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Ecotone Classification According to its Origin

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Abstract: Ecotone is not just a transition zone between two adjacent ecosystems. It represents the range of interference between two ecosystems, plant communities, small patches forming a mosaic structure of the vegetation or individuals. The width of this range (ecotone) is controlled in two ways: (A) the environmental factors at the first stages of interference, when the individuals of the two interfered ecosystems are in the seedling stage. (B) The biological characteristics of the two adjacent ecosystems individuals, at juvenility and maturity stages. It is difficult to separate the effects of environmental factors from biotic factors upon the ecosystems and their ecotones, but we can detect the main limiting factor. The interaction of the environmental factors and biological characteristics may lead to form a new hybrid ecosystem. This work is an attempt to classify the ecotones according to the factors which affect their characteristics. This suggested classification may help to facilitate the study of ecotones, explain the co-existence and the relations between adjacent ecosystems, communities and their structure and detect the maximum interference between individuals.

Key words: Ecological gradient, ecotone, plant ecology

Introduction

Nowadays the ecotone is considered one of the most important subjects in ecological research, because it is considered the most sensitive part to the surrounding environment of the interfered ecosystems. It is clear that ecotone is the most unstable part in any ecosystem, due to its sensitivity to environmental changes. Edges and ecotones are of concern in many different fields of fundamental and applied ecology (Forman and Gordon 1986; Holland *et al.,* 1991 and Hansen and diCastri 1992). Many scientists defined, explained and identified the meaning of ecotone. Weaver (1960) defined ecotone as a transition zone between vegetation types containing abiotic and biotic components. The ecotones in terrestrial systems involve transitions from a system dominated by one life form to a system dominated by another (Wiens *et al.,* 1985 and McCoy *et al.,* 1986). Holland (1988) defined ecotone as a zone of transition between adjacent ecological systems.

The co-occurrence of different species and different life forms is affected by the environmental changes whether inside the ecosystems and more affected at their boundaries where the ecotones may be formed. Several studies have investigated the environmental conditions allowing the co-existence of shrubs and grasses in dry seasons (Samriento 1984; Knoop and Walker 1985; Wilson and Keldy 1985; Keddy and Constabel 1986; Keddy and Reznicek 1986 and Goldstein and Sainriento 1987; Archer *et al.,* 1988; Brock 1991; Rea and Ganf 1994; Weiher and Keddy 1995; Casanova and Brock 1996; Nielsen and Chick, 1997; Shugart 1998).

In arid and semiarid regions where vegetation is highly dependent upon precipitation, changes in seasonal precipitation may cause major shifts in plant composition, distribution and abundance (Stephenson 1990, Weltzin and McPherson 2000). Soil moisture partition is one example of niche differentiation that is widely invoked to explain coexistence of grasses and trees in savannas and woodland throughout the world (Knoop and Walker 1985; Sala *et al.,* 1989; Brown and Archer 1990). At river margins, there is a water gradient that affects the plant community and subsequently ecotones. Many Scientists studied river systems and streams ecologically and vegetationally (Firth and Fisher 1992; Meyer and Pulliam 1992; Arnell, 1996; Bell *et al.,* 1999; Ward *et al.,* 1999; Gilvear *et al.,* 2000; Grimm *et al.,* 1997; Piegay *et al.,* 2000).

Holland (1988) emphasized that ecotone characteristics are defined by space and time scales. Ecotone emphasizes the functional responses of species that create a tension zone. Such functional species responses may be related to changes in underlying environmental conditions, biotic interactions or both (van der Maarel 1990). The study of Liu *et al.* (2001) showed that climatic change was the driving factor for ecotonal movement, but the positions of vegetational zones were nevertheless controlled by topographical and edaphic conditions and consequently boundaries between different vegetational zones responded individualistically.

According to Naiman *et al.* (1988) ecotones may include riparian forests, marginal wet land, littoral lake zones, floodplain lakes and forests and areas of significant groundwater-surface water exchange.

The attempt to classify the ecotones to different classes according to the main (limiting) factor forming the ecotone may be in the study of ecotonal dynamics and their characteristics. The aim of this paper is to suggest a classification of ecotones according to the factor responsible for the ecotone and its characteristics.

Materials and Methods

The study was carried out in south Egypt (Fig. 1), in three regions. At Qena, in the region between the eastern desert and the Nile basin. This area is arid and rain rarely falls, once every ten years.

The climate is subtropical without a rainy season but torrents may occur between October and March coming westward from the Red Sea mountains ; the last one in this area was in 1996. The mean annual temperature ranges between 15 and 40°C, humidity 30-60%.

In the last decade (1990-1996) torrents occurred annually or biennially. In November 1996 a strong torrent run toward Qena city, 600 km (map 1) south of Cairo. As usual it came from the eastern desert A canal was made as a passage for the torrent to the Nile river connecting the desert with the Nile to avoid flooding the cultivated land and to protect the city and the villages around it. Four surveys were made in 25/3/1997, 19/4/1998, 24/2/2000 and 31/12/2001 to study the torrents canal (as an ecotone) between the desert and the Nile Valley. Forty five stands at 100 meters intervals (100 m) were studied floristically along 5 km at the first year. After that 10 stands, as transacts across the canal 10m width, which represent the annual change in vegetation along 3 km., were selected. The Braun Blanquet method was used to analyze the vegetation (percentage of abundance and dominance).

The second site for this study locates in Aswan. The mean of temperature ranges between 24 and 43°C. There is no rainy season. There are many rocky islands in the Nile in Aswan. The soil accumulated in the depressions between the islands rocks result from the transferred silt by the floods before High dam construction, airborne dust or physical processes formed places ecologically vary from the islands margins and Nile shore. The soil water content in these depressions is very low in comparison with water content in the soil near the islands margins or Nile shore, because the surrounding rocks around depressions prevented the movement of water from Nile river to this places. So, a survey of vegetation in three small islands and the Nile shore in Aswan town (900 km. South of Cairo) was conducted in 27 March 2000.

The third site of study was in the Red Sea region. The temperature ranges between 43 in August and 25°C in January. The maximum average rainfall about 1.4 mm in December. The months from June to September are rainless. The survey of vegetation in the Red Sea region was conducted in 26 March 2000 at the Red Sea shore, as ecotone between the sea and a very dry desert, where water is available but the salinity is the limiting factor. The aim of this survey was to observe the ability of desert plants to survive near the sea shore where humidity is higher than inside eastern desert.

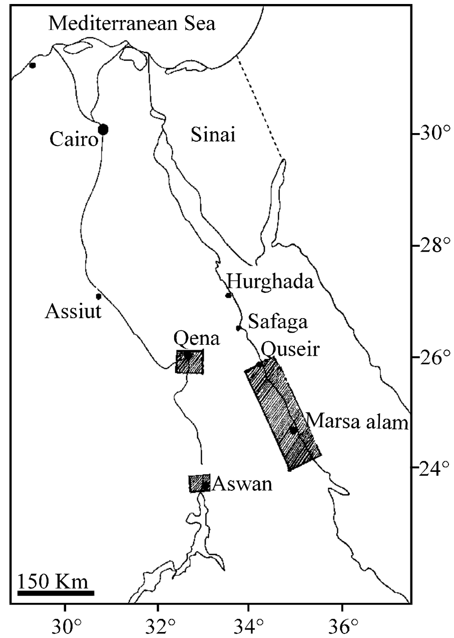

Fig. 1: Topographic map of Egypt showing the location of the study Sites at Qena, Red Sea shore and Aswan

The torrent canal was subjected to four surveys for many reasons. First, the water status was changeable with time. Second, the seeds of xerophytic species were carried with torrential water to a different place inhabited by different life forms. Third, the competition between the intruder species and the endemic ones was expected. Finally, the instability of vegetation due to the change in water status as a result to the continued drainage and evaporation. There are only one survey in the Nile in Aswan and another in the Red Sea, because is relatively stable water status. In Aswan flood have been prevented since 1960, after High Dam construction and in the Red Sea the rainfall is very rare in the area of study and did not occur for seven years before this study. So, the climatic conditions were stable to some degree and the seasonal change in temperature is not substantial to change the vegetation characteristics.

Results

Torrent canal vegetation: The starting point of the torrent was more than 100 km east of Qena and it flowed in the desert westward carrying the seeds of desert plants to the Nile Valley. The torrent was strong and the water covered a wide area of cultivated land north-east of Qena. The

Fig. 2: Plates 1, 2, 3 and 4 show the development of vegetation in the torrent canal at Qena during study. Plate 5 shows the vegetation at the west side of Nile at Aswan while Plate 6 shows the growing of *Arundo donax* and *Acacia* spp. in island at Aswan. Plate 7 shows part of vegetation in the delta of Wadi Gemal where *Sporbulus sp* grew on the high places and *Juncus* acutus in the lower ones. Finally Plate 8 shows one of many colonies of *Avicennia marina* that grew at the Red Sea

cultivated land was not studied because the farmers removed the wild plants directly after their germination, so only the torrent channel vegetation was monitored. The survey started from the last kilometer of the eastern desert westward to the eastern bank of the Nile River.

In the first survey on 25th March 1997, four months after the flow of the torrent, 45 stands at 100 meter intervals were analyzed vegetatively. The channel bed had some depressions, especially in front of the bridges as a result of turbulence when encountering obstructions. As shown in Fig. 2 that the depressions water accumulated and they were frequently colonized by the helophyte *Arundo donax* (Plate No. 1) which disappeared from some places after the evaporation of water under the effect of high summer temperature. The first stand examined (Plate No. 2) (nearest the desert) was dominated by xerophytes; the most abundant species were *Launaea* sp., *Pulicaria crispa, Salsola* sp., *Tamarix* sp., *Zygophyllum coccineum, Zilla spinosa* and *Zygophyllum simplex.* In the second stand (No. 20 of the 45 stands) familiar wild plants of the Nile Valley appeared; the most striking ones were *Ricinus communis* and *Imperata cylindrica* but the dominant species were desert plants. In the west side of the stand (Plate No. 3) *Ricinus communis* (mesophyte) increased, a mosaic of desert plants and *Imperata cylindrica* were formed. The third stand (No. 30) had an additional four Nile Valley species. They were *Alhagi graecorum, Melilotus indicus, Sonchus oleraceus* and *Trigonella glabra.* Finally in the last stands the pioneers of *Dalbergia sisso* trees, cultivated: commonly in the city, appeared and the edge plant (grow around canals and railways) *Imperata cylindrica* dominated the last stands with a decrease of desert species.

In the second survey in 19th April 1998, a desert-Nile gradient in vegetation was formed clearly. The stand nearest the desert (in the east) was dominated by xerophytes. The major abundant xerophytes were *Zygophyllum coccineum, Zilla spinosa* and *Salsola* sp. These species are also the major dominants in the eastern desert in Egypt. The diversity (number of species over canal) of xerophyte increased with time.

In the intermediate stands the mesophytes appeared, but the dominant species was the desert-edge plant *(Alhagi graecorum).*

Stands toward the Nile were dominated by mesophytes: *Sonchus oleraceus, Solanum nigrum, Chenopodium murale, Ricinus communis* and *Datura inoxia.* Some familiar cultivated species appeared such as *Raphanus sativus* and *Lycopersicon esculentum.* Also present were some pioneer shrubs and trees including *Sesbania sesban, Acacia nilotica* and *Ziziphus spina -christi.*

In the depressions where water accumulated the helophytes *Arundo donax* and *Typha domjngensis* as well as *Poa annua* occupied these places. Around depressions in the water-saturated soils the dominant species was *Polygonum equisetiforme.* Generally the diversity of mesophytes increased with time.

In 24 February 2000 the third survey showed that all the eastern depressions were occupied by *Arundo donax* (helophyte) and the bed of the canal supported a community dominated by *Zygophyllum coccineum* and *Tamarix* shrubs (Plate No. 4). The canal sides were colonized by *Salsola imbricata* for three kilometers westward. Toward the Nile valley gradual changes in the vegetation composition occurred as follows:

On the canal sides: *Tamarix* shrubs competed with *Salsola imbricata* and gradually *Ochradenus baccatus* and *Pulicaria crispa* (desert plants) entered the competition. All these desert plant gradually disappeared and a community of *Imperata cylindrica* and *Alhagi graecorum* (edge plants in the Nile valley) appeared.

In the canal bed: The eastern side of the bed was covered by a community of *Zygophyllum coccineum, Pulicaria crispa* and many shrubs of *Salsola imbricata* (desert plants). Westward a community of *Cynodon dactylon* and *Alhagi imbricata* developed. A patch of *Ricinus communis* shrubs were in this community but most of them dried up. Palm appeared followed by a pure stand of *Imperata cylindrica.* In a depression at the end of the studied part of the canal (2-3 kilometers from the Nile River) water was collected from drainage from cultivated land and the neighbouring canal which carries water from the Nile to the cultivated land. In this depression a community of helophytes appeared; the abundant species were *Cyperus papyrus, Arundo donax* and *Typha domingensis.*

The last survey in 31 December 2001 showed that, the eastern stands (desert ward) were inhabited by the true xerophytes. The soil moisture insured the growth of *Arundo donax* again in the eastern depressions in winter. The low winter temperatures decreased of the evaporation rate.

Abundance was absolutely greater for the xerophytes in the eastern stands. The most abundant species (in the canal bed) were *Zygophyllum coccineum, Puilcaria crispa, Lawnia* sp. and *Zilla spinosa.* Also there were several individuals of *Tamarix* sp in the canal bed. With the time, the edge plant *Alhagi graecorum* appeared and entered the competition east ward direction and disappeared from the west stands which were dominated by *Imperata cylindrica, Cynodon dactylon* and *Cyperus rotundus.* The canal sides east ward were inhabited by the

Table 1: The floristic composition in the torrent canal during the period of study

First survey in 25/3/ 1997 species	Second survey in 19/4/1998 species	Fourth survey 24/2/2000 species	Fourth survey 31/12/2001 species
Alhagi graecorum	*Anabasis setifera*	*Alhagi graecorum*	*Alhagi graecorum*
Arundo donax	*Ageratum conyzoides*	*Arundo donax*	*Arundo donax*
Atriplex sp.	*Alhagi graecorum*	*Acacia* sp.	*Acacia* sp.
Centaurea sp.	*Arundo donax*	*Cynodon dactylon*	*Cynodon dactylon*
Chenopodium murale	*Atriplex* sp.	*Cyperus papyrus*	*Cyperus papyrus*
Cynodon dactylon	*Avena fatua*	*Imperata cylindrica*	*Cyperus rotundus*
Cyperus sp.	*Calotropis procera*	*Ochradenus baccatus*	*Datura innoxia*
Dalbergia sesso	*Chenopodium murale*	*Pulicaria crispa*	*Imperata cylindrical*
Fagonia arabica	*Cynodon dactylon*	*Ricinus communis*	*Phoenix dactylifera*
Imperata cylindrica	*Datura innoxia*	*Salsola imbricata*	*Pulicaria crispa*
Launaea sp.	*Echinochloa colona*	*Tamarix aphylla*	*Salsola imbricata*
Malva sp.	*Fagonia indica*	*Typha domingensis*	*Tamarix aphylla*
Matthiola sp.	*Heliotropium* sp.	*Zygophyllum coccineum*	*Typha domingensis*
Melilotus indicus	*Imperata cylindrica*	*Zygophyllum coccineum*	
Oxygonum sp.	*Lolium* sp.	*Zilla spinosa*	
Pulicaria crispa	*Lycopersicon esculentum*		
Pulicaria sicula	*Morettia philaeana*		
Ricinus communis	*Ochradenus baccatus*		
Salsola sp.	*Orobanche* sp.		
Schouwia thebaica	*Poa annua*		
Sonchus oleraceus	*Pluchea dioscoridis*		
Tamarix sp.	*Polygonum equisetiforme*		
Trigonella glabra	*Polypogon monspeliensis*		
Zilla spinosa	*Pulicaria crispa*		
Zygophyllum coccineum	*Raphanus sativus*		
Zygophyllum simplex	*Ricinus communis*		
	Rumex vesicarius		
	Salsola imbricata		
	Schouwia thebaica		
	Sesbania sesban		
	Solanum nigrum		
	Sonchus oleraceus		
	Spergularia diandra		
	Tamarix aphylla		
	Typha domingensis		
	Zilla spinosa		
	Zygophyllum coccineum		
	Zygophyllum simplex		

desert shrubs of *Salsola* sp. with rare individuals of *Tamarix* sp.

Increased in numbers of *Alhagi graecorum* eastward due to the increase of soil water content in the early winter which supports weeds such as *Cynodon dactylon* and *Cyperus rotundus* to form a wide mat of their vegetation. The desert plant *Pulicaria crispa* was the stronger competitor westward where occurred to the 7th stand. The other xerophytes occurred in the 5th stand. The 8th and the 9th were occupied completely by *Imperata cylindrica* community. After the *Imperata* community all the next part (about 2 km) of the canal was inhabited by *Arundo donax, Cyperus papyrus* and *Typha domingensis* to the Nile shore. The floristic composition during the study is glossed in Table 1.

The study showed that water in the torrent carried the seeds of desert plants which can survive arid conditions to the Nile region which is occupied by native or cultivated mesophytes. There is an ecotone between the eastern desert and the Nile valley. The torrent injected the Nile region carrying the desert species. This produced a penetrating temporary ecotone. Bretscho (1995) considered the river system as an ecotone, on a continental scale, mediating between the terrestrial region and the sea. In this study, xerophytic plants in the Nile region quickly dominated the canal bed and its sides especially annuals which are able to completing their life cycle in a short time. On the other hand, mesophytes grew in their usual environment. The torrents transferred great amounts of sand that accumulated in some places in the canal beds and also erosion occurred in other places and this produced depressions which were water collectors. This last consequence allowed the colonization by hydro-helophytes that usually grow restricted to the Nile shore and canals in the Nile valley. As shown in Plate No. 4, xerophytes, mesophytes and hydrophytes grew together in the same place; the limiting factor in this case was the amount of water surrounding the roots.

Table 2: The most familiar species in the torrent canal during the study and their abundance through four surveys in stand (1) near desert, stand (5) in the middle of the surveyed area (3 km) and stand (10) toward the Nile

Species	Stand	Survey I	Survey II	Survey III	Survey IV
Alhagi graecorum	1	+	+	1	1
	5	2	2	2	2
	10	1*	2*	3*	3*
Arundo donax	1	2**	3**	dried	seedlings
	5	-	-	-	-
	10	2	3	3	4
Imperata cylindrica	1	-	-	-	-
	5	1	2	3	3
	10	1*	2*	3*	4*
Pulicaria crispa	1	1	2	3	3
	5	2	3	3	3
	10	2	+	-	-
Salsola imbricata	1	1*	2*	3*	3*
	5	+*	2*	2*	2*
	10	-	-	-	-
Tamarix aphylla	1	2	+	+	+
	5	+*	1*	2*	2*
	10	+	-	-	-
Typha domingensis	1	-	-	-	-
	5	+**	1**	-	-
	10	1	2	3	3
Zygophyllum coccineum	1	2	2	2	2
	5	2	2	+	-
	10	+*	-	-	-
Zygophyllum simplex	1	+	1	-	-
	5	2	-	-	-
	10	+*	-	-	-

* The plants grow at the canal sides
** The plants grow in the depressions
Unsigned values represent plants are grown in the canal bed

During the period from 1996 - 2001, the vegetation as shown in Table 2 was distinguished in the following groups

- Xerophytic plants grew at the higher sides of the canal; also at higher places in canal bed where the sand accumulated.
- Mesophytes occupied the canal bed; eastward there was scattered xerophytic vegetation which gradually disappeared westward.
- Hydrophilic plants grew in the depression where water collected. These plants dried up in the depressions which lost their water by evaporation and drainage.

The vegetation under the effect of water as a climatic factor was a mosaic of different life forms. The shift between these mosaics was rapid and dramatic in the first year owing to the quick change in the water status under the effect of temperature (evaporation) and drainage. Then, these microecotones were affected directly and strongly by the water status in the soil. With time the vegetation stabilized with the stabilization of water status; the soil water content as percent ranged between 18% at stand No.10 and 0.2% at stand No. 1 and ranged between 1-2% in the stands 4 - 7. Helophytes grew in the deep depressions where the drainage from the surrounding fields represented a stable source of water. Mesophytes dominated the canal bed where there was a moderate source of water while xerophytes occupied the higher sides of the canal

The vegetation in the Nile islands in Aswan: In Aswan the survey was limited to studying the co-occurrence of different plant life forms in small islands and at the Nile shore. Hydrophytes such as *Potamogen crispus* (Plate No. 5), helophytes such as *Arundo donax* and *Acacia seyal* that survive at the Nile bank far from the shore (also in desert) Co-occurred (Plate No. 6). The rocky structure of the islands was the main factor which prevents the water from reaching these places and maintained them suitable for *Acacia seyal*. So, the main limiting factor in this case was edaphic.

Red Sea shore vegetation: At the Red Sea shore, about 300 km. north of the Sudan border in Wadi Gemal (Wadi=Valley and Gemal=camels), an additional survey was conducted to study the effect of soil salinity on the characteristics of the ecotone. As shown in Plate No. 7, delta of Wadi Gemal, near the Red Sea shore in the lower places near sea water level *Juncus acutus* survived, while the higher areas near the sea shore were inhabited by *Sporobolus* sp. Far from the shore, palms *Phoenix dactylifera*, *Tamarix* sp. and other desert plants grew.

Zygophyllum coccineum is a widespread species in the Eastern Desert. With the severe aridity most plants of this species died, except in certain places near the water line which carries drinking water to the Red Sea Cities from Qena, due to water leakage from the pipes. This species was remarkable vegetationally near the Red Sea where the humidity is higher than in the Eastern Desert. Along the Red Sea shore both *Zygophyllum coccineum* (xerophytic species) and *Zygophyllum album* (halophytic species) can survive at the same places but the former grow in the higher places. The mangrove plant, *Avicennia marina* as shown in Plate (8) grew in the seawater.

The salinity at the Red Sea plays the main role in characterizing this ecotone.

Suggested ecotone classification: The following ecotone classification was suggested to differentiate the ecotones according to the type of environmental stress and biological interactions that forms the ecotone.

The suggested classification

Climatic ecotones: This type can be subdivided into:

- Thermo-ecotone, when temperature is the main limiting factor.
- Hygro-ecotone, when humidity is the main limiting factor.

Edaphic ecotones: This type of ecotone is controlled by the effect of the edaphic factors and can be subdivided into:

- Geo-ecotone, that is affected by the soil texture, soil depth or both.
- Hydro-ecotone, that is affected by the water status in the soil.
- Chemo-ecotone, that is affected by the soluble ions in the soil solution, including salinity.

Biological ecotones: This type of ecotones can be subdivided to:

- External biological ecotone concerning the boundaries between adjacent ecosystems which need the same demands to survive.
- Internal biological ecotone, concerning the relations between the individuals within the same ecosystem, especially at the period of change from one aspect to another.

Discussion

Recently ecotone became one of the most interesting subjects in ecology. Many scientists studied the ecotonal zones over the world. The results of many investigations attributed the changes in ecosystem characteristics and consequently ecotones to abiotic environmental conditions (Liu *et al.*, 2001). Others attributed the changes to the biotic factors, or moreover, to the abiotic factors (Weaver, 1960; van der Maarel 1990). With the increased interest in studying the ecotones it is necessary to put a universal classification to differentiate the ecotones to distinguished classes depending on the affecting environmental factors. The current work is first attempt putting a framework to a general classification of ecotones. This will allow to expect the changes which will occur in the ecotone and consequently in one of the interfered ecosystems or both. This due to the sensitivity of ecotones, which represent the ends of the ecological amplitude for the two interfered ecosystems, to the changes of the environmental factors.

The data collected here from three different places to insure the use of the most available environmental factors in Upper Egypt. In the first place (torrent canal) there are three environmental factors affect the vegetation which grew in the torrent canal the temperature eastward toward desert, the water status in the western stands toward the Nile and the competition in the middle stands. The high temperature in the summer accelerate the water evaporation from the depressions lied in the desert boundaries. This phenomenon lead to the disappearance of the helophyte plant *Arundo donax* and increases the abundance of the xerophytic plants. In the winter with the decrease in temperature the rate of water evaporation decreased and soil became wet, the seedlings of *Arundo donax* arise again from the rhizomes which are buried in the soil. It is clear that the temperature played the main role in determining the ecotone characteristic toward the desert. This type can be classified as thermo-ecotone.

Temperature is one of the most effective climatic factors which played an important role in distributing the plants on the earth from the equator to the poles. When temperature affects plants directly and there is no factor which can eliminate the stress caused by temperature. In this case the temperature stress in this area will represent the lower limits (minimum temperature) to the ecosystem which lies near the equator whereas it represents the higher limits (maximum temperature) to the next ecosystem far from the equator. The temperature will control the zone of interference between these two adjacent ecosystems. This type of ecotones is considered as a subclass of the climatic ecotones class which is called thermo-ecotones. Ecologists from around the world have begun experiments to investigate the effects of global warming on terrestrial ecosystems; the aspect of global climate change that attracts the most public attention (Woodwell and McKenzie 1995, Mooney *et al.,* 1999, Saleska *et al.,* 1999 and Walker and Steffen 1999). This type of ecotones is controlled by space and time. With the annual change in temperature, this type vacillates in north-south direction, or up-down on mountains. The disturbance resulting from the frequently temperature vacillation may help the adaptive annuals to coexist in the favorable seasons and may lead to form new ecosystem.

The western stands, toward the Nile, were affected by the water status where the water was drained continually from the surrounding cultivated lands. The continued accumulation of water in the Nile ward stands eliminate the temperature effects and insured the absolute~ abundance of the helophytic plants over the year. The ecotone in this case can be classified as hydro-ecotone because the water was the main factor affects the ecotone characteristics.

The hydro-ecotones are controlled by the water status in the soil. The importance of hydro-ecotones results from several reasons. The water deficiency is the greatest problem in arid zones over the world. The availability of water is the main factor which can decrease the rate of desertation. The hydro-ecotone is the most sensitive and remarkable reflector to the water status in the soil. It can help us to know the direction of soil water movement. The ideal management of hydro-ecotones can lead us to maintain the stability of the ecosystems. The characteristics of hydro-ecotones are controlled by the status of the permanent water above and under ground and water movement vertically and horizontally. Hydro-ecotones may include riparian forests, marginal wet land, littoral lake zones, floodplain lakes and forests and areas of significant groundwater-surface water exchange (Naiman *et al.,* 1988). River system is one of the most interesting types of hydro-ecotones. It was studied widely over the world (Sheldon *et al.,* 2000; Grimm *et al.,* 1997; Ward *et al*., 1999; Bell *et al.,* 1999 and Bradley and Gilvear, 2000).

The middle stands were inhabited by several mesophytes and were rich floristically especially in the second survey. The biological advantages of *Imperata cylindrical* as high number of seeds produced by every individual, the long distance dispersion due to the hairy structure of its seeds and the light weight of the seeds supported the high abundance of this plant with time. The high competition value of the xerophytic plant *Pulicaria crispa* insured its presence in the middle stands. In this case the ecotone can classified as biological type.

When the ecosystems become adapted with the same prevailing environmental conditions and with the development of these adapted ecosystems and due to the continued growth of their individuals and the increase in their demands to environmental resources, the competition between the different individuals will start. This competition will continue inside the same ecosystem and will lead it to the equilibrium in its vegetation structure and will control the ecosystem dynamics and the seasonal appearing (seasonal aspects). Between the different seasonal aspects there is a transitional period from one aspect to the next. Through this period, an internal (temporal) biological ecotone will arise.

At the boundaries in the regions of interference between the two adjacent ecosystems the competition will be strongest. The biological characteristics of the individuals at the ecotonal region may play an important role in determining the ecotone characteristics. The characteristics of this type (External biological ecotone) depend on the history of vegetation, phenology of individuals in both ecosystems, dispersion and competition ability. For instance, at the grass-forest ecotone, the roots of forest trees depend on a permanent underground water source while grasses depend more on rain. The ability of trees to compete and disperse helps the forest ecosystem to disperse in the adjacent grass ecosystem (Buffington and Herbel 1965, Grover and Musick 1990, Schlesinger *et al.,* 1990, Virginia *et al.,* 1992, Steffan-Dewenter and Tscharntke. 1999). These ecotones, which are controlled by the biological characteristics, can be classified as biological- ecotones. Several works discussed the role of biological characteristics (e.g., Bertness and Leonard 1997 and Martines and Fuentes 1993).

Edaphic factors, as soil water content (discussed as hydro-ecotone), salinity and soil structure, are not less than the climatic factors in their effect upon ecosystem and ecotone characteristics. The types of ecotones raised depend on the edaphic factors and can be called edaphic ecotones. For instance, in tropics where the soil depth is shallow trees may be replaced by shrubs and grasses.

Geo-ecotones are those affected by the soil structure and topography. The rocky structure of the surveyed islands in the Nile at Aswan lead to different ecological sites within a small area So, plants of different life forms were co-occurred. Several Scientists investigated the effect of soil characteristics upon ecosystems, ecotones and their dynamics (Doering and Reider 1992; Harmon *et al.,* 1986, Knapp and Seastedt 1986, Vogt *et al.,* 1986, Carson and Peterson 1990, Facelli and Pickett 1991 and Xiong and Nilsson 1997). Fox (1977) referred to the role of topography.

Chemo-ecotone: In the most arid regions in the world, salinity (as an edaphic factor) represents a great problem affecting crop production and natural vegetation. At the Red Sea shore, as ecotone between the sea and desert, there are two, environmental factors affecting the vegetation. The first was the salinity which insured the stability of halophytic vegetation near the shore and' the second was air humidity and seasonal rain. The halophytes not were restricted only to the shore, but grew inside the desert in places lied under sea level such as Wadi Melaha (salt marsh valley), 80 km north of Hurghada. This type was classified here as chemo-ecotone.

The higher places at the shore were inhabited by xerophytic plants as *Zygophyllum coccineum* which avoided reaching of their roots to the saline water and depended on the high level of air humidity near the sea. This was clear in the deltas of the Valleys (as Wadi Gemal), run toward the sea, where some xerophytic plants survive especially *Z. coccineum.* Toward the desert these plants died. The ecotone was controlled in the desert-sea direction by humidity and seasonal rain which insure the growth of annuals and decreases the salinity. The rainfall facilitates the shifting of xerophytes toward the sea shore. The rain here not only improves or increases the water status of the soil but also evaporates from the soil under the effect of high temperatures in the summer. The ecotone in this case was classified as hygro-ecotone. Stephenson (1990) attributed the shift in plant composition to the annual precipitation. The effect of precipitation was studied by several investigators (Houghton *et al.,* 1996 and Giorgi *et al.,* 1998).

I hope that this classification will help us to make a universal plan to manage the different types of ecotones and understand the ecotone and its dynamics more specifically.

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