Archiv für Naturschutz und Landschaftsforschung

Band 45
Heft 1
März 2006

Inhalt

Habitat survey, mapping, and assessment in the Mai Po Nature Reserve, Hong Kong (China)

Maja Willis[1], Stefan Zerbe[2, 4], and Werner Breitung[3]

[1] Technical University of Berlin, Institute of Ecology, Rothenburgstr. 12, D-12165 Berlin, Germany, Tel. ++49 30 314 71194, Fax. ++49 30 314 71355, Email: maja@luminousgreen.net

[2] University Greifswald, Institute of Botany and Landscape Ecology, Grimmer Straße 88, D-17487 Greifswald, Germany, Tel. ++49 3834 864108, Fax. ++49 3834 864114, Email: zerbe@uni-greifswald.de

[3] Zhongshan University, School of Geography & Planning, 135 Xingang Xi Lu, Guangzhou 510275, China
Tel. ++86 20 84114105, Fax. ++86 20 84113621, Email: breitung@gmail.com

[4]Corresponding author

Keywords:

Exotic species, habitat conservation, human impact, land-use types, nature reserve management, shrimp farming

Abstract: Habitat survey, mapping, and assessment in the Mai Po Nature Reserve, Hong Kong (China)

The Mai Po Nature Reserve in the border area between Hong Kong and Mainland China is the most important in Hong Kong and a significant one on the national level. It is however under threat due to the increasing openness of this border. In view of this, any efforts to reassure the position of nature conservation need to be based on systematic surveys and assessments of the habitats under consideration. In this study, the habitat types of the reserve are described and assessed with regard to nature conservation and future development. Vegetation structure, plant species composition as well as land-use types and management practices are taken into consideration. Thus, six habitat types, i.e. brackish and fresh water habitats, mangroves, reeds, grass, and tree dominated habitats are distinguished. It is revealed, that natural as well as anthropogenic habitats contribute to the diversity of the Mai Po Nature Reserve. On the basis of this survey, a habitat map is worked out, which is a necessary tool for practical purposes (e.g. management plan). From the assessment of the habitats' naturalness, diversity, and peculiarity the value of the Mai Po Nature Reserve with regard to nature conservation and cultural history is pointed out and suggestions are made for a comprehensive conservation policy.

Schlüsselwörter:

Anthropogener Einfluss, Biotopschutz, Landnutzungstypen, Naturschutzmanagement, nicht-einheimische Arten, shrimp farming

Zusammenfassung: Biotoperfassung, -kartierung und -bewertung im Mai Po Nature Reserve in Hong Kong (China)

Das *Mai Po Nature Reserve* im Grenzbereich zwischen Hong Kong und Festland-China ist das bedeutendste Naturschutzgebiet in Hong Kong und darüber hinaus auch auf nationaler Ebene herausragend. Eine Gefährdung liegt insbesondere durch die Öffnung der Grenzregion vor. Um Naturschutzziele für dieses Gebiet effektiv umsetzen zu können, ist eine systematische Erfassung und Bewertung der Lebensraumtypen (Biotope) notwendig. Wir stellen hier eine Erfassung und Beschreibung der wichtigsten Biotoptypen im *Mai Po Nature Reserve* als Grundlage für den Naturschutz und die zukünftige Entwicklung vor. Vegetation bzw. Vegetationsstruktur, Landnutzungstypen mit der entsprechenden Managementpraxis und Artenzusammensetzung werden hierbei berücksichtigt. Es werden 6 Biotoptypen differenziert, und zwar Brack- (1) und Süßwasserlebensräume (2), Mangrovenwälder (3), Röhrichte (4) und von Gräsern (5) bzw. Bäumen dominierte Biotope (6). Es wird aufgezeigt, dass sowohl die natürlichen als auch die anthropogenen Lebensräume einen wichtigen Beitrag zur Biodiversität im *Mai Po Nature Reserve* leisten. Auf dieser Grundlage wurde eine Biotopkarte erstellt, die ein wichtiges Instrument für die Naturschutz- und Landnutzungspraxis (z.B. Managementplan) bildet. Anhand der Kriterien Natürlichkeit, Vielfalt und Eigenart des *Mai Po Nature Reserve* wird die Bedeutung des Gebietes im Hinblick auf den Natur- und Kulturlandschaftsschutz hervorgehoben. Zudem werden Vorschläge für eine umfassende Naturschutzstrategie unterbreitet.

1 Introduction

One of the first and crucial steps along the process of nature conservation or ecosystem restoration is a survey and assessment of the habitats under consideration (KAULE 1991, USHER & ERZ 1994). In Europe, there is a long tradition of habitat (= biotope) mapping and assessment. Selective and comprehensive habitat surveys and mappings of rural landscapes (e.g. KAULE et al. 1979, OTTE & LUDWIG 1990) as well as of habitats within settlements and urban-industrial sites (SCHULTE & SUKOPP 2000) can build on a well-designed methodology and theoretical background (KAULE 1991, SCHULTE et al. 1993).

Whereas in Europe a large amount of habitat data has been gathered serving as a strong basis for active species and habitat protection, there often is a lack of habitat surveys, which include an assessment, in Asian countries. However, much has been done in recent years to fill this gap. Thus, e.g. in Korea habitats of the rural landscape (ZERBE & LEE 2000, KIM 2001) as well as of large cities (SEOUL CITY 2000) have been investigated in order to provide sound ecological information for the practical purposes of nature conservation and landscape planning (see also MÜLLER & FUJIWARA 1998 for Yokohama City, Japan). In Hong Kong, besides a 1:50,000 broad overview vegetation map (WWF HONG KONG 1993) occasional species-level surveys have been undertaken, mainly by students of The University of Hong Kong's Ecology and Biodiversity Department (e.g. WONG 1999) or in the context of environmental impact assessments.

In this study, habitats of the Mai Po Nature Reserve at the northern fringe of Hong Kong were investigated and assessed, in view of the necessity of creating a broad ecological and nature conservation information basis. The Mai Po area is essentially an anthropogenic environment, created in the 1940s through the construction of *gei wai*, which are traditional shallow shrimp farming ponds (MELVILLE & MORTON 1982). Much of the original mangroves were destroyed at that time. However, new and diverse habitats have developed in and around the *gei wai,* and the mangrove forest continues to thrive outside the fence marking the limits of the closed border area with China. Due to its large open water surfaces, the reserve and its surroundings attract numerous water birds, of which some species are threatened

(YOUNG 1999). It has therefore been designated a 'wetland of international importance' according to the Ramsar Convention (registered in 1995). Today's management of Mai Po by WWF Hong Kong focuses on maintaining a sanctuary for birds and conserving the open character of the area.

The major objective of this analysis is a survey and qualitative assessment of the different habitats, which partly are near-natural and partly are strongly changed by human impact. Vegetation structure, plant species composition as well as land-use types and management practices were taken into consideration. On the basis of this survey, a habitat map is worked out, which is a necessary tool for practical purposes (e.g. management plan). From the assessment of the habitats' naturalness, diversity, and peculiarity, the value of the Mai Po Nature Reserve with regard to nature conservation and cultural history is pointed out.

2 Study area

Hong Kong (22 °N, 114 °E) is situated on the northern margin of the Asian tropics. The climate is subtropical monsoon, thus both rainfall and temperature are highly seasonal. During the summer months, the climate is hot and humid with winds from the south and southeast, a maximum mean daily temperature of 31 °C and a relative humidity of more than 80 %. Winter is cool and dry (more or less temperate) with continental winds from the north and northeast and a minimum mean daily temperature of 12-13 °C. The mean annual total rainfall is 1,529 mm (data referring to Lau Fau Shan, near Mai Po; NG & CHAN 1999). Subtropical evergreen broad-leaved forest is considered the natural climax vegetation of Hong Kong (DUDGEON & CORLETT 1994, 2004).

The Mai Po Nature Reserve is situated in the northwest of Hong Kong's mainland (The New Territories), which borders the Shenzhen Special Economic Zone of Guangdong Province (China), and covers an area of lowlands on the eastern shore of Deep Bay (Fig. 1). The Deep Bay (Mainland Chinese name: Shenzhen Bay) is part of the Pearl River system, which has a catchment area of about 450,000 km^2 (IRVING & MORTON 1988). The bay has an average depth of 3 m and is nowhere deeper than 6 m. The maximum tidal range is around 2.8 m, and at low tide a vast mudflat is exposed. During the last glacial period, sea level was more than 100 m lower than today. A larger part of Hong Kong’s land lay above sea level and the Mai Po area was situated further inland. With the beginning of the Holocene, the sea level raised until about 6,000 years ago, when it reached its present level. A large part of the land was submerged, bringing the coastline inland.

Since then, the shoreline spread again towards the sea as a result of the deposition of silt in the bay. Today the process of shoreline accretion has a strong influence on the Deep Bay. The actual siltation rate is disputed (WAI & LUK 2001), but it is the highest along the Hong Kong coast and is obviously increasing in recent years (WILLIAMS 2004). Rivers and streams flowing into the bay, such as the Shenzhen River and the Yuen Long Creek, carry growing quantities of sediments, which deposit in the basin of the bay. Human activities accelerate the siltation process e.g. by large scale clearing of hillside forests. The shallow bay provides suitable growth conditions to mangroves. Whether they rather follow or encourage sedimentation (or both) is not immediately clear.

The alluvial and colluvial material of the soils around Mai Po is mainly derived from rocks of the Lok Ma Chau formation, consisting of metamorphosed siltstone, fine-grained sandstone and carbonaceous siltstone, but are also affected by porphyr and clay marine sediments. As the ground is often waterlogged, soils have a high salinity (YOUNG 2000).

Active land reclamation in the Mai Po area through the drainage of coastal swamps also has had a great impact on the landscape. The original habitats were converted to farmland or fish ponds. Today the lowlands of the New Territories represent attractive real estate for urban

and suburban expansion (see DUDGEON & CORLETT 1994, ZHUANG & CORLETT 1997, BREITUNG 2001, DUDGEON & CORLETT 2004 for landscape history of Hong Kong).

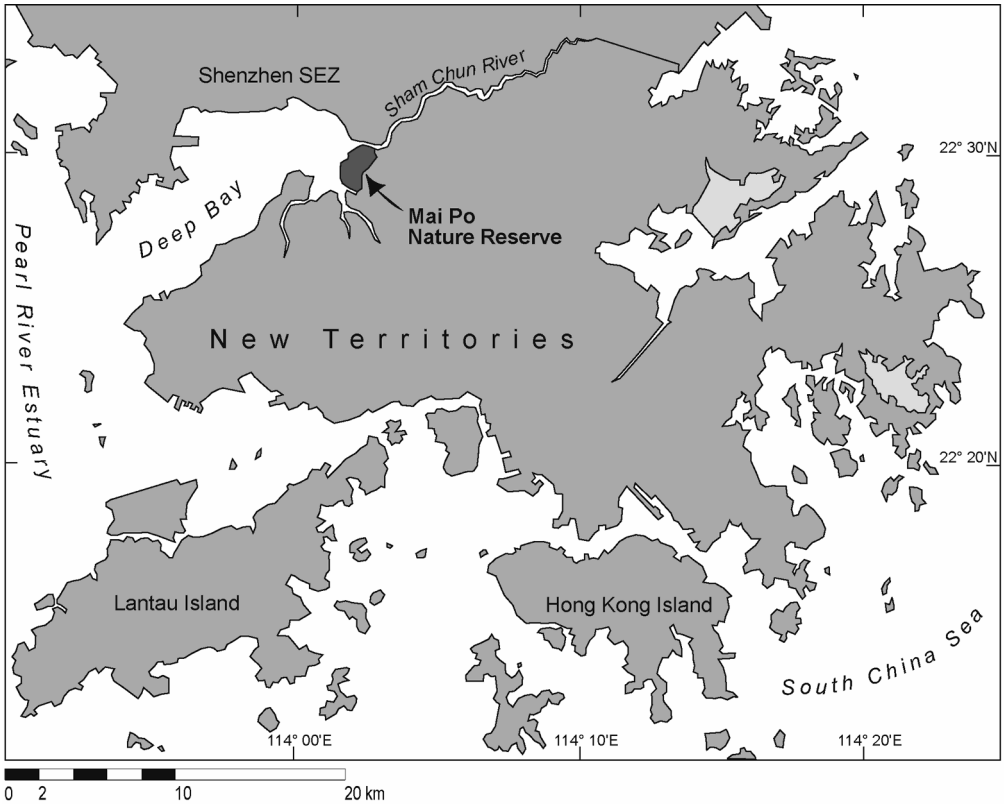

Fig. 1 Location of the Mai Po Nature Reserve northwest of The New Territories of Hong Kong, China. (based on BREITUNG 2001, DUKE & KHAN 1999, modified).

Abb. 1 Lage des Mai Po Nature Reserve im Nordwesten der New Territories von Hong Kong, China. (verändert nach BREITUNG 2001, DUKE & KHAN 1999).

Natural vegetation of the coastal lowlands around Mai Po is considered the broad belt of mangroves along the shore of Deep Bay. This coastal forest would most probably reach further inland than today if it had developed without human influence. The area of the Mai Po Nature Reserve would be covered by a dense mangrove forest, which would merge into a lowland forest on the landward side, as none of the factors that can maintain non-forest vegetation in a forest climate are present (YOUNG 1999, CORLETT, 2003, pers. comm.). Today, however, marshland with grasses and sedges also occurs in the back of the mangroves, especially near rivers (LEUNG 1986). ANDERSON (1994) distinguishes five ecological units in the present Deep Bay area: (1) rivers and streams flowing into the bay, (2) mangrove forest along the coast, (3) mudflats in front of the mangroves, (4) oyster beds being created in the mud, and (5) traditional shrimp farming ponds (*gei wai*) at the backside of the mangrove forests.

In the beginning of the 1940s, the mangrove forest at Mai Po was more than 1 km broad (ANDERSON 1994). Growing on sediment eroded from deforested hills and certainly reduced by the cutting of firewood, it had already up to then suffered from at least 1000 years of direct and

indirect human impact (CORLETT 2005, pers. comm.). Since the construction of *gei wai* on the seaward limit of the mangrove habitat in the mid 1940s, the forest has extended about 500 m further towards the bay. Today, the largest mangrove forest can be found in the Mai Po Nature Reserve, Hong Kong (Fig. 1) and the Futian National Nature Reserve on the Chinese coast of the bay (ANDERSON 1994). *Gei wai* were excavated from the original mangrove habitat with the seaward dyke being in line with the seaward edge of the mangroves. A sluice gate in the seaward dyke allows the pond to be flooded with water from the bay at high tide and to be drained at low tide. Each *gei wai* comprises a system of channels and islands, the latter being colonised by reeds and mangroves.

In 1984, the Mai Po Nature Reserve was established, and the World Wide Fund for Nature (WWF) Hong Kong started to manage the site. The main objectives of the management are to increase habitat and species diversity, to provide a sanctuary for birds, to promote the use of the area for educational purposes, and encourage environmental research (YOUNG 1999). In order to protect the nature reserve from negative impact of urbanisation, buffer zones have been designed in 1992 and 1999, which are partially effective.

The area owes its relatively unspoilt character to its location just behind the Hong Kong-Mainland China border fence. However, with the growth of the Shenzhen Special Economic Zone most of the adjacent wetland areas to the North of the border have disappeared, and the development pressure on the Hong Kong side increases rapidly, too (IRVING & MORTON 1988, BREITUNG 2001; and a series of satellite photographs by WILLIAMS, 2004). This context highlights the challenges for nature conservation in Hong Kong's most prominent nature reserve and with it the importance of well founded habitat assessments.

3 Materials and methods

From Oct. 2003 to Jan. 2004, all habitats within the Mai Po Nature Reserve were surveyed to create a mapping key following the recommendations from SCHULTE et al. (1993) for habitat mapping in populated areas. Six main habitat types were differentiated: (1) brackish water, (2) fresh water, (3) mangroves, (4) reeds, (5) grass dominated habitats, and (6) tree dominated habitats. The structure of these habitat types was described. Sampling of flora and vegetation structure was carried out on 2 x 2 m^2 squares in mangrove, reed, and grass habitats and 3 x 3 m^2 squares in tree dominated habitats. The squares were placed along a transect. The number of squares surveyed varied according to the diversity of the habitat and vegetation structure. In stands, which are homogeneous in regard to structure (such as reeds or grass dominated habitats), 6 squares were considered representative, whereas in more heterogeneous habitats, up to 20 squares were investigated. Information on the habitat structure was compiled together with a list of common and/or dominating plant species. Additionally, the following parameters were assessed: percentage cover of the dominating plant species, types of land use, human impact, and the average growth height of the herb, shrub, and tree layers.

On the basis of an existing survey of reed and mangrove habitats (YOUNG 1999), aerial photographs, and own field observations, a digital (ArcView) version of a habitat type map was created. The field survey of the intertidal mangrove forest was based on data collected by DUKE et al. (1993). Nomenclature of the plant species followed the check list of Hong Kong plants by WU et al. (2002).

4 Results

4.1 Description of the habitat types

Brackish Water (1)

Most of the *gei wai* in the reserve are connected to Deep Bay via sluice gates and are inundated regularly throughout the year with brackish water. They are occasionally drained completely at low tide and flushed again at high tide. The original *gei wai* are formed of a system of long channels excavated from the mangroves with a water depth, ranging from 1 to 1.5 m. Some *gei wai* have been partially converted into shallow ponds containing several small islands in order to attract birds. While other *gei wai* are still operated as traditional shrimp ponds, these are managed as bird habitats. Large quantities of silt are washed into the *gei wai* and accumulate inside the ponds, which leads the management to dredge the water channels every 10-12 years.

In the *gei wai* as well as in the ponds, the water's edge is often colonised by the grasses *Brachiaria mutica, Paspalum vaginatum*, and *Phragmites australis*, the latter often tending to expand into open water areas (Table 1). In some areas, which are overgrown by reed, herbicide is applied as a control measure to prevent further silting as sediments accumulate in the vegetation. Other plant species, which commonly occur in the brackish water or its margins are *Acanthus ilicifolius, Aegiceras corniculatum, Kandelia obovata, Scirpus littoralis,* and various *Cyperus* species.

Tab. 1 Species recorded within the habitat assessment with information on their life form (tree, shrub, climber, herb and grass), the habitats, in which they occur at Mai Po, and their origin (native to Hong Kong and non-indigenous with origin in Africa, other parts of Asia, and tropical America and with Pan-tropical origin, respectively).

Tab. 1 Arten, die im Rahmen der Biotoperfassung aufgenommen wurden, mit Informationen zur Lebensform (Baum, Strauch, Kletterpflanze, Krautige und Grasartige), zu den Biotoptypen, in denen sie in Mai Po vorkommen, sowie ihrer Herkunft (in Hong Kong einheimisch oder nicht-einheimisch mit Herkunft aus Afrika, anderen Teilen Asiens oder dem tropischen Amerika bzw. mit pantropischer Verbreitung).

Species	Habitat occurrence	Origin
Trees		
Aegiceras corniculatum	brackish water, mangroves, reeds	native
Avicennia marina	mangroves	native
Bruguiera gymnorrhiza	mangroves	native
Celtis sinensis	tree dominated habitats	native
Cerbera manghas	tree dominated habitats	native
Ficus microcarpa	mangroves, tree dominated habitats	native
Ficus subpisocarpa	mangroves, tree dominated habitats, reeds	native
Heritiera littoralis	tree dominated habitats	native
Hibiscus tiliaceus	tree dominated habitats	native
Kandelia obovata	brackish water, mangroves, reeds	native
Macaranga tanarius	mangroves, reeds, tree dominated habitats	native
Melia azedarach	mangroves, reeds, grass habitats, tree dominated habitats	Asia
Sapium sebiferum	mangroves, reeds, grass habitats, tree dominated habitats	native
Shrubs		
Acanthus ilicifolius	brackish water, mangroves, reeds	native
Ardisia elliptica	mangroves	native
Bridelia tomentosa	mangroves, tree dominated habitats	native
Clerodendrum inerme	mangroves, grass habitats	native

Species	Habitat occurrence	Origin
Lantana camara	grass habitats, tree dominated habitats	America
Pluchea indica	mangroves, reeds	native
Sageretia thea	grass habitats	native
Severinia buxifolia	mangroves	native
Climbers		
Canavalia maritima	mangroves	native
Cocculus orbiculatus	grass habitats	native
Derris trifoliata	mangroves, reeds, tree dominated habitats	native
Ipomoea triloba	grass habitats	trop. Am.
Lygodium flexuosum	mangroves, tree dominated habitats	native
Lygodium japonicum	mangroves, tree dominated habitats	native
Lygodium microphyllum	mangroves, tree dominated habitats	native
Mikania micrantha	mangroves, reeds, grass habitats	trop. Am.
Morinda umbellata	tree dominated habitats	native
Paederia scandens	mangroves, reeds, grass habitats, tree dominated habitats	native
Passiflora foetida	mangroves, reeds, grass habitats	trop. Am.
Woody climber		
Gymnanthera oblonga	mangroves, reeds	native
Herbs		
Acrostichum aureum	mangroves, reeds	native
Althernanthera philoxeroides	fresh water	trop. Am.
Althernanthera sessilis	fresh water, grass habitats	Pantrop.
Bacopa monnieri	fresh water	Pantrop.
Bidens alba	grass habitats, tree dominated habitats	trop. Am.
Ceratopteris thalictroides	fresh water	native
Colocasia esculenta	fresh water	SE Asia
Eclipta prostrata	grass habitats	native
Ludwigia adscendens	fresh water	native
Nymphaea spec.	fresh water	exotic
Wedelia trilobata	fresh water, grass habitats	trop. Am.
Grasses		
Brachiaria mutica	brackish water, fresh water, reeds, grass habitats	Africa
Cyperus div. spec.	brackish water, fresh water, grass habitats	native
Digitaria microbachne	grass habitats	native
Echinochloa crus-galli	fresh water	Pantrop.
Eleocharis dulcis	fresh water	Asia
Panicum maximum	grass habitats, tree dominated habitats	Africa
Panicum repens	fresh water, grass habitats	Pantrop.
Paspalum conjugatum	fresh water, grass habitats	trop. Am.
Paspalum vaginatum	brackish water, fresh water, mangroves, reeds, grass habitats, tree dominated habitats	native
Phragmites karka	grass habitats	native
Phragmites australis	brackish water, fresh water, mangroves, reeds, grass habitats	native
Scirpus littoralis	brackish water, fresh water, reeds	native

Fresh water (2)

Fresh water ponds in the southern part of the reserve were previously utilised as fish ponds and are fed by rainwater or connected to residential wastewater canals. Most of the banks of these fresh water ponds are covered with grass vegetation, which extends into shallow water areas, often forming a fringe of floating vegetation. Among the common species are *Brachiaria mutica*, *Panicum repens, Paspalum vaginatum, P. conjugatum, Phragmites australis*, and *Scirpus littoralis*. Additionally, the species *Althernanthera philoxeroides*, *A. sessilis*, *Bacopa*

monnieri, *Ceratopteris thalictroides*, *Colocasia esculenta*, *Cyperus* div. spec., *Echinochloa crus-galli*, *Eleocharis dulcis*, *Ludwigia adscendens*, *Nymphaea* spec., and *Wedelia trilobata* were recorded.

In some ponds, *Phragmites australis* forms dense populations. Also, in the fresh water habitats, herbicide is applied to prevent the expansion of the vegetation. The rain-fed ponds in Mai Po provide habitats for bird roosting, in particular for ducks.

Mangroves (3)

Mangrove trees are growing as single specimens in some of the *gei wai* and form an intertidal mangrove forest, which stretches outside the border fence towards the mudflat on the shore of Deep Bay. Mangrove habitats are characterised by brackish water conditions with fluctuating salinity, periodically wet and dry, alternating aerobic and anaerobic soil environments as well as finely particulate, unstable substrata (ANDERSON 1994, TAM & WONG 2000a and b). A distinctive character of a mangrove community is its relatively low plant diversity (TOMLINSON 1994). The term "mangrove" is commonly used for the mangrove plant species whereas the term "mangal", as proposed by MACNAE (1968), describes the community and the environment (TOMLINSON 1994).

Kandelia obovata is the dominant tree species in the Mai Po wetlands. In these stands, *Aegiceras corniculatus* and *Acanthus ilicifolius* form the lower tree and the shrub layer. Other common species in these mangrove habitats are *Acrostichum aureum, Avicennia marina*, and *Bruguiera gymnorrhiza*. *Avicennia marina* forms populations with relatively high densities in some areas of the *gei wai* and it even represents the dominant tree species in one central area of the intertidal mangrove fringe. *Bruguiera gymnorrhiza* occurs less frequently, with only a few isolated individuals growing among larger *Kandelia* stands. According to TOMLINSON (1994), mangal associate plant species include *Ardisia elliptica, Canavalia maritima*, *Cerbera manghas, Clerodendrum inerme, Derris trifoliata, Gymnanthera oblonga, Heritiera littoralis, Hibiscus tiliaceus, Pluchea indica,* and *Severinia buxifolia.* Transitional elements are *Bridelia tomentosa, Ficus microcarpa, F. subpisocarpa, Lygodium flexuosum, L. japonicum, L. microphyllum, Macaranga tanarius, Melia azedarach, Mikania micrantha*, *Paederia scandens, Paspalum vaginatum, Passiflora foetida, Phragmites australis, P. karka,* and *Sapium sebiferum* (Table 1).

The average height of the mangrove stands is around 4 m, in some areas the trees grow up to 6 m. The mangrove forest along the coast, which is more than 500 m wide, is influenced by natural tides whereas the *gei wai* mangroves depend on the flushing and draining of the ponds through the operation of the sluice gates. Ranging inland, the mangroves grow taller and the species diversity increases. In some landward mangrove stands inside the *gei wai*, the vines *Paederia scandens* and *Gymnanthera oblonga* are forming dense covers.

Reeds (4)

From the late 1970s onward, the expansion of reeds with *Phragmites australis* was encouraged by human activities at Mai Po (IRVING & MORTON 1988, LEE 1993). Today, reeds are growing inside the *gei wai* channels (HUNG 1995, 1997), along the water's edge of most ponds and in patches in shallow water. Areas hosting reeds range from moist sites to open waters up to 2 m in depth. The ecological range of *Phragmites australis* reaches from fresh to brackish water with stem heights of 1-3 m.

Silt and leaf litter accumulate between the reed stems and can lead to silting up of the open water. This silting process leads to a change in the species composition of the reed bed itself. As conditions become more dry, trees and shrubs, climbers (in particular *Paederia scandens* and *Gymnanthera oblonga*), herbs and other grasses invade the habitat. Ponds and channels can silt up completely within a couple of years. Ponds, which are connected to Deep

Bay via sluice gates can also be influenced by waste and silt deposition as well as polluted water.

As part of the *gei wai* management, water levels are sought to be kept in the range of 1-1.5 m in order to regulate the growth of reeds inside the ponds. Mud and reed rhizomes are dug from the channels around the edges and deposited on the dykes, thereby influencing the growth of the dyke vegetation. Additionally, herbicide is applied. Larger reed beds are occasionally cleared of climbers and tree seedlings.

In addition to some nearly mono-specific *Phragmites* stands, other reed habitats are interspersed with the mangrove trees *Aegiceras corniculatum* and *Kandelia obovata*, the shrub *Acanthus ilicifolius*, the woody species *Ficus subpisocarpa*, *Macaranga tanarius*, *Melia azedarach*, *Pluchea indica*, and *Sapium sebiferum*, the climbers *Derris trifoliata*, *Gymnanthera oblonga*, *Mikania micrantha*, *Paederia scandens*, and *Passiflora foetida*, and the herb species *Acrostichum aureum*, *Brachiaria mutica*, *Paspalum vaginatum*, and *Scirpus littoralis*.

According to the percentage cover of other species, which accompany *Phragmites australis* in the reed habitat, three vegetation types can be distinguished:

1. *Phragmites australis* predominant with up to 5 % other species in the plant cover: When water levels in the ponds are kept high (over 1 m) throughout the year only a few other species, such as *Gymnanthera oblonga*, *Paederia scandens,* and *Paspalum vaginatum* can be found in these reed stands.
2. Reed interspersed with up to 25 % other species: Reeds grow intermingled with mangroves, trees, or a mixture of both. Climbers often occur along with trees.
3. Fragmented reed vegetation with more than 25 % other species comprising the vegetation: The reed bed is fragmented through stands of mangroves, trees, grasses, or a mixture of vegetation. The cover percentage of climbers, mainly *Paederia scandens* and *Gymnanthera oblonga,* is very high.

Grass dominated habitats (5)

Most grass-dominated habitats at Mai Po are linear structures, which are found along dykes between the *gei wai*, at the banks of fresh water ponds, and along roads and walkways. Beside paths and on dykes dryer site conditions prevail. Additionally, grass-dominated habitats characterised by moist to wet site conditions occur adjacent to the reserve's fresh water ponds. These habitats are kept in an open state devoid of woody species through regular mowing. Grasses are usually the main constituents of the vegetation with a percentage cover between 60 and 90, but other herbaceous species also commonly occur.

With regard to the different site conditions, i.e. wetness, frequency of cutting, and the species composition of neighbouring habitats, different types of grassland can be distinguished. The vegetation around fresh water ponds is usually characterised by 1-3 dominating grass species, e.g. *Brachiaria mutica, Panicum repens*, or *Paspalum vaginatum*. These grasses cover about 90 % of a 2-3 m broad fringe along the water edge. Additionally, a number of moisture tolerant herbaceous species such as *Althernanthera sessilis, Cyperus* div. spec.*, Eclipta prostrata*, and *Wedelia trilobata* can be found, these having very low ground cover percentages.

Some dykes, which are mown less frequently, have a more diverse species composition. The grass cover percentage here is around 40 %, single specimens of tall trees are growing here and there as well as shrubs and a number of climbers and herbaceous species, among them *Bidens alba*, *Clerodendrum inerme*, *Lantana camara*, *Cocculus orbiculatus*, *Melia azedarach, Paederia scandens*, *Passiflora foetida, Sageretia thea*, and *Sapium sebiferum* (Table 1).

Along several dykes and footpaths, climbers such as *Ipomoea triloba*, *Mikania micrantha, Paederia scandens* or *Passiflora foetida* can reach high cover values. However, grasses are

still forming patches with high densities. The annual *Bidens alba* is another characteristic element of the habitat. This vegetation develops in particular along the sides of the dykes where mud, which was previously (1-2 years ago) dug from the *gei wai* channels, has been dumped. It can be observed that frequent mowing along the dykes seems to stimulate the growth of certain species, in particular *Mikania micrantha*.

Dykes adjacent to fresh water ponds and between some *gei wai* are mown up to four times per year, from spring to autumn, in order to maintain the open landscape which is attractive to water birds. Other areas are mown only occasionally or cleared of climbers and tree seedlings. Herbicide is occasionally applied to prevent the spread of certain species, such as *Brachiaria mutica, Mikania micrantha*, *Paspalum vaginatum*, and *Phragmites australis.* Without any management, these habitats would develop to shrub and tree dominated habitats in the course of natural succession.

Tree dominated habitats (6)

Habitats at Mai Po, which are dominated by trees, are mostly found as linear structures along dykes between the *gei wai*, along paths and beside the perimeter road. Most of the trees along the paths and the road have been planted whereas the tree dominated habitats along many of the dykes between and inside the *gei wai* have developed more or less spontaneously. There are also two small forest areas, one of which has developed naturally, the other has been planted. Among the native tree species *Celtis sinensi*s, *Ficus microcarpa*, *F. subpisocarpa, Macaranga tanarius*, and *Sapium sebiferum* commonly occur, growing wild and in planted formations. Seedlings of these species can be found in almost every other habitat at Mai Po. Additionally, single specimens of other native tree species such as *Cerbera manghas*, *Heritiera littoralis*, and *Hibiscus tiliaceus* have been planted. The most common tree in Mai Po, however, is *Melia azedarach*, native to China but not to Hong Kong (Table 1). This species has been planted along paths but well-developed individuals of varying ages can be found on most dykes and in all habitats where soil conditions are not too moist. The tree stands in general are characterised by a diverse undergrowth with a large percentage of climbing species, e.g. *Derris trifoliata*, *Lygodium microphyllum*, *Morinda umbellata*, and *Paederia scandens*. Shrubs such as *Bridelia tomentosa* and *Lantana camara* and herbs like *Bidens alba, Panicum maximum,* and *Paspalum vaginatum* are also quite common.

Along paths and the perimeter road, the understory of the tree stands is regularly mown, whereas on inaccessible dykes the climbers and tree seedlings are only occasionally removed. Some trees are trimmed from time to time in order to maintain an open landscape around bird roosting sites. During the winter months, thousands of cormorants congregate in the trees along several dykes, turning trees and the ground underneath white with their deposited droppings. The trees lose their leaves earlier than they normally would and the soil in such areas takes up large quantities of nutrients.

In Fig. 2, three transects document the structure and variety of the near-natural and anthropogenic habitats at Mai Po. The profile of a dyke dominated by trees (Fig. 2-1), a near-natural mangrove stand (Fig. 2-2) and a deteriorated mangrove habitat (Fig. 2-3) are presented.

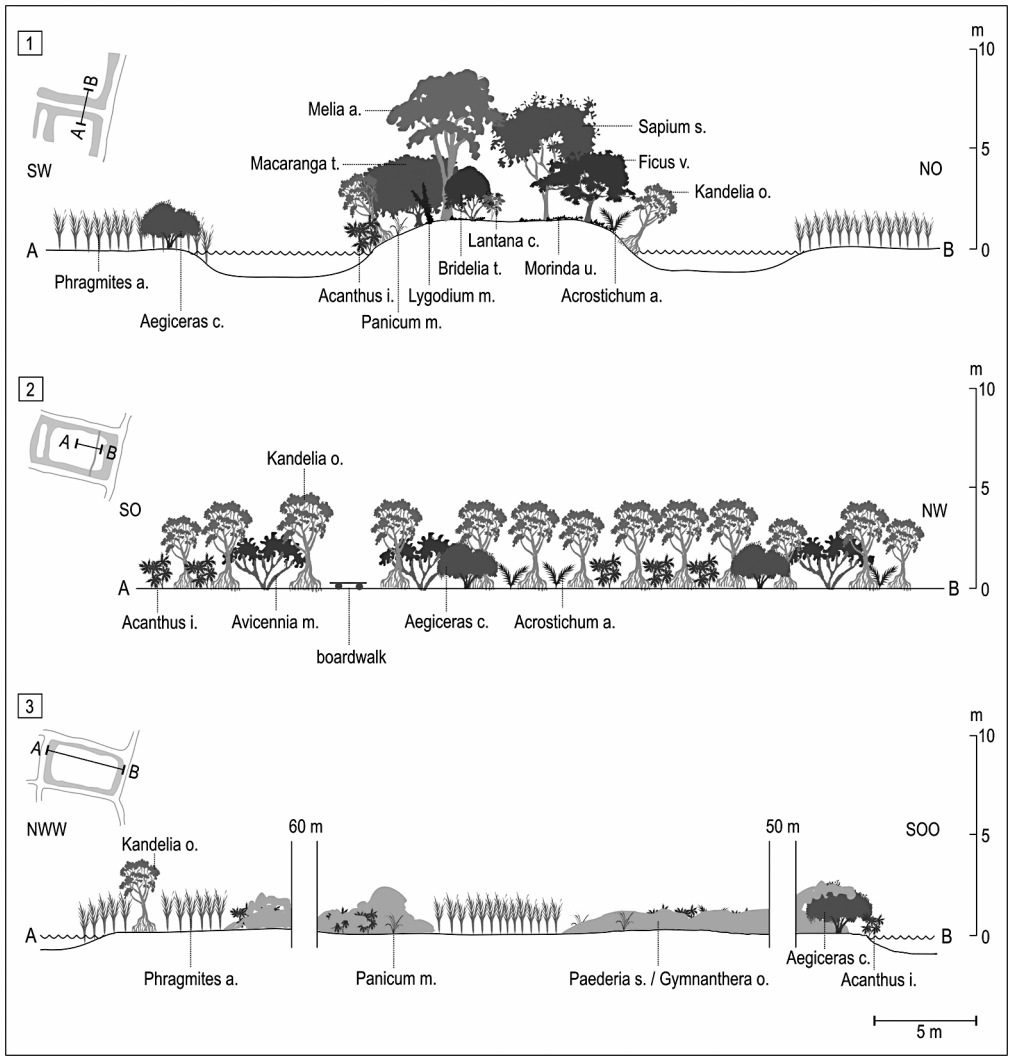

Fig. 2 (1) A profile of a dyke between two *gei wai*. Here, the habitat is dominated by trees and shrubs. (2) Transect through a near-natural mangrove stand on the landward end inside a *gei wai*, and (3) transect showing a deteriorated mangrove habitat on the landward end inside a former *gei wai*; for the location see Fig. 3; for full botanical names see Table 1.

Abb. 2 (1) Schematisiertes Profil durch einen Damm zwischen zwei *Gei wai* (Gräben). Dieser Lebensraum wird durch Bäume und Sträucher geprägt. (2) Transekt durch einen naturnahen Mangrovenbestand am landwärtigen Ende innerhalb eines *Gei wai* und (3) Transekt, das ein degradiertes Mangrovenhabitat am landwärtigen Ende innerhalb eines ehemaligen *Gei wai* zeigt; ihre Lage im Gebiet ist aus Fig. 3 zu ersehen; die vollständigen botanischen Namen sind in Table 1 zu finden.

4.2 Habitat map of the Mai Po Nature Reserve

The map of the habitat types (Fig. 3) reflects the diverse habitat structure of Mai Po with open waters, reeds, grass dominated vegetation, and shrub and tree dominated habitats. Noteworthy are the high proportion of near-natural mangroves along the coastline and the many open water habitats, which are typical elements of the Nature Reserve's landscape.

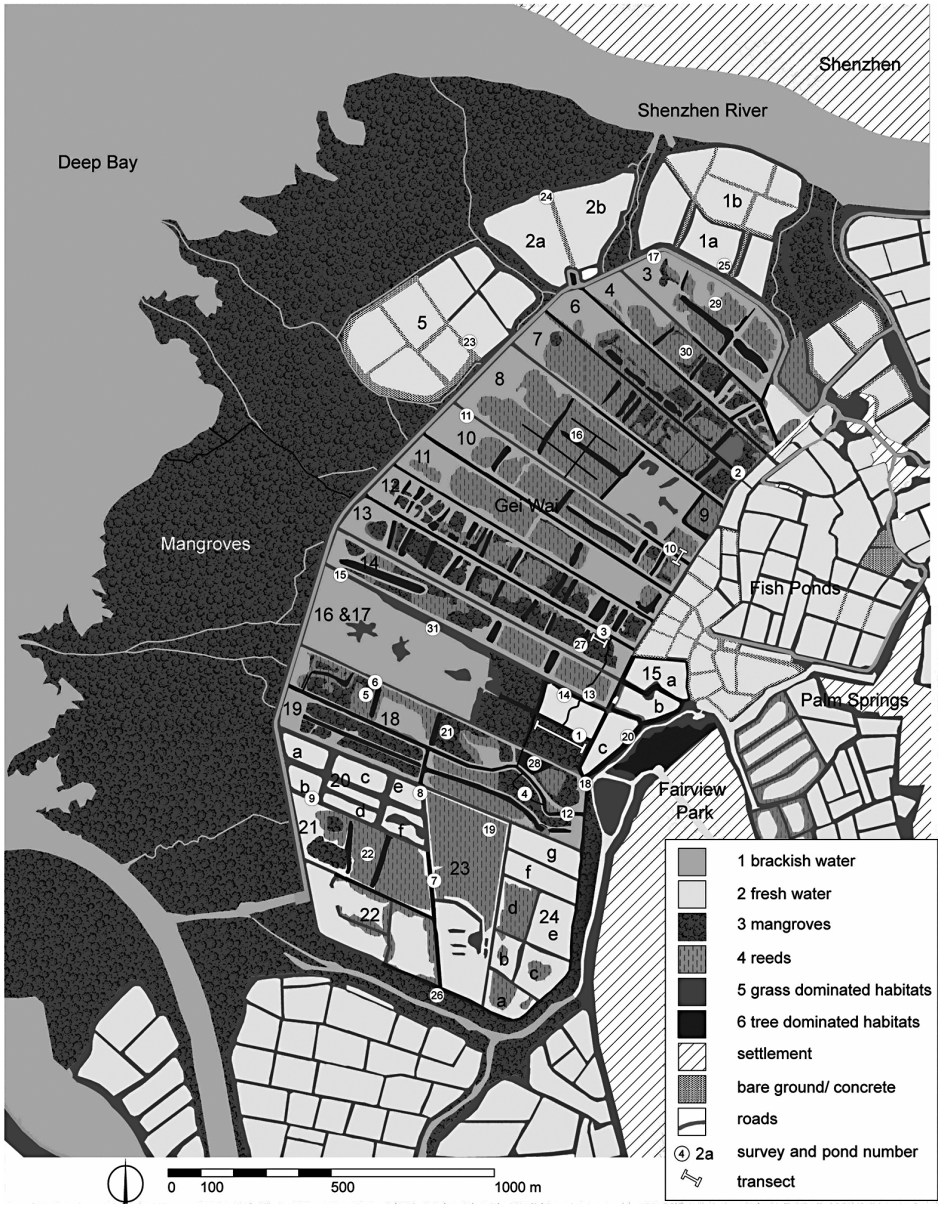

Fig. 3 Habitat map of the Mai Po Nature Reserve.

Abb. 3 Biotoptypenkarte des Mai Po Nature Reserve.

5 Assessing the habitat value

The Mai Po Nature Reserve has a high value for nature conservation, environmental education, the (sub-)urban environment, and as cultural heritage. Conservation efforts have to strike a balance between various matters of protection, such as the landscape, traditional land-use forms, the mangrove ecosystem, and the attractiveness for birds and bird watchers. The named objectives are of course interrelated, but they are not identical. The presence of birds clashes with the interests of the traditional fish farmers, attempts to maintain an attractive landscape compromise the naturalness of habitats, and the regeneration of mangrove habitats infringes on the open space desired by birds and bird watchers. Such intra-conservation conflicts are aggravated by the small size of the nature reserve and urbanisation processes in adjacent areas.

With the designation of the Mai Po Marshes as a Ramsar site, ornithologic interests naturally moved into the main focus of the reserve management. The people and institutions involved are however aware of the wider scope of their purpose. That is why our fieldwork (as well as similar efforts by other researchers) was warmly welcome and crucially supported. A thorough assessment of existing vegetation habitats and its value may help to fine-tune conservation policies and defend conservation interests against competing urban planning objectives.

According to USHER & ERZ (1994), diversity, naturalness, and peculiarity are considered to be important criteria for the assessment of habitats. We shall apply these three criteria on our case.

Although the Mai Po Nature Reserve covers a relatively small area of about 400 ha, it provides a diverse habitat structure and network for numerous plant and animal species (IRVING & MORTON 1988, REELS 1994, YOUNG 1999). On a small space, there are wet and dry habitats, those based on fresh water and on brackish water, and a range from open to tree dominated habitats, with different degrees of accessibility. This diversity is the result of intentional and unintentional human influence. Former land-use practices, as well as the nature reserve management and the consequences of the introduction and establishment of exotic species have all had a strong influence on the habitat composition and structure. Human activities during previous decades have thus created a set of unique habitats. This is typical for intensively utilised landscapes throughout the world (JEDICKE & JEDICKE 1992, KIM 2001). Reeds, for example, are not considered indigenous vegetation at Mai Po. However today, reed habitats are of considerable value in particular for many birds. Additionally, the dyke habitats attract a large quantity of butterflies (YOUNG 1999).

In terms of naturalness, it therefore has to be stated that only the intertidal mangrove forest with its dense tree stands are at least near-natural and represent a habitat which is typical for coastal mud flats in the tropics and sub-tropics (TOMLINSON 1994). All other habitat types in the Mai Po Nature Reserve are the consequence of land-use and management practices. A habitat state is maintained which is significantly removed from the natural state of the environment. The varying habitats at Mai Po are influenced actively by WWF management practice. Through the operation of the sluice gates, water levels inside most of the ponds are strictly controlled. Regular mowing along paths and other linear structures is carried out to prevent the growth of trees and expansive plant populations, since in particular the vegetation on the relatively dry dykes is invaded by exotic species such as the rapidly expanding climber *Mikania micrantha,* by *Bidens alba* and *Ipomoea triloba* (Table 1). It is however obvious that there is a strong relation between the intensity of disturbance, e.g. through mowing or the deposition of dredged material, and the establishment and spread of exotic species. This relationship has been revealed on many anthropogenous habitats (MOONEY & DRAKE 1989, MCINTYRE & LAVOREL 1994, DEUTSCHEWITZ et al. 2003, ZERBE et al. 2004, ZHANG et al. 2004). The expansion of *Mikania micrantha* and *Ipomoea triloba* seems to be limited by the wetness

of the site and in conclusion, none of the observed exotic species at Mai Po appear to cause real problems with regard to nature conservation objectives. Their management can be considered moderately successful up to now. CORLETT (1999) points out that, within ecological restoration of habitats, exotic species might be considered useful to a certain degree, at least on more degraded sites.

The peculiarity of the site has a local and a regional dimension. For Hong Kong, the North West New Territories are the largest piece of flat land which is not yet fully urbanised, and the Mai Po intertidal mangrove forest is the largest contiguous remnant of mangal habitats in Hong Kong. The *gei wai* at Mai Po represent the last remaining ones in Hong Kong and are maintained for their cultural and educational value as a form of extensive aquaculture, which was once common in South China. The peculiarity of Mai Po is thus derived from both its natural character (e.g. mangrove forest) and its cultural history (CHEUNG 2004; comp. ZERBE & LEE 2000 for rural settlements in Korea). It is an example of an anomaly created by the barrier function of a political border. Because of the particular historical and spatial constellation in colonial Hong Kong, there is now the chance to conserve a unique natural and cultural treasure. On the regional scale, many wetlands throughout South China are progressively vanishing due to the rapid industrial and agricultural development. Consequently, the remaining wet habitats such as the Mai Po Nature Reserve become even more important e.g. as a habitat for migratory birds and as one of the last examples of sub-tropical low-stem mangal ecosystems in China. Beside this ecological importance, the Mai Po Nature Reserve is significant on the national scale as a benchmark and training ground for reserve managers in China. The WWF Hong Kong at Mai Po plays an important role in advising practitioners and spreading more sophisticated concepts of conservation throughout the country.

6 Implications for habitat conservation

A striking 40 % of the Hong Kong territory enjoys some protected area (mostly country park) status. These are however mainly dry and grass dominated hilly areas, which are not the most valuable in terms of biodiversity. Therefore CORLETT (2004) points to the importance of conservation policies targeting the lowland areas. As a large contiguous landscape with open waters, mangroves, and other diverse habitats, which provide a living space for a large number of organisms, the Mai Po area plays a crucial role. Top priorities in its protection should be the integration of conservation and sustainable land use and the development of a comprehensive strategy (e.g. YOUNG 1999), which balances commercial, cultural, and environmental concerns and covers a wider region.

Although the Mai Po Nature Reserve has a protected status within its boundaries, it is not an island. Its ecosystems and populations of plants and animals are vulnerable to the deterioration of the surrounding wetlands as well as to residential and industrial pollution. The land-use pressure from urban, industrial, and residential development is steadily increasing. The surrounding wetlands become fragmented due to the filling of fish ponds for use as container storage, land reclamation, and urban sprawl. This trend will accelerate with the gradual increase in openness of the Hong Kong-Mainland China border (BREITUNG 2002). Furthermore, water pollution from the Pearl River, Shenzhen River, and some smaller streams, in particular from industrial and agricultural waste discharge, livestock farming, and the deposition of contaminated earth obtained from dredging has a negative impact on the flora and fauna of the whole Deep Bay area.

The need to minimise such exterior influences has led to the designation of buffer zones, which was a step into the right direction. It is now necessary to extend active management approaches into these buffer zones to strengthen their protective capacity. The ponds and dykes in these zones should be managed from an ecological rather than just economic perspective in order to enhance their value as habitats. This would in turn allow the nature

reserve management to convert more habitats inside the reserve to near-natural status, thus addressing concerns about too extensive management intervention in the reserve. A further relief for the Mai Po Nature Reserve will be the opening of a Wetland Park in the buffer zone, which shall divert a significant amount of visitor traffic from the core area. While most of the buffer zones should remain as open space, predominantly used for fish farming, some part, preferably towards existing residential developments, should be allowed to grow as a near-natural shrub and woodland. This would more effectively protect the nature reserve, enhance the biodiversity and provide the chance to study the presumed "natural" lowland vegetation in Hong Kong, including the succession from mangrove to dry woodlands.

The ambition would be to create a larger area under protection, for example south and southwest of the nature reserve as well as along the Shenzhen River northeast of Mai Po, with a different degree of naturalness in different zones. If this is the aim, it needs to be done soon, since the historical window of opportunity afforded by the Hong Kong-Mainland China border has already begun to close. While the diminished barrier function of the border is clearly a challenge, it is on the other hand only now that a broader conservation area could be conceived as a cross-border project comprising the Deep Bay and Shenzhen's Futian Nature Reserve as well.

Acknowledgements

We are indebted to the Mai Po administration, the Agriculture, Fisheries, and Conservation Department (AFCD), and to WWF Hong Kong. For their help in identifying plant species, we would like to thank Laura Wong, Dr. Sai Chit Ng, and Prof. Dr. R.T. Corlett. Special thanks to John Alcock for his patience and support. Many thanks also to Wilfrid Roloff for assisting with the graphics. Also, we would like to thank Prof. Dr. R.T. Corlett (University of Hong Kong) for his fruitful comments on the manuscript.

References

ANDERSON, C. (1994): The production ecology of the mangroves at the Mai Po Marshes Nature Reserve, Hong Kong. – Ph.D. thesis, University of Hong Kong, Hong Kong: pp. 157.

BREITUNG, W. (2001): Hongkong und der Integrationsprozess. Räumliche Strukturen und planerische Konzepte. – Basler Beiträge zur Geographie **48**: 1-228.

BREITUNG, W. (2002): Transformation of a boundary regime: the Hong Kong and Mainland China case. – Environment and Planning A **34**: 1749-1762.

CHEUNG, S. (2004): Keeping the wetlands wet: How to integrate natural and cultural heritage preservation. – Museum International **56**(3): 29-37.

CORLETT, R.T. (1999): Environmental forestry in Hong Kong: 1871-1997. – Forest Ecology and Management **116**: 93-105.

CORLETT, R.T. (2004): Sustainability and biodiversity conservation in Hong Kong. – In: MOTTERSHEAD, T. (ed.): Sustainable Development in Hong Kong: 421-444; Hong Kong (Hong Kong University Press).

DEUTSCHEWITZ, K., LAUSCH, A., KÜHN, I., KLOTZ, S. (2003): Native and alien plant species richness in relation to spatial heterogeneity on a regional scale in Germany. – Global Ecology & Biogeography **12**: 299-311.

DUDGEON, D., CORLETT, R.T. (1994): Hills and streams: an ecology of Hong Kong: Hong Kong (Hong Kong University Press): pp. 234.

DUDGEON, D., CORLETT, R.T. (2004): The Ecology and Biodiversity of Hong Kong: Hong Kong (Joint Publishing and Friends of the Country Parks): pp. 336.

DUKE, N.C., KHAN, M.A. (1993): Structure and composition of the seaward mangrove forest at the Mai Po Marshes Nature Reserve, Hong Kong. – In: LEE, S.Y. (ed.): The mangrove

ecosystem of Deep Bay and the Mai Po Marshes, Hong Kong: 83-104; Hong Kong (Hong Kong University Press).

HUNG, L.W. (1995): Distribution and Structure of Reedbeds Community in Gei Wai 14 of Mai Po Marshes. – B.Sc.(Hons) report, City University of Hong Kong, Hong Kong: pp. 45.

HUNG, L.W. (1997): Ecological value of Reedbeds (*Phragmites australis*) at Mai Po Marshes Nature Reserve. – M.Phil. thesis, City University of Hong Kong, Hong Kong: pp. 155.

IRVING, R.T.A., MORTON, B.S. (1988): A geography of the Mai Po Marshes. – Hong Kong (WWF Hong Kong): pp. 58.

JEDICKE, L., JEDICKE, E. (1992): Farbatlas Landschaften und Biotope Deutschlands. – Stuttgart (Ulmer): pp. 320.

KAULE, G. (1991): Arten- und Biotopschutz, 2nd ed. Stuttgart (Ulmer): pp. 519.

KAULE, G., SCHALLER, J., SCHOBER, M. (1979): Auswertung der Kartierung schutzwürdiger Biotope in Bayern. München Wien (Bayer. Landesamt f. Umweltschutz).

KIM, Y.-M. (2001): Flora, Vegetation und Biotoptypen in der dörflichen Kulturlandschaft Koreas. – Dissertation TU Berlin. http://edocs.tu-berlin.de/diss/2001/kim_yeon.htm.

LEE, S.Y. (ed., 1993): The Mangrove Ecosystem of Deep Bay and the Mai Po Marshes, Hong Kong. Hong Kong (Hong Kong University Press): pp. 189.

LEUNG, K.W. (1986): Land use and land-use changes in the Deep Bay area. – B.A. dissertation, Department of Geography and Geology, University of Hong Kong, Hong Kong: pp. 86.

MCINTYRE, S., LAVOREL, S. (1994): Predicting richness of native, rare, and exotic plants in response to habitat and disturbance variables across a variegated landscape. – Conservation Biology **8**: 521-531.

MELVILLE, D.S., MORTON, B. (1982): Mai Po Marshes. Hong Kong (WWF Hong Kong).

MOONEY, H.A., DRAKE, J.A. (1989): Biological invasions: a SCOPE program overview. – In: DRAKE, J.A., MOONEY, H.A., DI CASTRI, F., GROVES, R.H., KRUGER, F.J., REJMANÉK, M., WILLIAMSON, M. (eds.): Biological invasions: a global perspective: 491-509; Chichester (John Wiley).

MÜLLER, N., FUJIWARA, K. (1998): Biotope mapping and nature conservation in cities, Part 2: Results of pilot study in the urban agglomeration of Tokyo (Yokohama City). – Bulletin of the Institute of Environmental Science and Technology **24**: 97-119.

NG, M.C., CHAN, W.M. (1999): Climatology of Lau Fau Shan 1986-1997. – Technical Notes **95**; Hong Kong (Hong Kong Observatory).

NG, S.C., CORLETT, R.T. (2002): The bad biodiversity: alien plant species in Hong Kong. – Biodiversity Science **10**: 109-118.

OTTE, A., LUDWIG, T. (1990): Planungsindikator dörfliche Ruderalvegetation – ein Beitrag zur Fachplanung Grünordnung/Dorfökologie. Part I and II. – Materialien zur Ländlichen Neuordnung **18**: 1-150 and **19**: 1-273.

REELS, G.T. (1994): Management strategies for the reed *Phragmites australis* (Cav.) Steud. at Mai Po Marshes Nature Reserve, Hong Kong, with observations on the associated insect fauna. – M.Phil. thesis, University of Hong Kong, Hong Kong: pp. 156.

SCHULTE, W., SUKOPP, H., WERNER, P. (eds., 1993): Flächendeckende Biotopkartierung im besiedelten Bereich als Grundlage einer am Naturschutz orientierten Planung. Comprehensive biotope mapping as a basis for nature conservation oriented planning. – Natur und Landschaft **10**: 491-526.

SCHULTE, W., SUKOPP, H. (2000): Stadt- und Dorfbiotopkartierungen. – Naturschutz u. Landschaftsplanung **5**: 140-147.

SEOUL CITY (2000): Biotope mapping and its application for the development in Seoul City. – Seoul.

TAM, N.F.Y., WONG, Y.S. (2000a): Field guide to Hong Kong mangroves. – City University of Hong Kong Press, Hong Kong: pp. 88.

TAM, N.F.Y., WONG, Y.S. (2000): Hong Kong mangroves. – City University of Hong Kong Press, Hong Kong: pp.148.

THROWER, S.L. (1983): Hong Kong climbing plants. Hong Kong (Urban Council): pp. 134.

THROWER, S.L. (1984): Hong Kong shrubs Volume II. Hong Kong (Urban Council): pp. 137.

THROWER, S.L. (1988): Hong Kong trees. Hong Kong (Urban Council): pp. 438.

TOMLINSON, P.B. (1994): The botany of mangroves. Cambridge (Cambridge University Press): pp. 419.

USHER, M.B., ERZ, W. (1994): Erfassen und Bewerten im Naturschutz: Probleme, Methoden, Beispiele. Heidelberg Wiesbaden (Quelle und Meyer): pp. 340.

WAI, O.W.H., LUK, W.C. (2001): Numerical investigation of siltation patterns in Hong Kong waters. – XXIX IAHR Congress Proceedings, Beijing (Tsinghua University Press). http://www.iahr.org/e-library/beijing_proceedings/HTML/homepage.html.

WILLIAMS, M. (2004): Deep Bay wetland, Hong Kong, under threat. – http://www.hkoutdoors.com/News_&_Views/Hong_Kong_Outdoors/Deep_Bay_wetland, _Hong_Kong,_under_threat/125/.

WONG, Y.W. (1999): Ecology and biodiversity of a degraded landscape: Lamma Island, Hong Kong. – Ph.D. thesis, University of Hong Kong, Hong Kong: pp. 157.

WU, T.L., HU, Q.-M., XIA, N.-H., PATRICK, C.C.L., YIP, K.-L. (2002): Check list of Hong Kong plants. Hong Kong (Agriculture, Fisheries and Conservation Department): pp. 515.

WWF HONG KONG (1993): Hong Kong vegetation map. – Map produced in conjunction with Hong Kong Government, Survey and Mapping Office.

YOUNG, L. (1999): Management plan for the Mai Po Marshes Wildlife Education Centre and Nature Reserve 2000-2004. Hong Kong (WWF Hong Kong).

ZERBE, S., CHOI, I.-K., KOWARIK, I. (2004): Characteristics and habitats of non-native plant species in the city of Chonju, southern Korea. – Ecological Research **19**: 91-98.

ZERBE, S., LEE, Y.-M. (2000): Cultivated plants in farm gardens reflecting cultural history and current development of the rural landscape – Korean highland villages as an example. – Archive for Nature Conservation and Landscape Research **39**: 191-214.

ZHANG, L.Y., YE, W.H., CAO, H.L. and FENG, H.L. (2004): *Mikania micrantha* H.B.K. in China – an overview. – Weed Research **44**: 42-49.

ZHUANG, X.Y., CORLETT, R.T. (1997): Forest and forest succession in Hong Kong, China. – Journal of Tropical Ecology **14**: 875-866.

Archiv für Naturschutz und Landschaftsforschung

Archives of Nature Conservation and Landscape Research

Die Zeitschrift erscheint mit vier Heften pro Jahr (im Jahr 2003 waren es drei Hefte). Das Einzelheft ist zum Preis von 20 € (incl. Versand) zu beziehen. Ein Jahresabonnement kostet inclusive Versand 80 €. Bestellungen sind an die Schriftleitung bzw. direkt an den Verlag zu richten:

Verlag Dr. Kessel
Eifelweg 37, D-53424 Remagen-Oberwinter
nkessel@web.de, Tel.: 02228 - 493, Fax: 01212 - 512382426
www.ArchivNatur.de

ISSN 0003-9306

Hinweise für die Autoren

Das **Archiv für Naturschutz und Landschaftsforschung** publiziert Originalbeiträge sowie Reviews in deutscher oder englischer Spache, die das ganze Spektrum der landschaftsbezogenen Naturschutzforschung und Landschaftsökologie umfassen. Eingeschlossen sind dabei ausdrücklich Themen, die sich mit der zeitlichen Dimension, bis hin zu ausgesprochen palaeökologischen Fragen, auseinandersetzen. Beiträge aus dem Bereich der Einzelwissenschaften wie Bodenkunde, Vegetationskunde, Hydrologie, Klimatologie und Geomorphologie sollten einen konkreten Raumbezug aufweisen. Beiträge, die über den mitteleuropäischen Raum hinausgehen sind erwünscht.

Manuskripte können bei der Redaktionsleitung in zwei Exemplaren eingereicht werden. Der Text muss 1½-zeilig mit breiten Rand für vorzunehmende Korrekturen vorliegen. Jedes Manuskript wird von zwei Gutachtern beurteilt.

Nach positiver Begutachtung ist der Artikel in Form einer DOC-Datei mit einem Ausdruck einzureichen. Der Text ist außer Überschriften und Absätze als durchlaufender Fließtext (ohne Abb., Tab.; keine Silbentrennung) anzufertigen. Generelle Formatierungshinweise sind unter **www.ArchivNatur.de** zu erhalten.

Abbildungen, Tabellen und Fotos werden mit arabischen Zahlen nummeriert und mit deutschen sowie englischen Untertiteln versehen. Sie sind dem Manuskript gesondert beizufügen. Im Text ist ihre korrekte Position anzugeben. Abbildungen nur in Form von TIF-Dateien, andere Formate nach Rücksprache mit dem Verlag.

Die Autoren erhalten je ein Exemplar des Heftes, in dem ihr Beitrag publiziert ist, kostenlos. Zudem wird der Beitrag als pdf-file zur Verfügung gestellt.

Manuskriptgestaltung:

1. Überschrift (kurz und prägnant; ohne Großschreibung).
2. Ausgeschriebene Vor- und Nachnamen der Autoren/innen.
3. Institution, Anschrift der Autoren/innen.
4. Kurze Zusammenfassung in Deutsch und Englisch (Abstract einschließlich Titel), unter Angabe von 4-6 Schlüsselwörter/Keywords in alphabetischer Folge.
5. Zitate im Text mit Autor (KAPITÄLCHEN) und Jahreszahl [z.B. KOPP (2003) bzw. SUCCOW et al. (2001)].
6. Wissenschaftliche Artnamen *kursiv* geschrieben.
7. Grafiken und Schaubilder nur in zweidimensionaler Darstellungsweise.
8. Literaturverzeichnis (Autoren in alphabetischer Folge, Arbeiten zeitlich geordnet) in folgender Anordnung: Autorennamen (KAPITÄLCHEN), Vornamen (abgekürzt), Erscheinungsjahr in (), dann: Titel. – Zeitschrift (ausgeschrieben), Bandnummer (**Fettdruck**): Seiten; bei Einzelbänden Erscheinungsort und Verlag in ().

   Beispiele:

   MANTHEY, M. (1998): Bodenerosion auf Ackerflächen im Stechlinsee-Gebiet. – Archiv für Naturschutz und Landschaftsforschung **37**: 149-166.

   KOSKA, I., SUCCOW, M. & CLAUSNITZER, U. (2001): Vegetation als Komponente landschaftsökologischer Naturraumkennzeichnung. – In: SUCCOW, M. & JOOSTEN, H. (Hrsg.): Landschaftsökologische Moorkunde, 2. Auflage: 112-128; Stuttgart (Schweizerbart).