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A survey of various ecosystems in relation to habitat conservation and urban biodiversity in Mati City, Davao Oriental, Philippines

Edison D. MACUSI[1,2], Rancil Quin M. SALANG[1], Jireh R. ROSALES[1]

[1]*Institute of Agriculture and Life Sciences and Institute of Agriculture and Life Sciences (IALS); ORCID: Edison D. Macusi: https://orcid.org/0000-0002-9714-1074, Rancil Quin M. Salang: https://orcid.org/0009-0008-4752-3104, Jireh R. Rosales: https://orcid.org/0000-0002-3591-1299,*
[2]*Regional Integrated Coastal Resource Management Center (RIC-XI) Davao Oriental State College of Science and Technology (DOSCST), Mati City, Davao Oriental, Philippines*

Corresponding author: edmacusi@gmail.com

ABSTRACT. In ecology, the community structure of an ecosystem is paramount to demonstrating the integrity and interrelationship of the various flora and fauna of the ecosystem. The objectives of this paper are to show the variation of community structures from a microecosystem (log ecosystem) to a macroecosystem (mangrove forests and seagrass beds) and determine the biodiversity of these ecosystems. In this paper, class data gathered from the field were quantified to produce a coherent result showing that the ecosystem in a typical Philippine college or university can be used as a field laboratory to study biodiversity and increase the awareness of students and the academic community on understanding the various concepts of ecology. The relative abundance, rank abundance, Simpson and Shannon-Wiener biodiversity indices were measured and quantified for the various ecosystems. Furthermore, the apparent lack of concern for biodiversity is discussed, and how these fragmented ecosystems are being neglected because of a lack of coherent policy to address these issue and protect the ecosystem landscape.

Keywords: *Ecology, experiment, field investigative approach, log ecosystem, man-made forests, mangrove-seagrass ecosystems*

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INTRODUCTION

As the population increases in various municipalities and cities in the country, the amount of green space devoted to green landscapes is replaced by buildings that cater to various human activities. Development, which is synonymous with urbanization in developing countries, has been the consequence of high birth rates, high migration rates to urban areas, and, to some extent encouraged by government policies. For instance, the centralization of various services and infrastructure in the country to urban areas has encouraged the building up of businesses and the growth of job migrants to the cities. As a result, clogging of drainage, chronic flooding, rising water, air, and solid waste pollution, the development of urban heat islands, and rapid population growth rates are causing high strain on ecosystem goods and services (Gonzales and Magnaye, 2017).

The UN recently reported a more than 50% increase in urbanization around the world (Schwarz et al., 2017; Wu, 2010). Monitoring urbanization is critical to habitat conservation, as urbanization claims more land areas devoted to protected landscapes and transforms them into sprawling human habitations (Goddard et al., 2010). As a consequence, these areas are bulldozed to make way for road construction, buildings, business establishments, resorts, residential areas, malls, and schools. Often, these construction activities lead to a corresponding loss of wildlife species if they use coastal areas, clear forests for road building, and clear green spaces and convert them for public and private use. In this process, the shrinking space for wildlife habitat is turned into human-private space. These human private spaces are utilized for city residential areas, schools, market places, and malls that have been built without a view of human and nature ecology as one and vital to the other (Vitousek et al., 1997). In fact, this vitality is dependent on nature's ecological services, which include cultural, provisioning, and regulating services (Costanza et al., 1998; Martínez et al., 2007). Moreover, rapid urbanization has the effect of reducing the abundance and distribution of various native plant and animal species, where once there was teeming wildlife. These spaces have been transformed into residential and business areas that are devoid of experience encountering nature, which isolates them from important environmental issues of our time (Shwartz et al., 2014). When people have fewer opportunities to encounter nature in their backyard or city, concern and care for the environment diminish as they become separated from having nature consciousness (Strohbach et al., 2009). This nature consciousness, whether good or meant for conservation, or indifference towards nature, influences their outlook and decisions about whether to actively participate or not in the conservation of species or the adoption of sustainability. But when people are able to connect with nature, such as in the case of having a first-hand experience of appreciating the beauty of landscapes through people-biodiversity interactions in their everyday lives and being able to identify with that experience, the role of raising public conservation awareness becomes easier (Shwartz et al., 2014). This psychological connection between the behavior of man and his response to nature is not strictly linear, as educational inputs and advertisements can raise awareness of human-nature interaction.

The landscapes found in some Philippine colleges and universities offer green space and spacious areas for nature reserves, which can provide that urban ecosystem service to students and the public. Urban ecosystem services can be defined as the cultural, provisioning, and regulating services that the environment can offer. In an urban setting, there are altered biotic and abiotic conditions, whether in soil, air, plants, or water. The functional composition of species may have shifted due to the change in biotic and abiotic conditions, as well as the shift to non-native and

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short-lived plants or species, and urban areas present a challenge in terms of the socioeconomic conditions of the people, thereby affecting ecosystem goods and services (Schwarz et al., 2017).

In addition, the investments in green infrastructure by the various local governments can enhance not only the city's livability but also its overall functional biodiversity. According to Tilman et al., (1996), functional diversity is defined as the complementary nature of various species in a given location, so that when one species is missing, the overall function or service that those species can provide is reduced. In green infrastructure, the green spaces in school campuses and in cities are utilized and planted with various plant species, with the aim of alleviating urban heat island effects as well as indoor comfort (Chen et al., 2014; Mackey et al., 2012; Susca et al., 2011). By utilizing native species as well as other introduced species, this can enhance the biodiversity of the cities and their green spaces by adding or planting various species of trees, shrubs, and flowers (Shwartz et al., 2014).

In this paper, we examined how various ecosystem community structures found in the vicinity of school campuses can become an indicator of the health status of an urban area, with our school in Mati City as a case study. Urban biodiversity and its corresponding urban ecological services are highly dependent on maintaining a green space for wildlife species and, therefore, green zones in cities and schools. There are still living spaces found in our school that can be a foundation for continuing or enhancing such green spaces by facilitating greening projects in schools, neighborhoods, and the city as a whole. The provision for such projects will lead to enhanced habitat areas where birds, insects, and butterflies can dwell, enriching the biodiversity of a city or residential area (Schwarz et al., 2017; Shwartz et al., 2014). A problem in most urbanizing cities is the lack of a coherent approach to implementing plans of action to provide or enhance green zones that can act as buffers for climate change or for urban heat island effects (Gonzales and Magnaye, 2017; Mackey et al., 2012; Susca et al., 2011). In some cases, these greening programs are sometimes used as a political tool for influencing people's decisions. Thus, there is a coherent lack of awareness among the locals about how to care for their environment and what to teach them to do to become partners and protectors of the environment. When cities are left alone to develop into concrete jungles without green spaces, the living conditions of the people suffer because of air, noise, and water pollution (Alvey, 2006; Chen et al., 2014; Gonzales and Magnaye, 2017). By teaching our students to reconnect with nature through a better understanding of their immediate environment through hands-on fieldwork and practical experiments, biological conservation becomes second nature in their understanding. Urban biodiversity is a task that can be undertaken by everybody to preserve the remaining ecological services of nature in a city or school.

To begin with, ecology requires keen observation as a practical skill so that one can take note of the phenomena to be observed. Teaching students the skills of observation is essential to their success in becoming field ecologists. Observation is an essential skill, and it is defined as the systematic inquiry of an event, series of events, or environmental phenomenon and forming your hypothesis or reasoning to explain that phenomenon. In science, the systematic ordering of information concerning a thing or an event is a necessary skill, and it is processed through the five senses: sight, hearing, smell, taste, and touch. In ecology, giving the correct descriptions and providing accurate interpretations of data reveal the completeness of the study. By recording correct observations and organizing them, a simple methodical inquiry in nature becomes a useful and valid tool.

Hence the need for observation studies to show that, through simple ecological investigations or exercises, students and teachers alike can succeed in becoming better observers of nature. For instance, in ecosystem studies, parts of a tree or parts of an animal that were left behind decaying can become a tool to show students that this decaying log is a source of food for other living organisms. This can be acted upon by beetles, worms, ants, termites, or fungi that return the nutrients to the soil. They are essential for nutrient cycling as they break down dead organic matter. Dead organisms and trees are essential for the proper functioning of the ecosystem, as they become habitat and food for other organisms. Moreover, there are biotic components of an ecosystem, such as millipedes, fungi, ants, polychaetes, and even pillbugs, that interact with other decomposers to perform essential roles in the ecosystem. An ecosystem is a community of organisms functioning together as they interact with their abiotic environment. In the log ecosystem, the abiotic factors include chemical and physical factors that are related to inorganic and organic compounds in the tree, soil, and water or air; they also include the climate, rainfall, moisture, temperature, humidity, and soil, water, and air. This shows the interrelationship of various biotic components in nature and the different physical factors that influence their survival and growth.

Case study 1. The Log ecosystem

Log ecosystems are known to harbor various decomposers. These include rotting fungi, ants, pill bugs, termites, flies, and cockroaches that act to breakdown the dead organic matter from a chunk of wood into smaller pieces and from macromolecules into micromolecules and excrete these nutrients as waste products (Jensen, 2017). Decomposition in a log ecosystem occurs at various stages as it provides habitat to grazers and decomposers that speed up the process of decomposition (Galante and Marcos-García, 2004). Decomposers are often overlooked in the ecosystem, and despite their relatively small size, they play a vital role in nutrient recycling that is useful for the ecosystem. Although they appear to have no importance, decomposers inhabit decomposing logs and maintain the stability of the ecosystem through the periodic release of nutrients back to the ecosystem. Decomposers enhance the nutrient availability of soils and their surrounding environment (Mikol et al., 2002). These ecological functions thus prove their importance in maintaining ecosystems.

Case study 2. Grassland ecosystem

Other examples of ecosystems that are easily encountered on school grounds include the grassland ecosystem. Some vacant lots, untouched and usually used for grazing, are sometimes found in farm areas. Land grant colleges and universities have large portions of available pastures, and to a small degree, some smaller public colleges and private universities have available lands, such as DOSCST. Observation of growing weeds and grasses and the interaction of various species, including its grazers and other inhabitants, can be observed in that patch of grassland area available and within reach. The grassland ecosystem can teach students about the necessity of continual biological disturbanceto maintain a unique ecosystem. Disturbance in an ecosystem creates opportunities for more species to co-exist compared to a non-disturbed area where one or a few species dominate such an area. Grassland is a major vegetation type in the world, accounting for almost 40% of the terrestrial surface (Shantz, 1954). These grassland ecosystems occur in various parts of the world where the annual precipitation ranges between 150 and 1200 mm and the mean annual temperature is between 0 and 25 °C (Whittaker, 1978). The diversity of flora in grasslands varies broadly, with many natural types of grassland

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having a very high level of plant species diversity; there are even times where it approaches that of mainland tropical forests (Groombridge and Jenkins, 2002). The different plant species in grasslands can be categorized into four functional types: grasses, shrubs, succulents, and herbs (Sala et al., 1997). In these grassland ecosystems, insects are a diverse element of the terrestrial macrofauna, reflecting general patterns of diversity for terrestrial ecosystems in which insects represent more than 50% of the species. Also, insects found in grasslands hold important roles as herbivores, pollinators, predators, parasitoids, and decomposers (Botha, 2017). Herbivorous insects are probably the most conspicuous functional group (Crawley, 1989) and are even considered capable of replacing large grazing mammals as the primary consumers in some South American grasslands (McNaughton et al., 1983).

Case study 3. Man-made forest ecosystem

Forests are defined as local or regional segments of landscapes in which biological and ecological conditions and processes are dominated by the presence of trees, which are large, generally long-lived perennial plants characterized by a large woody stem and a large woody root system (Kimmins, 2004). There are three major types of forests: tropical, temperate, and boreal forests (Ollinger, 2002). Tropical forests occupy regions that lack a distinct period of winter dormancy, although dormant periods can still occur as a result of seasonal patterns of rainfall. In tropical regions, it is the seasonality of rainfall that determines the type of forest that occurs in a particular area. In contrast, temperate forests occur at mid-latitudes where winter temperatures fall below 0 °C, but rarely as low as -40 °C. Most temperate forests are made up of broad-leaved deciduous species, but evergreens are also common. The importance of forests are: (1) Protection from natural disasters such as tsunamis and typhoons by absorbing wave impacts and causing wave attenuation (Alongi, 2008) as well as serving as a buffer against strong winds (Danielsen et al., 2005; Zhang et al., 2012); (2) Soil erosion control, wherein forest vegetation would enhance soil profile stability, reduce sedimentation in adjacent reefs, coastal areas and reduce soil erosion (Mimura, 2006); (3) Air quality, trees in the forests trap airborne particular matter and thus improve air quality and human health (Bertram and Rehdanz, 2015); (4) Climate regulation and carbon sequestration, trees help regulate climate by trapping moisture and cooling the earth's surface (Lasco, et al., 2004; Lascco et al., 2008); (5) Recreation and tourism, scenic beauty and recreational amenities associate with forests make them popular recreation destinations (Alvey, 2006; Goddard et al., 2010); (6) Non-timber commercial forest products, forests produce many commercially valuable products other than timber, including mushrooms, floral greens, medicinal plants, edible plants and wildlife species (Krieger, 2001); And lastly, cultural values, where cultural values associated with forests include what economists call passive use values for forest goods and services, the aesthetic value of forest scenery and values associated with a region's cultural heritage (Bertram and Rehdanz, 2015; Palliwoda et al., 2017).

Case study 4. Mangrove forests and seagrass beds

The mangrove and seagrass ecosystems are associated with tropical and subtropical latitudes, providing food, habitat, and shelter for numerous marine organisms (Cuenca et al., 2015). The mangrove ecosystem is composed of a mangal or forest community of mangroves along with the associated microbes, fungi, plants, and animals, as well as the abiotic factors present. These mangroves can be trees, shrubs, palms, or ferns and generally exceed one-half meters in height, normally growing above sea level in the intertid-al zone of marine coastal environments or estuarine margins. Mangroves are well distributed, with various estimates of global coverage ranging from 10 to 24 million hectares; roughly half of them are found in Asia (Macusi et al., 2011; Martínez et al., 2007). Seagrass beds, which consist of about 60 species of marine angiosperms worldwide, are found in shallow coastal waters throughout tropical and temperate oceans (Fortes, 1991; Fortes, 2004). Sea grasses have prostrate stems buried in sand or mud and produce ribbon-like leaves on erect branches that can vary in length from less than a millimeter to half a meter or more. These two coastal ecosystems support various macrobenthic marine organisms that play diverse ecological roles (Venkatesan et al., 2010). Macrobenthos play significant roles in mineralization, mixing of sediments, fluxes of nutrients, and cycling of organic matter (Cuenca et al., 2015).

METHODOLOGY

In order to assess the various community structures of log, grassland, mini-forest, and mangrove-seagrass ecosystems, these were investigated separately on various dates, with one day of sampling dedicated to each ecosystem study, except for the grassland, which took five days, and the mangrove-seagrass, which took three days, with a few days in between for grassland species and gastropod identification. The study on log, grassland, and man-made forests was all conducted inside the campus of Davao Oriental State College of Science and Technology (DOSCST), while the mangrove-seagrass ecosystem was investigated in a nearby coastal area adjacent to the college. A further description of the methodology used is elaborated below:

A) Log ecosystem

The research work for this study was conducted at the main campus of DOSCST on August 14, 2017. The log ecosystem was found in an intermediate stage of decomposition, near the gymnasium of the college. The decomposing log was first identified, then measured in terms of length and diameter (119 cm x 20 cm). Then a trowel was used to pry open random parts deemed manageable enough to facilitate the viewing and counting of decomposers within the decomposing star apple log (*Chrysophyllum cainito*). Each observed organism was photographed for documentation, and abiotic factors influencing the log decomposition were also identified and documented.

B) Grassland ecosystem

To quantify the community structure of a typical grassland, the transect-quadrant method was used. A transect measuring 10 m was laid on the selected area and held in place on both ends by two stakes driven to the ground. The transect was laid roughly two meters from a pathway and oriented parallel to it. On the transect, 10 quadrants measuring 1 x 1 m (1 m^2) were laid, with 5 quadrants per side. Through the drawing of lots, the location of the individual quadrants on each side of the transect was randomly determined. To aid in identification and counting, each quadrant was further subdivided into six subquadrats. The plants were identified *in situ* in the area using the published references of Naidu (2012) and Moody et al., (1984) as field guides. The plants were then counted individually, and their number per species was duly noted. The different plant species were photographed individually for the purpose of documentation. The species of grasses identified in the transect were compared to those present in the other transects established parallel to the original transect. The different insects present in the quadrants were also identified. The data gathered from the transects were analyzed for the following components: relative abundance, diversity, and similarity, using the appropriate formulas and indices.

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C) Man-made forest ecosystem

The study area was located in the mini-forest of the school, where the transect-quadrant method was also used. A 30 m transect was laid at the center of the man-made forest to cover and represent the outward and middle parts of the forest. On the transect, three 5 x 5 m (25 m^2) were established on both ends of the transect and in the middle. An interval of 5 m was observed between each quadrant. To randomly determine which side of the transect the quadrant will be established on, a coin was tossed, with the head signifying its establishment on the left part of the transect and the tails signifying its establishment on the right. The trees present within each established quadrant were identified to the species level using a published reference guide (Lanting and Palaypayon, 2002). The number of individual trees per species was counted; trees with a height exceeding 3 m were measured for height through careful estimation and expressed in the unit of meter. Circumference at Breast Height (CBH) or trunk circumference at 1.5 m from the ground was also measured through the use of a tape measure and expressed in the unit of centimeter. The coverage of the canopy inside the transect by each tree that is present inside or near the transect was measured with a meter stick and expressed in the unit of a square meter. The data gathered was duly noted, and photos of the individual trees were taken for documentation. The data gathered from the transects were analyzed in this study for the following components: density, relative abundance, frequency, relative frequency, coverage, and relative coverage using the appropriate formulas and indices adopted from Magurran (1988).

RESULTS

A) Log ecosystem

Through ocular observation of the surface and internal parts of the decomposing log, a total of ten different species were found in the log, and three of them were still unidentified (Table 1). Millipedes, carpenter ants, and woodlice are common species found in rotting log (Figure 1). Millipedes and woodlice need damp, sheltered places to retain the moisture in their skin in order to survive, while ants survive by foraging on the dead wood. The bugs and wood-burrowing worms were found in the crevices of the log. There was also a piece of grass found on the log with the decayed portion and some soil substrate on it. The abiotic factors affecting these organisms are the following: sunlight, oxygen, water, temperature, and the decomposing log or substrate.

Table 1. Common organisms found on a decaying log at DOSCST.

Family	Scientific name	English name	Local name	Number of Individuals
Spirobolidae	*Narceus americantus*	Millipedes	Labod	10
Formicidae	*Camponatus* sp.	Ants	Alamigas	100
Glomeridae	*Glomerus marginata*	Wood louse	Baboy -baboy	30
Unidentified	Unidentified	Wood-burrowing worm	Unidentified	5
Unidentified	Unidentified	Bugs	Unidentified	5
Dacrymy cetaceae	*Dacryopinax spathularia*	Orange jelly fungi	Kabuti	5
Cortinariaceae	*Galerina sp.*	brown fungi	Kabuti	50
Unidentified	*Unidentified*	Fungi	Kabuti	10
Poaceae	*Dactyoctenium* sp.	Grass	Damong balang	2
	Lepraria sp.	Lichen	Kupas -kupas	2

Figure 1. Common grazers and decomposers in a log ecosystem: A) Black ant; B) Pillbugs; C) Lichens and shelf fungi; D) Millipede; E) Polychaete worms; F) Millipede; G) Orange jelly fungi; H) Brown mushrooms; I) Red ants.

B) Grassland ecosystem

The most abundant plant species in the three transects were yellow nutsedge (Transect 1 = 3719; Transect 2 = 1689; Transect3 = 1745 individuals), followed by an unidentified species in Transect 1 (635), crowfoot grass in Transect 2 = 817, and carabao grass in Transect 3 = 879 individuals (Table 2; Figure 3). The other plant species were present with small representatives that are almost negligible, with the lowest abundance on rottboellia (T1), false mallow (T2), and Indian cooper leaf grass (T3), with only 2 individuals, or merely 0.04%, 0.07%, and 0.06% of the entire plants present in each of the three transects. It was also observed that there were only three plant species common to the three transects: yellow nutsedge, crowfoot grass, and neem tree. Overall, there was higher grass diversity (*H* = 1.337; D = 0.65) found in Transect 3, which was located in a highly disturbed area, compared to Transect 2 (*H* = 1.23; D = 0.59); and Transect 1 (*H* = 1.29; D = 0.54). The Shannon-Wiener Diversity Index (*H*) incorporates the richness and evenness of the plants as its components (Table 2), with a higher value denoting a higher diversity and a lower value denoting a low diversity. The value of *H* being 1.33 in transect 3 and 1.29 in transect 1 denotes high biodiversity, while an *H* of 1.23 also signifies moderate plant diversity. The Simpson's Diversity Index (D), on the other hand, is a measure of diversity whose values range from 0 to 1, with increasing values corresponding to a higher diversity of plants. The calculated values of 0.54, 0.59, and 0.65 signify high plant diversity.

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Table 2. Relative abundance and diversity indices of various grass species found in the study area.

Transect 1 (moderate disturbance)			**Transect 2 (no disturbance)**			**Transect 3 (high disturbance)**		
Species	Count	Relative abundance	Species	Count	Relative abundance	Species	Count	Relative abundance
Yellow nutsedge (*Cyperus esculentus*)	3719	66.20	Yellow nutsedge	1689	56.9	Yellow nutsedge	1745	51.3
Unidentified	635	11.30	Crowfoot gras	817	27.5	Carabao grass	879	25.9
Graceful sandmat	362	6.44	Chinese lovegrass	196	6.6	Large crab grass	326	9.6
Crowfoot grass	322	5.73	Goose grass	143	4.8	Crowfoot grass	225	6.6
Bermuda grass	154	2.74	Stone breaker	31	1.0	Grass-like fimbry	169	5.0
Blue Bell	104	1.85	Neem tree	27	0.9	Unidentified	20	0.6
Large crab grass	95	1.69	Barnyard grass	25	0.8	Neem tree	14	0.4
						Paper tree		
Spine-seeded False mallow	75	1.33	Paper tree	23	0.8		12	0.4
						Snake weed		
Grass-like fimbry	53	0.94	Asthma herb	19	0.6	Indian copperleaf	8	0.2
			Tiger foot morning glory	5	0.2		2	0.1
D. sundium	49	0.87	Indian copper leaf	5	0.2			
Goose grass	31	0.55						
Asthma herb	8	0.14	Crowe flower	4	0.1			
Stone breaker	6	0.11	Spine-seeded False mallow	2	0.1			
Neem tree	3	0.05						
Blanket grass	2	0.04						
Simpson's diversity (D)		0.540			0.593			0.654
Shannon-Wiener index (*H*)		1.297			1.237			1.337

The species rank abundance of various grass species found in the different transects shows a higher species richness in transect 1, followed by transect 2, and least in transect 3 (Figure 2). This was also similar in the case of the rank abundance plot of the various insect species (Figure 4), where transect 1 has the highest species richness, followed by transects 2 and 3.

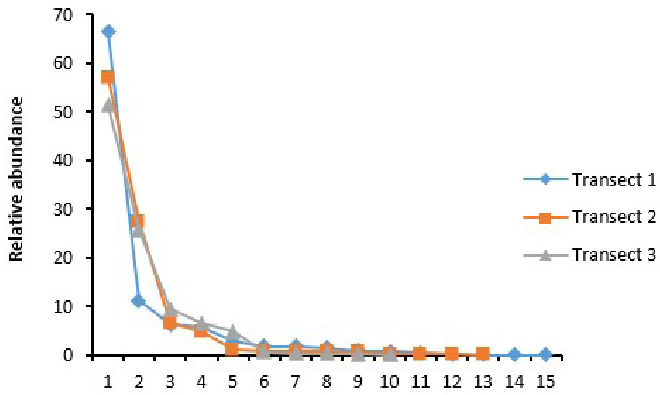

Figure 2. Rank abundance plot of various grass species found in the study area. (Transect 1 has higher species richness compared to transects 2 and 3, with transect 3 having the least).

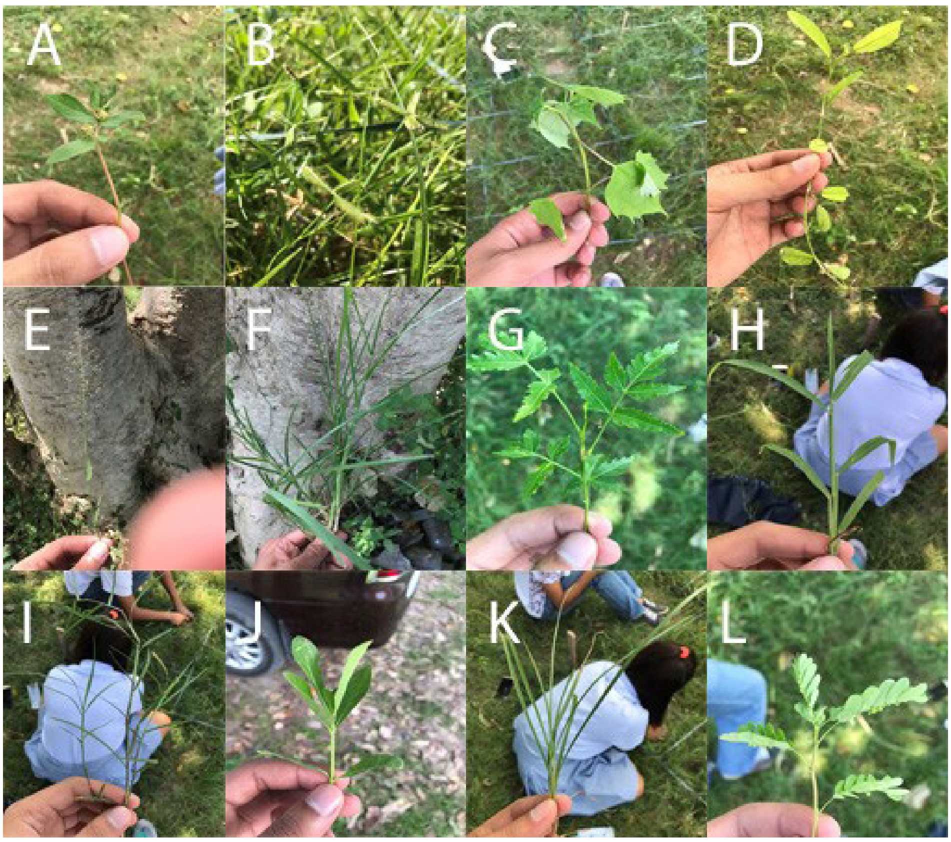

Figure 3. Common grass species found in the transect-quadrats of the study area: A) Asthma herb (*Euphorbia hirta*); B) Crowfoot grass (*Dactyloctenium aegyptium*); C) False mallow (*Malvastrum* sp.); D) Graceful sandmat (*Euphorbia hypericifolia*); E) Fimbry (*Fimbristylis miliacea*); F) Crab grass (*Digitaria sanguinalis*); G) Neem tree (*Azadirachta indica*); H) Rottboellia (*Rottboellia cochinchinensi*); I) Bermuda grass (*Cynodon dactylon*); J) Snapdragon root (*Ruellia tuberosa*); K) Yellow nutsedge (*Cyperus esculentus);* L) Stonebreaker grass (*Phyllanthus niruri*).

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There were six (6) insects found and identified in the first transect and five species in the other two transects. These were: pill bugs, black garden ants, millipedes, dragonflies, land snails, centipedes, flies, cockroaches, and other worms. The most abundant insect species was the pill bug or pill woodlouse in transect 1, which comprised 37%; in transect 2, black ants were most abundant, which comprised 42%; and in transect 3, flies were most abundant at 38%. The least abundant insect was the dragonfly, with only 2 individuals, or 0.8%, followed by worms and millipedes at 1.2% and 0.3%, respectively. There were only two insects common to the three transects: pill bugs and ants. This lownumber of common insects present resulted in a low result in the calculated similarity indices, with only 0.375 on the Sorensen's Index and 50.4 on the Percent Similarity (PS) index. The calculated diversity of the insects in transect 1 was determined to be *H* = 1.88 and D = 0.3011, signifying the high diversity of insects in this transect. Transects 1 and 3 were revealed to have the highest diversity (HD = 1, *H* = 1.30, and D = 0.70), followed by transect 2 (*H* = 1.15, D = 0.65), which had the least diversity on the Shannon-Wiener Diversity Index. This high diversity of insects in transects 1 and 3 could be attributed to the higher number of insect species counted and their abundance compared to transect 2, where a large disparity in the number of individuals could be found, indicating the domination of a few insectspecies.

Table 3. Relative abundance and similarity indices of various insect species found in the study area.

Transect 1 (moderate disturbance)			**Transect 2 (no disturbance)**			**Transect 3 (high disturbance)**		
Species	Count	Relative abundance	Species	Count	Relative abundance	Species	Count	Relative abundance
Pill bugs	93	37.8	Ant	414	41.7	Flies	454	38.6
Ant	77	31.3	Pill bugs	382	38.5	Pill bugs	353	30.0
Millepede	61	24.7	Unidentified	165	16.6	Ant	240	20.4
Land snail	8	3.2	Cockroach	19	1.9	Cockroach	125	10.6
Centipede	5	2	Worms	12	1.2	Millipede	3	0.3
Dragon fly	2	0.8						

Common Species	Transect 1	Transect 2	Transect 3
Pill bugs	37.8	38.5	30
Ants	31.3	41.7	20.4
Sorensen's index of Similarity (CC)	0.375	0.375	
Percent Similarity (PS)	50.4	50.4	
Simpson's index of diversity (D)	0.69	0.65	0.70
Shannon's diversity index (*H*)	1.30	1.15	1.30

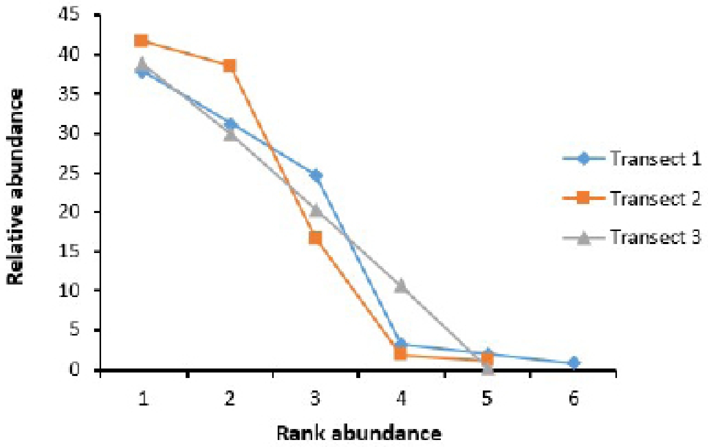

Figure 4. Rank abundance plot of various insect species found in the study area. (Transect 1 has higher species richness compared to transects 2 and 3 which have lesser species richness).

C) Man-made forest ecosystem

Only two (2) species of tree were found and identified in the study area of the man-made forest in front of DOSCST's Science building. These were of paper tree (*Gmelina arborea*) and mahogany (*Swietenia macrophylla*).

Paper tree

Paper tree (*Gmelina arborea*) was introduced in large tropical areas due to the well-known silvicultural techniques and wood quality produced by fast growth trees that were managed in short rotation systems (Dvorak, 2004). paper tree is a moderate-sized to large unbuttressed, deciduous tree (Figure 5A) with opposite, broadly ovate, acuminate, usually cordate leaves, glaucous beneath, or stellately hairy or tomentose beneath in one variety (Lamb, 1968). The bark on young trees and on the crown and the upper part of the stem in older treesis smooth, corky, pale brown to grey in color. It exfoliates near the swollen base of the stem in trees over five to eight years old exposing smooth paler colored bark beneath. Form varies greatly with varying conditions of growth. If grown in the open, heavy branches and a wide crown develop and the stem is short, seldom straight, swollen at ground level and markedly tapered. The root system varies in depth of penetration with soil depth and texture. Roots have the same pale corky bark at the ground surface as the branches (Lamb, 1968).

Mahogany

Mahogany (*Swietenia macrophylla)* is an evergreen tree with a dense, dome-shaped, rounded but somtimes spreading crown (Figure 5B). It is native to the West Indies and southern Florida. This tree is best known for its heavy, dark reddish-brown wood. Mahogany typically grows to 40-50 feet tall, but mature trees in its native habitat will grow to 80 feet (less frequently to over 100 feet) tall. Mature trees are distinctively buttressed at the trunk base. Scaly gray bark often splits to expose reddish inner bark. Branches are clad with pinnate-compound deep green leaves. Each leaf has 4-10 pairs of oval, glossy, leathery green leaflets (Little, 1978).

Density and Relative density

Results on the density and relative density of the trees on the study area were tabulated on Table 4. The gathered data revealed an inconsistent trend on the domination of paper tree and mhogany on the different plots; with equal density of both trees in Plot 1, higher density of paper tree in Plot 2 and higher density of mahogany on Plot 3.

Table 4. Density and relative density of the trees in the study area.

	Scientific name	Common name	Count	Density species (m^2)	Relative density (plot)
Plot 1	*Gmelina arborea*	Paper tree	2	0.08	0.50
	Swietenia macrophylla	Mahogany	2	0.08	0.50
Plot 2	*Gmelina arborea*	Paper tree	4	0.16	0.80
	Swietenia macrophylla	Mahogany	1	0.04	0.20
Plot 3	*Gmelina arborea*	Paper tree	1	0.04	0.17
	Swietenia macrophylla	Mahogany	5	0.20	0.83
	Relative density all plots				
	Gmelina arborea	0.466			
	Swietenia macrophylla	0.533			

Frequency and Relative frequency

The data on Table 5 shows the frequency and relative frequency of the trees on the study area. It showsthat both tree species have equal frequency in Plot 1 with 0.67. Higher frequency of paper tree was observed in Plot 2 with 1.33 and mahogany followed with only 0.33 and higher frequency of mahogany was observed on Plot 3 with 1.66 and paper tree with only 0.33.

Table 5. Frequency and relative frequency of the trees in the study area.

	Scientific name	Common name	Count	*f* (plot)	Relative frequency (plot)
Plot 1	*Swietenia macrophylla*	Mahogany	2	0.67	0.13
	Gmelina arborea	Paper tree	2	0.67	0.13
Plot 2	*Gmelina arborea*	Paper tree	4	1.33	0.27
	Swietenia macrophylla	Mahogany	1	0.33	0.07
Plot 3	*Swietenia macrophylla*	Mahogany	5	1.67	0.33
	Gmelina arborea	Paper tree	1	0.33	0.07

	Frequency (all plots)	Relative frequency (all plots)
Paper tree (*Gmelina arborea*)	2.33	0.46
Mahogany (*Swietenia macrophylla*)	2.66	0.53

Figure 5. The study area located at the DOSCST campus where the forest assessment was conducted. Paper tree (A) and mahogany tree (B) which were most dominant in the area.

Circumference at breast height (CBH) and canopy cover (CC)

Figure 6A shows the measured and calculated circumference at breast height (CBH) of the trees inside the plots in the study area. A trend is observable, with paper tree dominating in terms of having the higher calculated average and highest maximum in the range of CBH. Figure 6B shows the coverage and relative coverage of the tree canopies in the study area. The data revealed that Plot 2 and 3 have the same trend in the dominance of canopy cover, where in Plot 2, paper tree has the highest average canopy cover (Figure 6) with 8.0775 m^2, while mahogany only has an average of 4.68 m^2, and in Plot 3, paper tree has an average of 46 m^2, while mahogany only has 28 m^2. A different trend was observed in Plot 1, with mahogany having a higher average canopy cover of 28.26 m^2 while paper tree had 23 m^2, and the same was also observed on the relative canopy cover of all plots, with mahogany having an average of 25 m^2 while paper tree had 18 m^2.

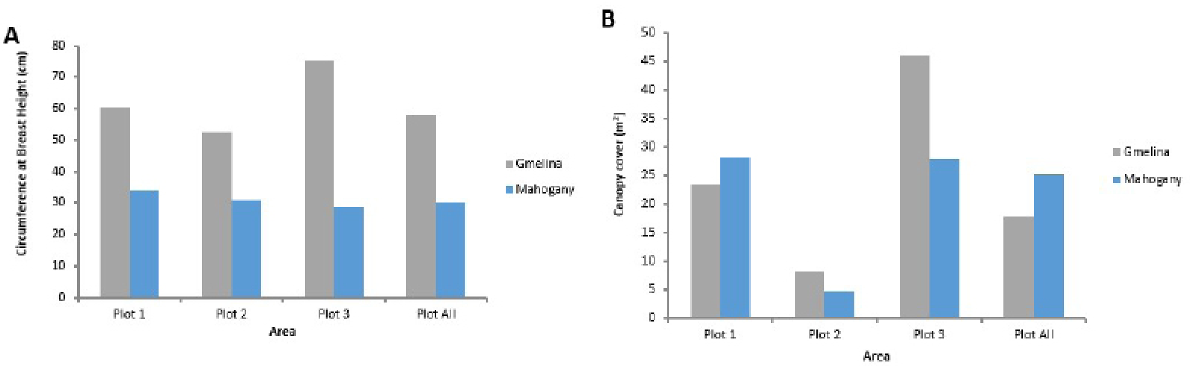

Figure 6. Average of the circumference at breast height (A) and canopy cover (B) from the different plots.

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Importance Value of Species

The importance value is the sum of these three measures (relative density, coverage, and frequency), with results ranging from 0 to 3. A high importance value indicates that a species is well represented in an area because of some combination of a large number of individuals of a species compared with other species in the area or a smaller number of individuals of a species, but the trees are large compared with others in the area. The calculated importance value of the trees in the study area (Table 6) was revealed to be low, with only 1.32 for paper tree and 1.68 for mahogany. This signifies that both of these species in the area have a very close number of individuals, and since they are relatively young, they have low canopy coverage and are generally undersized.

Table 6. Calculated importance value and diversity indices of the trees in the study area.

	Paper tree (*Gmelina arborea*)	Mahogany (*Swietenia macrophylla*)
Relative density (RD)	0.467	0.533
Relative frequency (RF)	0.467	0.533
Relative coverage (RC)	0.383	0.616
Importance value (IV)	1.317	1.682
Simpson's Diversity index (D)		0.498 (low)
Shannon-Wiener Diversity Index (*H*)		0.691 (low)

The Shannon-Wiener Diversity Index (*H*) incorporates the richness and evenness of the plants as its components on the Shannon-Wiener Diversity Index, the higher the value of which denotes a higher diversity and the lower the value denotes a low diversity. The value of *H* being 0.6909 signifies low tree diversity. The Simpson's Diversity Index, on the other hand, is a measure of diversity of which the values ranges from 0 to 1, with increasing values corresponding to a higher diversity of plants. The calculated value of 0.498 signifies low tree species diversity.

D) Mangrove and seagrass ecosystem

Despite being known to host 18 mangrove species, only *Rhizophora stylosa*, locally known as *bakauan-bangkau*, was present in the selected study area. This mangrove species is known for its adaptability and tolerance to climate and soil, which allowed it to inhabit a wide variety of areas ranging from muddy, sandy, and stony soil as well as corals.

There were nine (9) associated gastropod grazers found in the transects and on various parts of *Rhizophora stylosa* (Figure 7A). These species were identified: *Monilea callifera, Pomacea canaliculata, Crassostrea iredalei, Trochus pyramis, Spisula solidissima, Zeacumanthus lutulentus, Cominella glandiformis, Diloma subrostrata*, and *Haustrom scobina*. There was a higher abundance of grazers in transect 2 (1142), followed by transect 3 (987), and the least in transect 1 (987). The highest biodiversity was measured in transect 3 (*H* = 1.88; D = 0.801), followed by transect 2 (*H* = 1.68; D = 0.78), and then transect 1 (*H* = 0.56; D =0.25).

Among the gastropods identified, only 6 species were generally present on every part of the mangroves (Figure 7B). These were *Monilea callifera, Pomacea canaliculata, Zeacumanthus lutulentus, Cominella glandiformis, Diloma subrostrata and Haustrom scobina*. On the leaves, the most abundant gastropods were *Monilea callifera* comprising 54.43% with *Zeacumanthus lutulentus* as the least abundant comprising only 0.97%. On the trunks, *Diloma subrostrata* was the most abundant comprising 29%, with the least abundant being *Spisula solidissima*, comprising only 3.86%. On the roots, *Trochus pyramis* has the highest abundance, comprising 28.28%, and similar to the leaves, *Zeacumantus lutulentus* has the least abundance, comprising only 1.94% of the entire gastropod population.

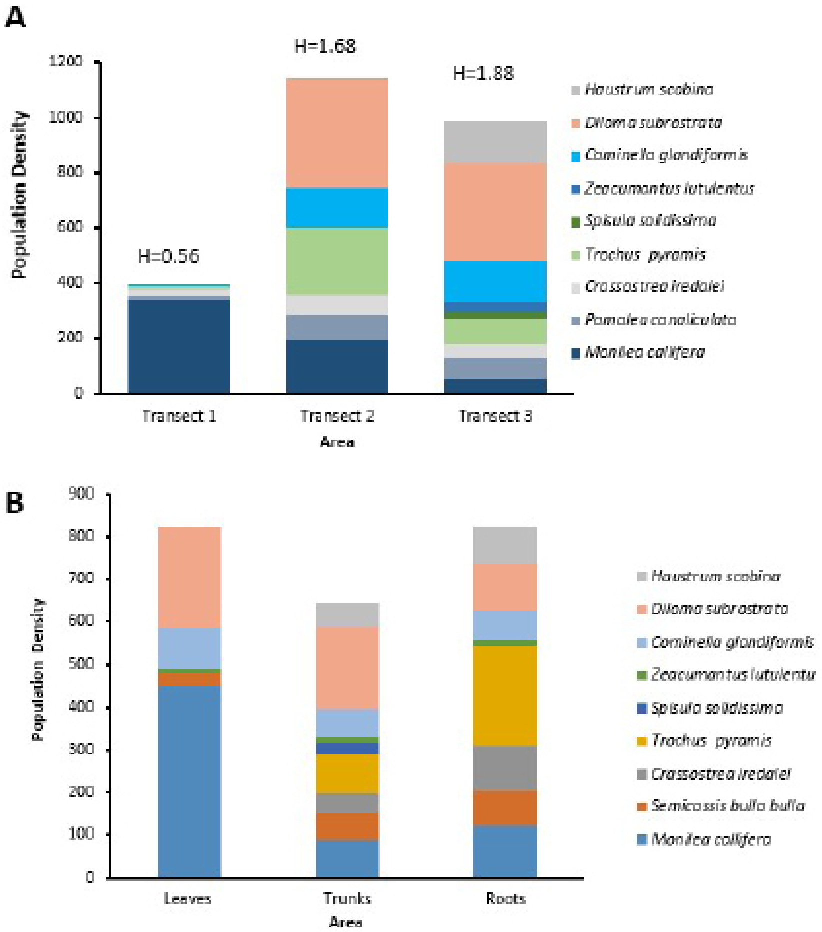

Figure 7. Relative abundance and diversity of grazers found in the study area (A) and on the different parts of mangrove (B).

Seagrasses and algae

On the intertidal zone adjacent to the mangal forest, several species of seagrass along with macroalgae were found (Table 7). These include the seagrass species *Enhalus acoroides, Thalassia hemprichii* and *Halophila ovalis* and the macroalgae *Halimeda* sp. and *Padina* sp. It was observed that the seagrass *Thalassia hemprichii* was present in all the transects and the most abundant as well, comprising 55–98% of the overall marine plants present in the three transects. The second most abundant was the macroalgae, *Padina* sp. Followed by Enhalus acoroides, both present only in transect 3. These were followed by the seagrass *Halophila ovalis*, which was present only on transect 2, with the least abundant being the macroalgae *Halimeda* sp. on transect 1. The seagrass *Thalassia hemprichii* was observed to dominate the study area, present in dense meadows disrupted only by the presence of a different substrate, such as some characteristic powdery sands and broken shells on the substrate. The other seagrass species and macroalgae are present only in small numbers and interspersed either on their own or alongside *Thalassia hemprichii.*

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Table 7. Seagrasses and macroalgae present in the study area.

English name	Scientific name	Transect 1	Transect 2	Transect 3
Tape seagrass	*Enhalus acoroides*			23
Turtle grass	*Thalassia hemprichii*	374	278	159
Funnel weed	*Padina gymnospora*			110
Dugong grass	*Halophila ovalis*		10	
Halimeda	*Halimeda* sp.	7		
Total		381	288	292

Macrobenthos and trophic relationships

Various macrobenthos were found in the intertidal (Table 8), with the most number of macrobenthos species found in transect 1 having eight species present; transects 2 and 3 were found to have five species. In terms of macrobenthic abundance, transect 2 was observed to have the highest number of individual macrobenthos, totaling 42 individuals. This was followed by transect 1 with 30 individuals, and the least abundance was observed in transect 3 with only 10 individuals present. Calculation of macrobenthic diversity from the different transects revealed that transect 1 is the most diverse (H = 1.57; D = 0.70), followed by transect 3 (H = 1.55; D = 0.78), and then transect 2 (H = 0.98; D = 0.51). This moderately high biodiversity of macrobenthos in the study area supports the idea that mangrove habitats have a positive influence on macrobenthic diversity.

Table 8. Abundance and diversity of macrobenthos found in the seagrass ecosystem.

English name	Scientific name	Transect 1	Transect 2	Transect 3
Starfish	*Asterias rubens*	5		3
Hermit crab		1	4	1
Sand dollar	*Laganum laganum*			2
Mud crab	*Scylla serrata*	2		2
Mussel	*Mytilus edulis*		28	
Gastropods	Assorted species	15	8	2
Shrimp	*Penaeus* sp.	2	1	
Brittle star	*Ophiotrix fragilis*	3	1	
Fish		1		
Jellyfish	*Aurelia* sp.	1		
Total		30	42	10
Shannon-Wiener Diversity Index (H)			0.98	1.55
Simpson's Diversity Index (D)		0.70	0.51	0.78

DISCUSSION

This study investigated various ecosystems that are generally found on the campus of DOSCST and its surrounding environs. While the campus may not be the ideal setting for ecological investigations because of lack of a larger spatial area, it presents a microcosm of what is generally found in nature, and the processes that affect these ecosystems are similar. For instance, in the log ecosystem, this reflects a microecosystem that demonstrates the interrelationships of both biotic and abiotic factors that affect the living organisms inhabiting a particular area (Ostroumov et al., 2015). The ecosystem is comprised of biotic and abiotic factors that are intertwined (Odum and Barrett, 1971). These biotic components are the living members of the ecosystem and are comprised of lichens, mosses, fungi, polychaete worms, termites, woodlice, and ants. On the other hand, the abiotic components, which are the non-living components of the ecosystem, are comprised of sunlight, soil, oxygen, water, temperature, and the decomposing log, which facilitates the decomposition of the log substrate. All the living components in this log ecosystem are dependent on the log substrate for nutrients and for an environment conducive to growth and survival. These decomposers were able to survive and acclimate to this environment. Their growth and survival, however, depend on limiting factors or environmental constraints that influence their physiology and behavior (Marshall, 1988; Lutz et al., 2012). Limiting factors are physical factors that limit the growth or reproductive potential of an organism. These limiting factors include temperature (life can only exists normally within the range of -200 °C); light, its quality, intensity, and duration affect both plants and animals (Bonan and Shugart, 1989). Individual plants can either become shade-adapted or sun-adapted depending on their physiological tolerance and adaptation (Billings, 1938; Pastor et al., 1988). In addition, humidity and oxygen, or atmospheric gases, can also be limiting to plants and animals, as well as biogenic salts and nutrients. In the case of nutrient cycling that occurs in a log ecosystem, the grazers breakdown the remaining part of the wood into small pieces while the decomposers remove any remaining nutrients from the dead wood and then release those nutrients into the ecosystem (Fenchel and Blackburn, 1979; Jordan and Kline, 1972; Pastor et al., 1988). This fundamental ecological process enables nutrient cycling to sustain the various trophic structures in the ecosystem.

Grassland ecosystem

There were fifteen (15) species of plants present in the transect, which was considered moderately disturbed, while there were thirteen (13) species on the relatively undisturbed transect, while there were only ten (10) species present on the disturbed part, which was established on a parking area. A consistent trend in terms of the dominant species was observed in the three transects regardless of the degree of disturbance, and this was the dominance of yellow nutsedge in the study area. In all established transects, the common plants were yellow nutsedge, crowfoot grass, and neem trees, while the common insects were pill woodlice and ants. Grassland ecosystems are susceptible to changes induced by both man-made and natural disturbances. Fires, for instance, interact with other factors, including topography, soil, insects, herbivores, and herbaceous plants, to restrict woody plant establishment in grasslands (Dodd et al., 1994; Naidu, 2012). Grazing by herbivores aids in promoting plant diversity through the reduction of the pressure of competition between different plant species on a minute scale (Collins and Steinauer, 1998), although this action could present a risk of invasion of foreign plant species and result in the extinction of the native plant species (Hobbs and Huenneke, 1992). Grazing is also known to influence plant diversity by causing heterogeneity in resources at various spatial scales through general or selective grazing (McNaughton et al., 1983). Climate, particularly rainfall patterns, affect grassland ecosystems. Fluctuating precipitation results in drought, which has a severe impact. Meanwhile, anthropogenic activities such as cultivation of agricultural crops and urbanization put pressure on the grassland ecosystem to the point of disruption and even destruction, as demonstrated by the extensive damage of about 75% to the North American grasslands as a result of agriculture (Savage, 2011), and in the Philippines, the grasslands, which previously constituted three million hectares, or roughly 11% of the total land area, have been reduced to 6% over the past few decades, mainly due to conversion into agricultural lands (Moog,

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1990). In the typical Philippine grassland ecosystem, the food chain is centered on the plants, particularly the abundant weeds and grasses, which act as producers and provide energy to the secondary consumers, herbivore animals, and insects such as cows, carabaos, water buffalos, goats, and others, which feed on weeds and grasses through their grazing activities. Decomposing organic matter, such as dead animals and detritus, is consumed and broken down by decomposers, with the end product providing nutrients for the growing weeds and grasses in the grassland ecosystem.

Forest canopy cover and its importance

A forest is known as an essential sanctuary for the diversity it contains and the ecological functions it serves. It can be defined as a landscape dominated by trees (Ollinger, 2002). Trees can be considered ecosystem engineers because they build the structure of a forest and attract other organisms to live on them. They play an important role in the structure, dynamics, and function of many temperate and tropical rainforests (Lutz et al., 2012). In the man-made forest examined, there were only two species of trees found and identified in the study area: Paper tree (*Gmelina arborea*) and mahogany (*Swietenia macrophylla*), and since the forest was man-made, it has low biodiversity (0.49 and 0.69) and low density (0.46 and 0.53). In the natural forest, the distribution of trees is affected by substrate, community composition of the forest, topography, sunlight, and climate (Richards, 1996). This can also be modified by the nutrients present in the area as well as other biotic interactions such as competition, predation of propagules, seeds, and fruits, and allelopathic interactions with other plant species (Bawa, 1990; Lathwell and Grove, 1986; Swank and Oechel, 1991). Plant distribution can have regular patterns of distribution in the wild, strong and clumped, or random distribution. These distributions are affected by physical factors such as light, wind, water, soil type, and biological agents of pollination and fruiting (Marshall, 1988; Lutz et al., 2012). Plants need light energy from the sun to perform photosynthesis, which is an essential process for manufacturing their own food. Light is also essential in forests for plant growth, survival, and reproduction. Tree canopies affect the biodiversity of the forest and can serve as a habitat for other organisms in the forest (Parker et al., 1995; Norman and Campbell, 1989). Tree canopies are essential for maintaining regional and global productivity and climate conditions (Foster and Bhatti, 2006; Lasco et al., 2008). It can serve as a new source for food, shelter, a hiding place, and areas for interaction with other species, e.g., insects and birds. It is estimated that about 70–90% of life or biodiversity can be found in a tree (Hunter, 1999). The relative importance of the variation between tree species is a key factor in the conservation and management of species richness in a forest ecosystem. Therefore, the low value of relative importance in the survey means the area can still be enhanced in terms of planting other tree species in the case of a man-made plantation, while in the case of a natural forest, this would mean there is a need to increase the efforts for conservation and management.

Mangroves and coastal protection

During the conduct of this study, only one mangrove species (*Rhizophora stylosa*) was found in the three transects, as this was mainly an area that was replanted. The biodiversity of mangroves was not the goal of this assessment, but the abundance and distribution of various mollusc species found attached to or grazing on the various parts of the mangrove tree. In this study, the biodiversity of gastropods was found to be higher in transect 3 than in transect 2, and least in transect 1. There was also a greater abundance of gastropods found in the leaves and roots of the tree than on its trunks.

This could be due to the softer texture of the leaf and its smaller lignin and tannin content compared to its trunk or roots (Ashton, 2002; Robertson, 1986). There was also a higher abundance of green algae found in the root area compared to the mangrove trunk. Algal mats found in the study area are an important factor in the food chain. In the case of the roots, the high abundance of encrusting algae present clinging in the root system could have made it more palatable to grazers as algae contain a greater amount of nitrogen compared to mangrove barks or leaves (Nordhaus and Wolff, 2007). Mangrove leaves contain low amounts of nitrogen and high amounts of tannin as protection from grazers and from dehydration. Tannins are responsible for unpalatable tastes in mangrove leaves, and they are responsible for the astringent taste of unripe fruit and red wine (Kaiser, 2011; Nordhaus and Wolff, 2007). Mangroves are important in nutrient cycling, control of sedimentation, coastal protection, nursery grounds, carbon storage, fishing grounds, and in terms of cultural and aesthetic values (Alongi, 2008; Siahainenia, 2016; Sinfuego and Buot, 2014; Zhang et al., 2012). Mangroves play a significant role in coastal ecosystems and provide substantial benefits for human welfare (Cuenca et al., 2015; Lee et al., 2014). Although this is the case, mangroves are in decline in the Philippines as a result of overexploitation and conversion to fish ponds and settlements (Macusi et al., 2011; Primavera and Esteban, 2008). Meanwhile, mangrove reforestation efforts are plagued with problems; it has been stated that the increasing efforts and funding for mangrove refore station did not translate to an increase in the survival of mangroves (Primavera, 2005; Walters et al., 2008). Poor site selection and inadequate knowledge of implementing agencies on the ecology of mangroves led to poor survival of mangrove seedlings in reforestation programs.

Seagrass and associated species

During the conduct of this study, only one mangrove species (*Rhizophora stylosa*) was found in the three transects, as this was mainly an area that was replanted. The biodiversity of mangroves was not the goal of this assessment, but the abundance and distribution of various mollusc species found attached to or grazing on the various parts of the mangrove tree. In this study, the biodiversity of gastropods was found to be higher in transect 3 than in transect 2, and least in transect 1. There was also a greater abundance of gastropods found in the leaves and roots of the tree than on its trunks. This could be due to the softer texture of the leaf and its smaller lignin and tannin content comparedto its trunk or roots (Ashton, 2002; Robertson, 1986). There was also a higher abundance of green algae found in the root area compared to the mangrove trunk. Algal mats found in the study area are an important factor in the food chain. In the case of the roots, the high abundance of encrusting algae present clinging in the root system could have made it more palatable to grazers as algae contain a greater amount of nitrogen compared to mangrove barks or leaves (Nordhaus and Wolff, 2007). Mangrove leaves contain low amounts of nitrogen and high amounts of tannin as protection from grazers and from dehydration. Tannins are responsible for unpalatable tastes in mangrove leaves, and they are responsible for the astringent taste of unripe fruit and red wine (Kaiser, 2011; Nordhaus and Wolff, 2007). Mangroves are important in nutrient cycling, control of sedimentation, coastal protection, nursery grounds, carbon storage, fishing grounds, and in terms of cultural and aesthetic values (Alongi, 2008; Siahainenia, 2016; Sinfuego and Buot, 2014; Zhang et al., 2012). Mangroves play a significant role in coastal ecosystems

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CONCLUSION

A survey of the microcosm of biodiversity present in the various study areas reveals the presence of various types of ecosystems within the small college and the coastal area of Mati. The grassland patch, though small and disturbed, harbors a variety of grazers and decomposers able to degrade the nutrients from plants, which could then sustain the soil as it breaks down larger molecules from these nutrients. In addition, the man-made forest ecosystem inside the campus helps with climate regulation and provides habitat for birds with its spreading canopies. The coastal area adjacent to the school, with mangrove and seagrass ecosystems existing together, harbors abundant grazers and macrobenthos and juvenile forms of various fish, shrimp, and invertebrates. This shows that there is a need to double the existing efforts of the school administrators, LGU, and DENR to protect the landscape and the biodiversity found in these key areas to conserve trees, coastal zones, seagrass beds, and mangrove forests, which are fast becoming degraded as human populations increase and tourism development booms. A zone plan that includes buffer zones and no harvesting zones should be urgent for the conservation and protection of these ecosystems.

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