gaertn.	1	3	2	0.58	0.53	0.41	1.03	2.32	6.33				0.4	0.5	0.8
	Alternanthera ficoidea (L.) P.Beauv.	56	44	32	0.21	0.18	0.15	18.2	8.73	4.48				1.3	1.2	1
	Acalypha indica L.	48	20	6	0.54	0.48	0.39	10.7	9.02	8.19				0.5	0.6	0.7
	Achyranthes aspera L.	26	6	3	0.58	0.56	0.55	13.2	10.6	9.79				1.6	1.8	2
	Dicliptera paniculata (Forssk.) I.Darbysh.	4	5	8	2.22	1.94	1.74	1.93	1.6	1.05				0.3	0.4	0.6
10	*Ocimum tenuiflorum* L.	6	2	3	0.80	2.7	4.36	14.6	9.13	5.8	1.65	0.5	0.41	0.9	1	1.2
	Tephrosia purpurea (L.) Pers.	12	5	0	1.57	3.3	0	13.4	16.6	0				0.3	0.4	0
	Ligustrum lucidum W.T.Aiton	2	1	1	18.69	19.7	20.1	42.2	25.4	7.54				0.7	1	1.3
	Alternanthera ficoidea (L.) P.Beauv.	20	16	12	4.78	5.1	6.21	12.4	8.83	5.54				1.2	0.8	0.6
	Acalypha indica L.	3	4	8	10.9	12.5	15	10.1	11.7	11.6				0.4	0.6	0.8
	Heliotropium indicum L.	1	4	6	30. 46	26	22.6	11.1	18.7	42.5				0.2	0.4	0.6

different functional types develop acclimation mechanisms to optimize light utilization under low light conditions, as evidenced by studies (Miller 2004, Yoshimura 2010, Hitsuma 2012, Wyka 2012). Natural growth and regeneration in low light conditions are associated with photosynthetic capacity coupled with morphological and physiological adaptations (Gommers 2013). Changes induced by light competition reflect a plant's ability for shade avoidance or tolerance (Gommers 2013). In the present study, the evergreen *Alternanthera ficoidea*, showed increased ratios, in the homogenous patch as a result of the increase in LAI and height, which indicates that the species performs well under survival conditions also. *Eragrostis gangetica*, *Tephrosia purpurea,* and *Lantana camara* had poor shade acclimation, indicating a trade-off between high light (in the Heterogenous patch). We observed that the mortality of *Alternanthera ficoidea* was approximately two times higher than that of other species in both of the patches. The different mortality is a good indicator of their interspecific differences in high and low light tolerance. During the patch dynamics, *Alternanthera ficoidea*, *Eragrostis gangetica*, *Lantana camara,* and *Tephrosia purpurea* exhibited a higher degree of change, which was in accordance with its shorter leaf life span and higher potential photosynthetic rates. The greater changes within the patch dynamics were inherently associated with the higher flexibility in utilizing available resources in different patches. Accepting these species, other species of the Heterogeneous patches exhibited small changes with slow growth and little variation in eco-physiological traits during the patch dynamics, for evergreen species have a stable physiological performance (Böhnke & Bruelheide 2013). The various interspecific responses to the four different types of patches provide new insights into the extinction and coexistence mechanism.

Generally, an increase in the number of individuals in an area can lead to a higher leaf area index. This is because more plants contribute to the total leaf area, resulting in a denser canopy and a higher LAI. Moisture content can also affect LAI. In areas with adequate moisture, plants tend to have more leaves and a denser canopy, leading to a higher LAI. However, in drought or water-stressed conditions, plants may have fewer leaves or smaller leaf sizes, resulting in a lower LAI. (Jin et al. 2017) So, the relationship between LAI, number of individuals, and moisture content is not straightforward. It depends on various factors such as plant species, environmental conditions and management practices. The findings underscore the significance of temporal and spatial variations across different patches during patch dynamics, highlighting the fluctuating partitioning of eco-physiological traits as crucial factors for stable coexistence and avoidance of extinction (Table 5).

CONCLUSION

Based on the findings and discussions presented above, it has been demonstrated that heterogeneous patches of herbs exhibit more favorable growth conditions compared to homogeneous patches. The competition for similar resources accelerates the degradation of homogeneous patches in contrast to heterogeneous ones. The higher plant diversity observed in heterogeneous patches contributes to their increased survival rate. Therefore, the dynamic analysis of these patches holds significant importance in predicting and conserving biodiversity within urban areas. In heavily disturbed urban environments, such patches may play a vital role in plant conservation efforts, as they offer greater resilience against disturbances and invasions by other species and human activities.

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Fig. 5: Reduction in Mean Patch Area over time a. Homogenous Patches b. Heterogenous Patches.

Table 5: Rate of change in patch characteristics in patch dynamics.

No.	Rate of Change	Heterogeneous patches	Homogeneous patches
1.	Number of Individuals	7.23	15.18
2.	Moisture content	6.90	12.27
3.	LAI	0.42	-1.25
4.	Mean Patch Area	2.23	4.23
5.	Height	0.23	-0.45

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