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# Assessing Impacts of Habitat Modification on Plant Diversity of an Urban Wetland

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## ABSTRACT

Wetland plant species composition is highly sensitive to habitat modification. It is influenced by climate change, eutrophication, and other anthropogenic activities. The present study emphasizes impacts of habitat modification of an urban wetland (Bhosari Lake) on plant species composition in rapidly developed Pune suburban area. The influence of urbanization and subsequent beautification of lakes on an aquatic ecosystem was assessed to know the transformation of plant species and composition. Intensive field surveys of this area resulted into documentation of more than 100 plant species. After analyzing the results, it was observed that the species composition has been significantly altered. The main factor responsible for species alteration was habitat modification and subsequent invasion of introduced and naturalized alien species. Though the species diversity increased, most of the naturally occurring aquatic species had disappeared. The plants that disappeared were sensitive to habitat modification: *Coix lacryma-jobi* L., *Najas indica* (Willd.) Cham., *Nymphoides hydrophylla* (Lour.) O. Ktze., *Ottelia alismoides* (L.) Pers., *Vallisneria spiralis* L. and *Caesullia axillaris* Roxb. Species like *Ipomoea carnea* Jacq., *Eichhornia crassipes* Solms., *Persicaria glabra* (Willd.) Gomez, *Alternanthera philoxeroides* (Mart.) Griseb invaded the wetland area. There was major loss in typical submerged, rooted and marshy macrophyte species, whereas the number of free-floating, facultative and obligate upland plants increased significantly. Upland and fringe plant species occupied the newly modified wetlands area. This signifies the impacts of habitat modification. In the process of recreation and beautification, lake vegetation has changed from marshy to upland.

**Keywords:** habitat alteration, human activities, land use change, macrophytes, urban lakes

## INTRODUCTION

Wetlands are transitional zones between terrestrial and aquatic habitats and vary widely because of regional and local differences in soils, topography, climate, hydrology, water depth and chemistry, vegetation, and other factors, including human disturbance. The various tanks, shallow ponds and reservoirs supports wetland biodiversity and add to the country's wetland wealth. It is estimated that freshwater wetlands alone support 20% of the known range of biodiversity in India (Deepa and Ramachandra 1999).

Aquatic macrophytes play a crucial role in balancing ecosystems. They are primary producers of oxygen through photosynthesis, provide a substrate for algae and habitat for many invertebrates, amphibians and birds, support in nutrient cycling to and from the sediments, and also help to stabilize river and stream banks. Aquatic macrophytes have served humans well over the centuries, providing food and medicines. They have been used effectively to distinguish environmental stresses including hydrologic alterations, excessive siltation, nutrient enrichment and other types of human disturbances (Moore and Kerry 1989; Kantrud and Newton 1996; Philippi *et al*. 1998).

The current loss of wetlands in India could lead to serious consequences as large populations are dependent on these wetlands (World Development Report 1994). Lakes undergoing eutrophication generally have a reduction in number of species and abundance of aquatic macrophytes (Philippi *et al*. 1998). The first step in conservation of biodiversity is to assess the diversity of natural resources present and to identify those which are important and most irreplaceable. The increased destruction of natural habitats due to human activities and excessive exploitation has intensified the need for collecting biodiversity data for support to conservation and management decisions (Sorensen 2004).

The status of a wetland depends on its management, level of anthropogenic activities, management of land, solid waste collection and disposal, disposal of used water and attitude of the people at large (Ramchandra *et al*. 2005). Among aquatic ecosystems, urban lakes and streams have undergone most varied and severe human-caused alternations (Paul and Meyer 2001; Suren and Elliott 2004). One of the main factors contributing to environmental deterioration of a lake is human settlements along its fringes. With population growth within the municipal area, the pressure on the lake and its surrounding as potential settlement areas and reclaimed land, has increased.

Subramanyam (1962) made a major contribution to the aquatic vegetation of India as a whole. As far as Maharashtra is concerned, Mirashi (1954, 1957, 1958) has concentrated mainly in and around Nagpur district. Gaudet (1963) has worked on the aquatic plants of Khandala talao. Jafari *et al.* (2006) concluded that due to various developmental activities in and around the banks of Mula, Mutha and Pavana rivers (Pune) the dominance of weed species were more common than natural vegetation. Gunale (1981) worked on the bio-monitoring of eutrophication in the Pavana, Mula and Mutha rivers flowing through Poona. Human activities are influencing the aquatic vegetation; as a result, the species composition and diversity studies of macrophytes became an essential component for understanding the lake ecosystem due to its ecological, economical and aesthetic role and ability to characterize water quality.

Earlier, systematic attempts have been made to analyze

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Research Note

the plant species composition of Bhosari Lake at the floristic level only. Investigations on hydrophytic flora and vegetation in and around Pune have been carried out by Vartak (1957, 1961), Puri and Mahajan (1958) and Ghate and Vartak (1981) etc. Razi (1951) have documented the herbaceous flora of Pune but had not commented upon the distribution across habitat types and localities. During this study efforts were made to document the factors that were causing and regulating the alterations in species composition. In order to correlate the change and alterations in composition due to urbanization and recreation on wetland biodiversity, previous information on aquatic flowering plants (Ghate and Vartak 1981) was taken into account.

## METHODOLOGY

Bhosari Lake is located between 18° 37′ 25.5″ N to 18° 37′ 36.3″ N and 73° 50′ 50.1″ E to 73° 51′ 8.1″ E and at 580 m ASL. The lake area is around 3.2 ha and somewhat circular in outline. Bhosari Lake is a man-made lake in Pimpri-Chinchwad Municipal Corporation (PCMC) area (Maharashtra, India). Pimpri-Chinchwad is a twin city of Pune urban area with India's largest industrial area. Bhosari Lake was used as a source of water for various purposes and also as wasteland and for open defecation by local people. Small drainage channels flow into the lake bringing domestic wastewater from nearby settlements. The lake also receives rainwater during the monsoon. Its isolated location on state-owned land meant that the lake did not receive nutrient-rich pollutants related to industrial activity. However, during last few years, the lake receives some waste water related to constructional activity.

The lake area was visited at periodic intervals i.e. in pre monsoon season (May first week), monsoon season (July last week) and post monsoon (December first week) between 2006 and 2008. In order to collect the existing number of species the lake was surveyed extensively, covering the flowering period of plants to facilitate identification. Observations of each species were made in the field. Specimens were processed for the herbarium by standard methods (Santapau 1955). For identification of macrophytes the methods of Subramanyam (1962), Karthikeyan *et al*. (1982), Singh *et al*. (2000, 2001) and Sharma *et al*. (1996) were referred. The data obtained was compared with previous work done by Ghate *et al*. (1981). The plants were recorded and categorized based on their growth form and place of occurrence within the wetland. Based on the field observations, following codes were assigned to the macrophytes.

**Submerged macrophytes (SM):** Plants that occur below the water surface in wetlands under natural conditions and anchored to the substratum. With the possible exception of flowering, submerged macrophytes typically spend their entire life cycle beneath the water surface and are distributed in coastal, estuarine, and freshwater habitats. Generally, the terminal portion of the plant does not reach the water's surface although it may lie in a horizontal position just beneath it.

**Rooted and floating leaves (RL):** Plants that occur almost in wetlands with floating leaves under natural conditions. The leaves of floating-leaved species (also known as floating attached) float on the water surface while their roots are anchored in the substrate.

**Free floating macrophytes (FF):** Plants that occur almost in wetlands under natural floating conditions. The leaves and stem of floating macrophytes (also known as floating unattached) float on the water's surface. If roots are present, they hang free in the water and are not anchored in the sediments. Floating plants move on the water's surface with winds and water currents.

**Emergent macrophytes (EM):** Plants that occur almost in wetlands with partially submerged plant body under natural conditions. Emergent macrophytes are rooted in soil with basal portions that typically grow beneath the surface of the water. Where ever saturated soils are present, rather than standing water, all the aboveground portions of the plant are aerial. Emergent herbaceous plants often inhabit shallow waters in marshes, along lakeshores or stream banks, and because of their ability to intercept sunlight before it reaches the water surface, they often dominate floating-leaved and submerged plants in these habitats.

**Marshy plants (MP):** Plants that occur in wet soil along the periphery of wetlands under natural conditions.

**Fringe plants (FP):** Plants that occur in partially dry soil along the periphery of wetlands under natural conditions.

**Facultative plants (FaP):** Plants with a similar likelihood of occurring in both wetlands and non wetlands.

**Facultative upland plants (FUP):** Plants that occur sometimes in wetlands, but occur more often in non wetlands.

**Obligate upland plants (OUP):** Plants that occur rarely in wetlands, but occur almost always in non wetlands under natural wetlands. Most of the plants in this group are herbaceous, also includes woody wetland species.

## RESULTS AND DISCUSSION

The lake has special historical importance. Initially, it was a marshy place. However, Pimpri-Chinchwad Municipal Corporation developed the marshy wetland areas around the lake into a tourist area (Wetland Development Plan 2001). It took 3 years to develop and establishment the beautiful tourist place around the lake. PCMC developed a meditation centre inside the lake. Fishing and boating activities are also permitted. The constructional activities were responsible for habitat alteration. This resulted in a gradual change in composition of aquatic and marshy flora.

The surveys resulted in a list of 128 species belonging to 38 families (**Table 1**). The categories used to group wetland plants includes submerged, free-floating, rooted macrophytes, emergent, marshy, fringe plants, facultative plants, facultative upland plants and obligate upland plants, as illustrated in **Table 2**. The loss or gain in number of macrophytes over 27 years has been illustrated graphically in **Fig. 1**. There was major loss in typical submerged, rooted and marshy macrophytes species, whereas number of free floating, facultative and obligate upland plants has been increased significantly.

Ghate and Vartak (1981) enumerated 61 species of macrophytes from the lake, including three submerged (*Vallisneria spiralis* L., *Hydrilla verticillata* (L.f.) Royle and *Najas minar* All.), two free floating (*Wolffia arrhiza* (L.) Wimmer, *Lemna gibba* L.) and two emergent macrophytes (*Typha angustata* Bory & Chaub and *Panicum repens* L.). When the present survey results were compared with those of Ghate and Vartak (1981), three submerged species, two rooted floating macrophytes and one emergent macrophyte were disappeared from the lake (*Coix lacryma-jobi.* L., *Najas minor* All, *Nymphoides hydrophylla* (Lour.) O. Ktze., *Ottelia alismoides* (L.) Pers. and *Vallisneria spiralis* L.). The population of *Ipomoea carnea* Jacq., *Eichhornia crassipes* Solms., and *Persicaria glabra* (Willd.) Gomez. had increased greatly, appearing as a dense growth around the shoreline. Plant diversity has increased although some plant species which have a positive impact on water quality disappeared from the area. This depicts the change in ecosystem composition. Some of the plants reported during the present investigation were not typical wetland plants and these invaded the area during beautification and landscape gardening.

In 1981, the family Cyperaceae was the most dominant followed by Poaceae, while in 2008, family Asteraceae became dominant. The families that disappeared during last 27 years were Acanthaceae, Elatinaceae, Gentianaceae, Hydrocharitaceae, Lobeliaceae, Lythraceae, Menyanthaceae and Najadaceae. While the families which made their appearance after beautification of lake includes Azollaceae, Boraginaceae, Caesalpiniaceae, Cleomaceae, Euphorbiaceae, Fumariaceae, Lamiaceae, Malvaceae, Molluginaceae, Nyctaginaceae, Oxalidaceae, Papaveraceae, Polygonaceae, Portulacaceae, Pontederiaceae, Solanaceae and Tiliaceae.

Based on the present investigation, there was a gradual change in species composition. Submerged macrophytes had totally disappeared (i.e. *Hydrilla verticillata* (L.F.) Royle, *Vallisneria spiralis* L.), whereas, the number of rooted macrophytes decreased. In the case of emergent macrophytes, although the number of plant species remained the same, species composition changed. In 2008, *Persicaria glabra* (Willd) Gomez. was recorded along with

**Table 1** Status of the plant species reported in Bhosari lake area in 1981 and 2008. For explanation of the codes assigned to the macrophytes, see main text.

| Name of the plants | Family | Code | 1981 | 2008 |
|---|---|---|---|---|
| *Aeschynomene indica* L. | Fabaceae | MP | √ | |
| *Ageratum conyzoides* L. | Asteraceae | FUP | | √ |
| *Alternanthera bettzichiana* (Regel) Nicols. | Amaranthaceae | FP | | √ |
| *Alternanthera philoxeroides* (Mart.) Griseb. | Amaranthaceae | MP | | √ |
| *Alternanthera sessilis* (L) R. Br. ex DC. | Amaranthaceae | FP | √ | √ |
| *Alysicarpus* sp. | Fabaceae | FP | | √ |
| *Amaranthus roxburghianus* Nevski. | Amaranthaceae | FaP | | √ |
| *Ammannia multiflora* Roxb. | Lythraceae | MP | √ | |
| *Ammannia baccifera* L. | Lythraceae | MP | √ | |
| *Argemone mexicana* L. | Papaveraceae | FUP | | √ |
| *Azolla pinnata* R. Br. | Azollaceae | FF | | √ |
| *Bacopa monnieri* (L) Penn. | Scrophulariaceae | MP | √ | √ |
| *Bergia ammannoides* Roxb. ex Roth. | Elatinaceae | FP | √ | |
| *Bidens biternata* (Lour.) Merr. & Sherff. | Asteraceae | FUP | | √ |
| *Blumea lacera* (Burm.f.) DC. | Asteraceae | FUP | | √ |
| *Blumea mollis* (D. Don) Merr. | Asteraceae | FP | | √ |
| *Boerhavia repens* L. | Nyctaginaceae | OUP | | √ |
| *Brassica juncea* (L.) Czern & Coss. | Brassicaceae | OUP | | √ |
| *Caesulia axillaris* Roxb. | Asteraceae | MP | √ | |
| *Canscora decurrens* Dalz. | Gentianaceae | FaP | √ | |
| *Cassia tora* L. | Caesalpiniaceae | FUP | | √ |
| *Cassia uniflora* Mill | Caesalpiniaceae | FUP | | √ |
| *Centaurium meyeri* (Bunge) Druce | Gentianaceae | FP | √ | |
| *Chloris virgata* Swartz | Poaceae | OUP | | √ |
| *Chrozophora rottleri* (Gies.) Juss. | Euphorbiaceae | FUP | | √ |
| *Cleome felina* L. f. | Cleomaceae | OUP | | √ |
| *Coix lacryma-Jobi* L. | Poaceae | EM | √ | |
| *Commelina benghalensis* L. | Commelinaceae | FP | √ | √ |
| *Commelina hasskarlii* Cl. | Commelinaceae | MP | √ | |
| *Corchorus fascicularis* Lam. | Tiliaceae | FP | | √ |
| *Cyanotis fasciculata* J. A. & J. H. Schult. | Commelinaceae | FaP | √ | |
| *Cynadon dactylon* Pers. | Poaceae | FUP | | √ |
| *Cyperus alulatus* Kern. | Cyperaceae | FP | | √ |
| *Cyperus compressus* L. | Cyperaceae | FaP | √ | |
| *Cyperus difformis* L. | Cyperaceae | FP | √ | |
| *Cyperus digitatus* Roxb. | Cyperaceae | MP | | √ |
| *Cyperus iria* L. | Cyperaceae | FP | √ | |
| *Cyperus nutans* Vahl. | Cyperaceae | MP | √ | |
| *Cyperus pangorei* Rottb. | Cyperaceae | MP | √ | |
| *Cyperus rotundus* L. | Cyperaceae | FP | | √ |
| *Dactyloctenum aegyptium* Willd. | Poaceae | FUP | | √ |
| *Datura metal* L. | Solanaceae | OUP | | √ |
| *Digitaria ciliaris* Koel. | Poaceae | OUP | | √ |
| *Dinebra retroflexa* Panz. | Poaceae | OUP | √ | √ |
| *Echinochloa colona* Link. | Poaceae | MP | √ | √ |
| *Eclipta alba* (L.) Hassk. | Asteraceae | FP | √ | √ |
| *Eichhornia crassipes* Solms | Pontederiaceae | FF | | √ |
| *Eleocharis acutangula* Schult. | Cyperaceae | MP | √ | |
| *Eleocharis atropurpurea* J. & K. Presl. | Cyperaceae | MP | √ | |
| *Eleocharis geniculata* R. & S. | Cyperaceae | MP | √ | |
| *Eleusine indica* Gaertn. | Poaceae | FaP | √ | |
| *Eragrostis gangetica* Steud. | Poaceae | FUP | | √ |
| *Erigeron sublyratus* DC. | Asteraceae | FaP | | √ |
| *Euphorbia geniculata* Orteg. | Euphorbiaceae | FUP | | √ |
| *Euphorbia hirta* L | Euphorbiaceae | FUP | | √ |
| *Euphorbia latea* Heyne ex Roth. | Euphorbiaceae | OUP | | √ |
| *Euphorbia notoptera* Boiss. | Euphorbiaceae | OUP | | √ |
| *Euphorbia thymifolia* L | Euphorbiaceae | OUP | | √ |
| *Exacum pedunculatum* L. | Gentianaceae | FP | √ | |
| *Fimbristylis ovata* (Burm) Kern. | Cyperaceae | FaP | √ | |
| *Fimbristylis ferruginea* (L) Vahl. | Cyperaceae | FaP | √ | |
| *Fimbristylis tetragona* R.Br. | Cyperaceae | FP | √ | |
| *Fuirena wallichiana* Kunth. | Cyperaceae | FP | √ | |
| *Fumaria indica* (Haussk.) Pugsley. | Fumariaceae | FP | | √ |
| *Glinus lotoides* L. | Molluginaceae | FUP | | √ |
| *Gomphrena serrata* L. | Amaranthaceae | FUP | √ | |
| *Grangea maderaspatana* (L.) Poir. | Asteraceae | MP | | √ |
| *Hoppea dichotoma* Heyne ex Willd. | Gentianaceae | FaP | √ | |
| *Hydrilla verticillata* (L.F.) Royle. | Hydrocharitaceae | SM | √ | |
| *Hygrophila schulli* (Buch.-Ham.) M.R. & S.M. Almeida | Acanthaceae | MP | √ | |
| *Ipomoea aquatica* Forssk.. | Convolvulaceae | RL | √ | √ |
| *Ipomoea carnea* Jacq. | Convolvulaceae | FaP | | √ |
| *Juncellus alopecuroides* Cl. | Cyperaceae | FP | | √ |

**Table 1** (Cont.)

| Name of the plants | Family | Code | 1981 | 2008 |
|---|---|---|---|---|
| *Justicia quinqueangularis* Koen. Ex Roxb. | Acanthaceae | FUP | √ | |
| *Kyllinga brevifolia* Rottb. | Cyperaceae | MP | √ | √ |
| *Lagascea mollis* Cav. | Asteraceae | OUP | | √ |
| *Lantana camara* L. | Verbenaceae | OUP | | √ |
| *Launaea procumbens* (Roxb.) Ramayya & Rajagopal. | Asteraceae | OUP | | √ |
| *Lemna gibba* L. | Lemnaceae | FF | √ | √ |
| *Lemna perpusilla* Torr. | Lemnaceae | FF | | √ |
| *Limnophila indica* (L) Druce. | Scrophulariaceae | MP | √ | |
| *Lobelia alsinoides* Lam.. | Lobeliaceae | OUP | √ | |
| *Ludwigia octovalvis* (Jacq) Raven. ssp. Octovalvis. | Onagraceae | MP | √ | √ |
| *Malvastrum coromandelianum* (L.) Garcke. | Malvaceae | OUP | | √ |
| *Mariscus squarrosus* (L) Cl. | Cyperaceae | MP | √ | |
| *Micromeria capitellata* Bth. | Lamiaceae | FP | | √ |
| *Najas minar* Hook.f. | Najadaceae | SM | √ | |
| *Nymphoides hydrophylla* (Lour.) O. Ktze. | Menyanthaceae | RL | √ | |
| *Ottelia alismoides* (L) Pers. | Hydrocharitaceae | RL | √ | |
| *Oxalis corniculata* L. | Oxalidaceae | FP | | √ |
| *Panicum repens* L. | Poaceae | FaP | √ | |
| *Parthenium hysterophorus* L. | Asteraceae | OUP | | √ |
| *Paspalidium flavidum* Camus. | Poaceae | FaP | | √ |
| *Paspalidium geminatum* Stapf. | Poaceae | FaP | | √ |
| *Paspalidium punctatum* Camus. | Poaceae | FaP | √ | |
| *Paspalum scrobiculatum* L. | Poaceae | FaP | √ | |
| *Paspalum vaginatum* Swartz. | Poaceae | FaP | √ | |
| *Pennisetum hohenackerii* Steud. | Poaceae | FUP | √ | |
| *Persicaria glabra* (Willd) Gomez. | Polygonaceae | EM | | √ |
| *Phyla nodiflora* (L.) Greene. | Verbenaceae | MP | √ | √ |
| *Phyllanthus fraternus* Webster. | Euphorbiaceae | FP | | √ |
| *Portulaca oleracea* L. | Portulacaceae | FA | | √ |
| *Pycreus flavidus* Koyama. | Cyperaceae | MP | | √ |
| *Pycreus globosus* Reichb. | Cyperaceae | MP | √ | |
| *Pycreus pumilus* Cl. | Cyperaceae | MP | √ | |
| *Rorippa indica* (L.) Hiern. | Brassicaceae | FP | √ | |
| *Schoenoplectus lateriflorus* Lye. | Cyperaceae | MP | √ | |
| *Setaria pumila* R & S. | Poaceae | OUP | | √ |
| *Sida acuta* Burm.f. | Malvaceae | OUP | | √ |
| *Sida rhombifolia* L. | Malvaceae | OUP | | √ |
| *Sonchus asper* (L.) Hill. | Asteraceae | FUP | | √ |
| *Sonchus oleraceus* L. | Asteraceae | FUP | | √ |
| *Sphaeranthus indicus* L. | Asteraceae | FP | | √ |
| *Spilanthus calva* DC. | Asteraceae | FUP | | √ |
| *Spirodela polyrhiza* Schleid. | Lemnaceae | FF | | √ |
| *Striga densiflora* (Bth.) Bth. | Scrophulariaceae | FaP | √ | |
| *Synedrella nodiflora* (L.) Gaertn. | Asteraceae | FaP | | √ |
| *Synedrella vialis* (Less.) A.Gray. | Asteraceae | FaP | | √ |
| *Tagetus erecta* L. | Asteraceae | OUP | | √ |
| *Tridax procumbens* L. | Asteraceae | UOP | | √ |
| *Typha angustifolia* L. | Typhaceae | EM | √ | √ |
| *Vallisneria spiralis* L. | Hydrocharitaceae | SM | √ | |
| *Verbascum chinense* (L.) Sant. | Boraginaceae | FUP | | √ |
| *Vernonia cinerea* (L.) Less. | Asteraceae | FUP | | √ |
| *Vigna trilobata* (L.) Verdc. | Fabaceae | OUP | | √ |
| *Wolffia arrhiza* Wimmer. | Lemnaceae | FF | √ | √ |
| *Xanthium indicum* Koen. | Asteraceae | FUP | √ | √ |
| *Zornia diphylla* (L.) Pers. | Fabaceae | OUP | √ | |

**Table 2** Macrophyte categories.

| Type of plant | Code | 1981 | 2008 |
|---|---|---|---|
| Submerged macrophyte | SM | 3 | 0 |
| Rooted and floating leaves | RL | 3 | 1 |
| Free floating macrophyte | FF | 2 | 6 |
| Emergent macrophyte | EM | 2 | 2 |
| Marshy plants | MP | 19 | 9 |
| Fringe plants | FP | 10 | 13 |
| Facultative plants | FaP | 10 | 7 |
| Facultative upland plants | FUP | 4 | 19 |
| Obligate upland plants | OUP | 3 | 20 |

*Typha angustifolia* L. In the case of facultative plants, the number of plant species decreased. The numbers of marshy plants were reduced drastically, whereas the number of facultative upland plants and obligate upland plants increased. This indicates a gradual change in habitat from marshy to upland.

Aquatic macrophytes play an important role in the structure and function of an aquatic ecosystem. Lakes serve as an important ecosystem, not only for the environment, but also for human development. The current pressure of urbanization is a major threat to its function and survival in general and therefore must be preserved. The species composition and relative abundance of aquatic macrophytes are the indicators of the status of the wetland. Thus this data can be used for planning conservation and management strategies for this wetland.

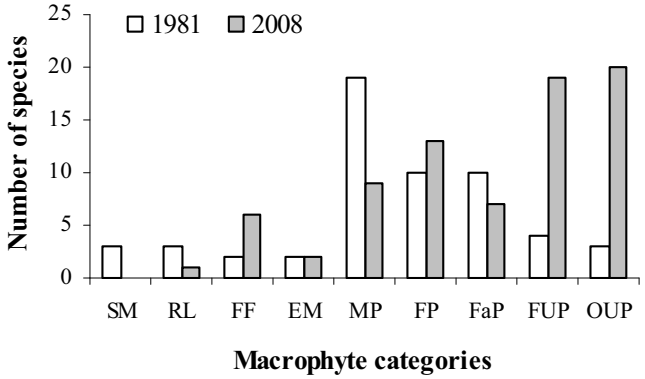


**Fig. 1 Change in number of macrophytes over 27 years.**

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