

THE BIODIVERSITY OF THE TONLE SAP BIOSPHERE RESERVE 2005 STATUS REVIEW

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INFORMATION SOURCES

This study is in essence a literature review. All traceable documents relating to biodiversity in the Tonle Sap floodplain have been viewed by the editor, including published journal papers (relatively few), occasional book chapters, the bi-annual journal *Cambodia Bird News*, published reports (numerous, notably from the Wildlife Conservation Society and the Mekong River Commission/WUP-FIN, also the United Nations Food and Agriculture Organisation – FAO), identification and species reference guides, unpublished reports (very numerous, including many “trip reports” from field surveys, often in Khmer) and even posters. In cases where references could not be viewed directly this is indicated in the text by the phrase “cited in” (e.g. Anon. 2003 cited in Anon. 2005).

Reference material was gathered from the libraries of the following organisations and institutions: Tonle Sap Biosphere Reserve Secretariat (Ministry of Environment - MoE), Department of Fisheries and the Forest Administration (Ministry of Agriculture, Forests and Fisheries – MAFF), Wildlife Conservation Society (WCS), World Wide Fund for Nature (WWF), Conservation International (CI), Flora and Fauna International (FFI), Cambodia Development Resource Institute (CDRI), Cambodia National Mekong Committee (CNMC), Mekong River Commission (MRC, now based in Vientiane, Lao PDR) including the Water Utilisation Programme – Finnish Environment Institute (WUP-FIN), United Nations Development Programme (UNDP), the World Fish Centre, the Royal University of Agriculture (RUA) and the Royal University of Phnom Penh (RUPP).

Additional material was gathered through personal correspondence and discussion between the editor and many people working on different aspects of biodiversity in the TSBR (see Acknowledgements).

SYNOPSIS OF BIODIVERSITY STUDY IN THE TSBR

The exceptional biodiversity of the Tonle Sap was first documented as early as the 13th Century by Zhou Daguan, a Chinese visitor to Cambodia, who noted the abundance of fish, frogs, tortoises, turtles, lizards, large crocodiles and molluscs on and around the lake (Zhou 2002). The bas-reliefs of the Angkorian Bayon Temple depict several key elements of the Great Lake’s fauna, in particular fish, crocodiles, turtles and large waterbirds (Roberts 2002, Bailleux 2003).

French explorers reported on the rich fisheries of the Tonle Sap (e.g. Garnier 1996), and by the early 20th Century the exceptional productivity of Tonle Sap fisheries for export was well known (Petillot 1911, Chevey 1935 cited in Hurtle *et al.* 2004). Fish studies conducted during the French colonial period, synthesised in Chevey and Le Poulain (1940) and Blache and Goosen (1954) are still the most comprehensive reviews of fish status, distribution and diversity conducted on the Tonle Sap (E. Baran, World Fish Centre, verbally September 2005). French naturalists resident in Cambodia during the first half of the 20th Century published the first significant information from the Tonle Sap region, on birds (Delacour 1929, Delacour and Jabouille 1928, 1931, Engelbach 1940).

During the post-colonial era (ca.1953-1970), the French synthesised information on the flora of selected parts of Cambodia, including the Tonle Sap (e.g. Dy Phon 1970, 1982, Legris and Blasco 1972, Rollet 1972). Bill Thomas made further ornithological observations and collated these with the earlier studies of birds (Thomas and Poole 2003), and Bardach (1959) conducted a study of the fisheries. No significant biodiversity work was conducted between 1970 and the early 1990s.

Immediately after the civil war period, the Tonle Sap formed a central focus for biological exploration. This began with short aerial and

boat-based surveys for birds (Archibald 1992, Scott 1992, Carr 1994), followed by more comprehensive aerial, ground and interview surveys during the dry seasons of 1994 (Mundkur *et al.* 1995) and 1996 (Parr *et al.* 1996). This work established that breeding colonies of several globally threatened large waterbirds persisted in the forested habitats along the north-western shores of the Tonle Sap, south-west of the floating village of Prek Toal, but that they were being heavily exploited for their eggs and chicks. Surveys investigating the socio-economic drivers behind the waterbird harvest, conducted in 1997, included conservation awareness work, which led to a substantial reduction in collection that year (Ear-Dupuy *et al.* 1998).

In February-March 1997, a detailed study of the inundated forest-shrubland flora was conducted as a contribution to the nomination of the Tonle Sap as a UNESCO Biosphere Reserve (McDonald *et al.* 1997). This remains the most comprehensive (indeed, the only major field) study of the vegetation of the Tonle Sap floodplain.

Since 2000, Prek Toal Core Area's waterbird colonies have been the focus of annual counts, and with the establishment of the Prek Toal Conservation Team in 2001, the site has had almost year-round field coverage (Goes 1998, Goes and Hong 2002, Goes 2005, Cambodia Bird News nos.4-13). Conservation outreach and Bengal Florican monitoring research activities were initiated in the middle-outer floodplain grasslands in Kompong Thom in 2000 (Goes *et al.* 2001, Davidson 2004, Davidson *et al.* in prep.). Widespread interview and follow-up field surveys were conducted for

birds in parts of the outer floodplain in Banteay Meanchey, Siem Reap and Kompong Thom provinces during 2001-2002, as part of the Important Bird Area identification process (Seng *et al.* 2003, BirdLife International 2004a). Similarly, widespread interview and follow-up field surveys were conducted for crocodiles in 2001-2002 (Platt *et al.* 2004). First attempts to quantify the watersnake were conducted in 2000 (Stuart *et al.* 2000), and have since been followed up with more detailed investigations (Brookes *et al.* 2005).

Fish catches from the Tonle Sap have been reported on annually and in some detail since the mid-1990s (e.g. van Zalinge and Touch 1996, Nao 1997, van Zalinge *et al.* 1999, Lieng and van Zalinge 2001), but very few studies of fish diversity and distribution have been conducted (Lim *et al.* 1999, Lamberts 2001). Since 2002, a series of documents summarising knowledge of fish and fisheries in the Lower Mekong Basin has been published by the Mekong River Commission (e.g. Mattson *et al.* 2002, Poulsen *et al.* 2002 & 2004, Coates *et al.* 2003, Hurtle *et al.* 2004), and modelling of the physical processes of the Tonle Sap has been addressed with reference to biodiversity by WUP-FIN (e.g. Kummu *et al.* 2005, in press a & b).

PHYSICAL GEOGRAPHY AND CLIMATE

The Tonle Sap Great Lake (hereafter simply referred to as Tonle Sap) is the largest permanent freshwater lake in Southeast Asia (Scott 1989). It is situated in the centre of the low-lying Cambodian plain, which has an average elevation of 10-30 m asl (Lamberts 2001). Quaternary sediments of 15-30 m cover large portions of this plain (Rundel 2000). The lake itself was formed by subsidence of the plain approximately 5,700 years ago (Carbonnel 1963, Tsukawaki 1997 cited in Hortle *et al.* 2004). The Tonle Sap floodplain (defined as the area at maximum flood encompassed by the 10-m asl contour line, including the open lake; Giesen 1998) extends 250-300 km along a north-west to south-east axis, and is up to 100 km wide (Scott 1989, Lamberts 2001).

The region experiences a tropical monsoon climate, characterised by a pronounced May to November rainy season determined by the south-west monsoon, with mean monthly maximum rainfall reaching ca. 270mm in September and October (Giesen 1998, Lamberts 2001). Nonetheless, the Tonle Sap basin is one of the driest areas in Cambodia (together with lowland areas to the west and the lower Mekong basin south-east of Phnom Penh), receiving 1,000-1,500 mm of annual rainfall (Catling 2001), with a mean of 1,477 mm at Siem Reap and 1,350 mm at Battambang (Crocker 1962), and 1,550 mm (2000-2003 four-year mean) at Kompong Thom (Kompong Thom Provincial Department of Forestry data).

DRAINAGE AND HYDROLOGY

The overall drainage basin of the Tonle Sap covers 67,600 km² (Pantulu 1986; see map in Lamberts 2001). Major tributaries include the Stung Sen and the Stung Chinit, which drain much of northern Cambodia, and the Stung Sangke and Stung Poutisat that drain western

Cambodia and the northern slopes of the Cardamom Mountain coastal ranges.

The Tonle Sap Lake expands and contracts seasonally in response to monsoonal rainfall and the flow of the Mekong River, in effect acting as a storage reservoir which regulates flooding in the Mekong Delta. When the depth of the Mekong reaches approximately 9m (Lamberts 2001) in the early wet season, water is forced north-west 'up' the Tonle Sap into the lake, which results in extensive inundation of the surrounding floodplain. The lake can increase in depth from its dry-season (Dec-June) depth of 1-2 m up to 8-10 m at the peak of the flood, and its surface area expands from 2,500-3,000 km² in the dry season up to 15,000 km² during the flood season, when at maximum flood level it covers about 6-8% of the land area of Cambodia (Nao 1997, MRC 2003, Kummu *et al.* in press a). During the wet season, the volume of the lake increases from about 1.3 km³ up to 60-70 km³, depending of the flood intensity. The reverse Mekong flow phenomenon results in peak water levels in Tonle Sap lagging 1-2 months behind the peak of seasonal rainfall. Floodwaters begin to recede in the early dry season in November, with the lowest water levels occurring at the end of the dry season in early May (Scott 1989).

The Mekong River yields approximately 51% of this inflow of water, but is responsible for the majority (ca.75%) of the sediment deposited in the Tonle Sap Lake (Kummu *et al.* in press a). It is estimated that more than 80 % of the sediment the Tonle Sap system receives from the Mekong River and its tributaries is stored in the lake and its floodplain. The dynamic nature of sediment movement into and out of Tonle Sap has been the subject of much speculation, i.e. that the lake is rapidly filling up with sediment due increasing sediment loads coming from its catchment. However, recent studies have shown that net sediment accumulation within the Tonle Sap Lake itself is low, and not accelerating with respect to the long-term sediment dynamics of the system (Kummu *et al.* 2005). The majority of the sediments settle in the inundated forest

and shrubland areas of the floodplain (Sarkulla *et al.* 2003). However, there are local problems associated with high sedimentation and erosion rates in the TSBR (Heinonen 2005 cited in Kumm *et al.* 2005).

DEMOGRAPHY AND LAND-USE

The human population on and around the Tonle Sap was estimated to have at least tripled between the 1940s and 1995 (Baran *et al.* 2001), when it was thought that the number of people in fishing dependent communes in the six provinces bordering the lake numbered almost 3 million (Nao *et al.* 1996 cited in Baran 2004). Giesen (1998) reports one hundred and sixty communes inhabited by an estimated 1.02 million people are located on the periphery of Tonle Sap, and about 170 floating villages ranging in size from two to over 100 households occur on the lake itself and move relative to the seasonally fluctuating water levels. The most recent and accurate estimate is of approximately 470,000 people living within the 10 m inundation zone (up to NR-5 and NR-6), and approximately 1.19 million in all zones including urban centres (Keskinen 2003). A small out-migration of people from all provinces surrounding the lake but for Kompong Chhnang has recently been reported (Haapala 2003 cited in Baran 2004), due to decreasing fish catches, droughts and unpredictable flooding which is impacting on rice yields, and reduction in river water quality due to increased sediment loads.

Rice cultivation, fuelwood collection, aquaculture (chiefly fish), and subsistence and commercial fishing are the principal economic activities of the communities living on the lake and surrounding the floodplain (Nesbitt 1997, Giesen 1998, Gum 1998). Fishing is the mainstay of communities situated closer to open water and major waterways; rice cultivation and other agriculture are economically more significant to communities in the outer floodplain (Keskinen 2003). Commercial fishing is concentrated in 57 administrative fishing lots, which encompass extensive areas of the lake and surrounding wetlands (Giesen 1998).

Fishing lots are enclosed with bamboo fences that extend for many kilometers and lot operators strictly control access for the duration of the fishing season (November – May inclusive). Rice cultivation has traditionally been almost exclusively of deepwater (floating) rice; historically about half (200,000 ha) of Cambodia's deepwater rice was grown in the Tonle Sap inundation zone, but by 2000 only ca.70,000 ha remained, of which 38% was in Kompong Thom province (Catling 2001). Dam construction for more intensively cultivated dry season rice has become prevalent in the floodplain since 2000 (Evans *et al.* 2005).

CONSERVATION STATUS OF THE TONLE SAP FLOODPLAIN

The Tonle Sap Lake and most of its floodplain was approved as the Tonle Sap Biosphere Reserve (TSBR) under UNESCO's Man and the Biosphere Program (MAB) in October 1997 (UNESCO 2005). This approval was recognised within Cambodia by the Royal Decree for the Establishment of the Tonle Sap Biosphere Reserve passed in April 2001. The UNESCO Biosphere Reserve conceptual design consists of strictly protected core areas surrounded by buffer and transitional zones, where sustainable resource extraction and human occupancy is permitted. In contrast to this standard, subsistence and commercial fishing are permitted in the TSBR core areas. Three core areas were proposed: Prek Toal (31,282 ha), Moat Khla - Boeng Chhma (32,969 ha), and Stoeng Sen (6,586 ha) (Giesen 1998), each considered to represent unique ecosystems demarcated for long-term protection and conservation (Neou 2001). By the time the TSBR was legally established in April 2001, however, the Prek Toal Core Area had been reduced to 21,342 ha, and the Moat Khla - Boeng Chhma Core Area was reduced to 14,560 ha (encompassing Boeng Chhma only) (e.g. Goes 2005). The three core areas are surrounded by a buffer zone of just under 500,000 ha, which in turn is encompassed within a transition zone of approximately 900,000 ha, bordered to the south-west by National Route 5 (NR-5) and to

the north-east by NR-6 (Giesen 1998, Gum 1998). The transition zone does not cover the entire Tonle Sap floodplain. A substantial portion (approximately 90,000 ha) of the outer floodplain in Kompong Thom province lies outside the transition zone, comprising a grassland/agro-ecosystem mosaic of considerable biodiversity conservation importance (e.g. Seng *et al.* 2003).

Eight designated fish sanctuaries are physically demarcated on the Tonle Sap Lake itself. These reportedly became operational between 1980 and 1982 (Cheng Phen verbally 2005), although it is not clear on what basis they were designated (E. Baran and Cheng Phen verbally 2005). They are manned by armed personnel for 4-6 months of each dry season, and essentially function as dry season no-fishing and boat exclusion zones. Experimental protection from fishing of the lower water column has begun in two fish sanctuaries using concrete tubes (Cheng Phen verbally 2005).

The Boeung Chhma Core Area was designated as a 28,000 ha site of international significance under the Ramsar Convention (Boeng Chhmar and Associated River System and Floodplain) in June 1999 (Wetlands International 2005). It is one of only three Ramsar sites in Cambodia. The other two are the Mekong River north of Stung Treng (the "Stung Treng Ramsar site") and Koh Kapik and associated islets on the Gulf of Thailand coast in Koh Kong province.

The TSBR wholly encompasses or overlaps nine Important Bird Areas (IBAs), which are internationally recognised sites of conservation importance because they regularly support populations of globally threatened birds and/or regionally significant populations of congregatory waterbirds (Seng *et al.* 2003, BirdLife International 2004b).

Since 2001, the WCS Cambodia programme's Tonle Sap Project has been conducting wide-ranging conservation action in the Prek Toal Core Area (e.g. Goes and Hong 2002, Goes 2005) and in grassland and agro-ecosystem

habitats in Stung, Stung Sen and Santuk districts of Kompong Thom province, and adjacent Chikreng district in Siem Reap province (e.g. Goes *et al.* 2001). BirdLife International has been conducting conservation outreach in two IBAs within the TSBR, in Siem Reap and Banteay Meanchey provinces.

The biodiversity of the Tonle Sap Lake and its floodplain is relatively species poor in comparison to other tropical lowland ecosystems, primarily due to the extreme stresses imposed on the ecosystem by the annual climatic and hydrological fluctuations. Unique floral and faunal assemblages have evolved to cope with these harsh environmental conditions, however, and the annual flood-pulse and nutrient replenishment cycle supports abundant populations of this adaptive flora and fauna. These include significant populations of many species of global conservation concern. The TSBR is one of the most important wetlands for biodiversity conservation in Southeast Asia, particularly for birds, reptiles and plant assemblages.

The Tonle Sap is widely believed to be one of the most productive inland waters in the world (e.g. Lamberts 2001, Lieng and van Zalinge 2001, Baran 2004, and references therein). Key factors behind this exceptional productivity include i) the annual inundation cycle with its extensive, long-lasting monsoon floods, ii) the floodplain vegetation, in particular the “flooded forest” and “flooded shrub”, and iii) high rates of nutrient cycling (Lamberts 2001). Another highly plausible factor is the sustained high exploitation of fish over the past century (Petillot 1911, Chevey 1934, both cited in Baran 2004), which may have resulted in selection for dominant fast growing and short life span species, mostly Cyprinids (Baran 2004). The precise mechanisms of this productivity remain rather poorly understood and require detailed further research.

Seasonality of key processes and their implications for conservation

The wet-season flood-pulse is the primary physical process driving a sequence of significant ecological events that are the mainstay of the Tonle Sap ecosystem’s annual cycle. The annual flood-pulse from the Mekong transfers the floodplain’s terrestrial primary products into an aquatic phase (e.g. Lamberts, 2001). Table 1 presents the major physical and land/human-use processes, and the major annual ecological events as they occur chronologically in the Tonle Sap ecosystem’s highly seasonal annual cycle.

Because of the extreme environmental changes experienced in the TSBR through the course of a year, many species are only able to use the Tonle Sap on a seasonal basis. Their conservation therefore depends not only on measures taken within the TSBR, but also on factors operating in other parts of these species’ annual ranges. For many, there is currently little or no conservation regulation implemented in other parts of their range; indeed, the other parts of many of these species’ ranges are often rather poorly known.

Ecological Processes / Events by Habitat Type

Season	Month(s)	Key Physical, Land- and Human-use Processes	Open Lake	Swamp forests	Ecological Processes/Events by Habitat Type	
					Short-tree shrublands	Grasslands/agro-ecosystems
Early monsoon	May-July	Reversal of Tonle Sap River flow into Tonle Sap Lake - flood-pulse begins	In-migration of "white fish" from Mekong via Tonle Sap River	Tree and shrub flowering and fruit production	Tree and shrub flowering and fruit production	Out-migration of terrestrial breeding species (grassland birds and larger mammals) as flood rises
		Deepwater rice crops germinating in outer floodplain		In-migration of "white fish" for feeding, nesting and spawning	In-migration of "white fish" for feeding, nesting and spawning	In-migration of post-breeding large waterbird congregations (storks, ibises, herons and egrets, pelicans)
		Watersnake harvest begins		Lateral migrations of "black fish" to nesting and spawning habitats	Lateral migrations of "black fish" to nesting and spawning habitats	In-migration of wet-season breeding waterbirds (e.g. rails, crakes, bitterns)
				Departure of large waterbird breeding colonies (storks, pelicans, ibises, herons and egrets)		In-migrations of some black and white fish species for nesting, spawning and juvenile growth.
Mid-monsoon	August-October	Expansion of Tonle Sap Lake to max. inundation through reverse flow mechanism and catchment rainfall		Tree and shrub flowering and fruit production	Tree and shrub flowering and fruit production	
		Largest sediment inputs		Deciduous tree leaf fall (underwater)	Deciduous tree leaf fall (underwater)	
		Fishing (outside lot system) in outer floodplain agro-ecosystems		Fish nesting, spawning, feeding and juvenile growth period	Fish nesting, spawning, feeding and juvenile growth period	Fish nesting, spawning, feeding and juvenile growth period
		Deepwater rice crop main growth phase		Cormorants and Darters return to nest colonies and commence breeding		Main phase of deepwater rice growth in the outer floodplain agro-ecosystems
		Watersnake harvest peaks		Watersnake breeding period	Watersnake breeding period	Fish perform function of natural pest regulators in traditional rice agricultural systems

Season	Month(s)	Key Physical, Land- and Human-use Processes	Open Lake	Swamp forests	Ecological Processes/Events by Habitat Type	
					Short-tree shrublands	Grasslands/agro-ecosystems
Late monsoon	October- November	Flood water begins to recede as Mekong River level drops and Tonle Sap River reverses flow again and begins draining the lake	Out-migration of "white fish" to Mekong River via Tonle Sap River and floodplains	Leaf flush in all deciduous and evergreen tree species	Leaf flush in all deciduous and evergreen tree species	Continued growth of "floating grasses"
		Large-scale commercial fishing begins in all fishing lots and main waterways draining Tonle Sap lake		Watersnake breeding period	Watersnake breeding period	
		Deepwater rice ripening phase				
		Large-scale commercial fishing continues in all fishing lots and main waterways draining Tonle Sap lake	Out-migration of "white fish" to Mekong River via Tonle Sap River and floodplains continues	Cormorants and Darters complete breeding and fledge		In-migration of terrestrial breeding species begins (grassland birds including Bengal Florican) as land re-exposed on flood recession
Early dry	November-January	Flood waters recede increasingly rapidly	Large feeding aggregations of terns and gulls	Large waterbirds (storks, ibises, pelicans, herons and egrets) return to nesting colonies		Large in-migration of Palearctic "winter visitor" bird populations (raptors, chats, hirundines, warblers, pipits, wagtails)
		Second watersnake harvest peak				
		Deepwater rice harvest				
Mid-late dry	January-May	Large-scale commercial fishing begins in all fishing lots and main waterways draining Tonle Sap lake	?Concentration of black fish as surrounding floodplain dries out	Main breeding period for large waterbirds (storks, ibises, pelicans, herons and egrets)	Black fish concentrated in remaining waterbodies and performing "overland" migrations	Main breeding period for terrestrial grassland birds (e.g. Bengal Florican, quails and buttonquails)
		Increasingly drought like conditions develop in outer floodplain	Large feeding aggregations of terns and gulls	High concentrations of fish behind fish traps in fishing lots	Estimated main breeding period for turtles and pythons	Black fish concentrated in remaining waterbodies and performing "overland" migrations
		Extensive burning of grassland and shrubland Livestock grazing (January-early April)		Estimated main breeding period for turtles and pythons		Local movements of Palearctic birds in response to availability of key food resources
		Preparation of land for deepwater rice cultivation				Domestic livestock may partly fulfil grazing function of extirpated herbivore populations

FUNGI

The only information traced on fungi is from McDonald *et al.* (1997). Several fruiting Basidiomycetes were observed on large trunks drifting in the water in Moat Khla in late February, one of which resembled *Pholiotus* morphologically. Two polypores (tough, leathery poroid mushrooms, similar to boletes) were also observed in large colonies on floating logs, one bright orange the other dull whitish in colour (McDonald *et al.* 1997).

Aquatic fungi were not observed by McDonald *et al.* (1997), but evidence for their occurrence was apparent in the boles of *Barringtonia* and *Diospyros* tree spp., which were frequently “scarred throughout with exposed patches of black, carbonised heartwood”, creating an effect reminiscent of a lightning strike.

FLORA

PHYTOPLANKTON

The phytoplankton of the Tonle Sap itself has not received specific study, but during the late 1980s, a Vietnamese study (Nguyen and Nguyen 1991 cited in Lamberts 2001) identified 197 species of phytoplankton in “the Mekong, the Tonle Sap channel and the floodplains”, with the largest number of species found in the Mekong mainstream. Green algae and diatoms account for 64% of the plankton species; one quarter comprise blue-green algae and the remainder are composed of Euglenophyta, Xantophyta, Pyrrophyta and Chrysophyta. Approximately 10% of the diatoms are specific to the river or to the floodplain. Phytoplankton densities are generally higher in the flooded areas than in the rivers, where they vary considerably, being about 40 times higher in the dry season than during the flood period (Nguyen and Nguyen 1991 cited in Lamberts 2001). McDonald *et al.* (1997) report an alga occurring in submerged green masses, apparently *Hydrodictyon* sp., usually found interlacing populations of *Utricularia aurea* Lour.

DISTRIBUTION OF HABITATS

The floodplain vegetation can be crudely differentiated in irregular concentric bands radiating out from the dry season low water mark of the Tonle Sap Lake (Fig. 1). Forest (up to 20 m tall) and scrub (up to 5 m in height) forms a semi-continuous belt of vegetation, 7–40 km wide, surrounding the open water surface. Trees and scrub become lower in stature with increasing distance from the lakeshore and as duration of flooding decreases, and patchily distributed grasslands occur within this vegetation belt (McDonald *et al.* 1997). The scrub is encircled by an outer band of grassland and

agriculture, much of which is probably the result of hundreds or thousands of years of human modification (e.g. Chandler 2003). In places, scrub, grassland and agriculture form a complex mosaic landscape (Davidson 2004). Widespread and numerous permanent and seasonal wetlands are found beyond the dry season low water mark. Large areas of the seasonal inundation zone are effectively “common land” and heavily utilised by the human communities surrounding the floodplain (e.g. Davidson 2004, Evans *et al.* 2005).

Fig. 1. Cross section of floodplain habitats in Kampong Thom province during (a) October/November (above) and (b) May/June (below); reproduced from Balzer *et al.* (2002).

FLOODLAND OF THE TONLE SAP & KOMPONG THOM DURING OCTOBER/NOVEMBER

FLOODLAND OF THE TONLE SAP & KOMPONG THOM DURING MAY/JUN

Open Lake	Swamp	Forest	Short-tree shrublands	Grasslands and Floating Rice	Settlements	Deciduous Dipterocarp Forest
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DIVERSITY, FLORAL AFFINITIES AND ENDEMISM

The Tonle Sap floodplain supports a low overall diversity of plant species, but is rich in species that are unique to the Indochinese floristic region (Rundel 2000), some of which are entirely restricted to the Tonle Sap floodplain (McDonald *et al.* 1997). The Cambodian National Mekong Committee (1998 cited in Rundel 2000) published a preliminary checklist

of approximately 200 vascular plant species present in the Tonle Sap floodplain; this list needs to be evaluated to determine its correctness and completeness (Rundel 2000). Based on four main sources (Rollet 1972, McDonald *et al.* 1997, Lamberts 2001 and Davidson 2004), 206 species are identified from the Tonle Sap floodplain, a further 19 additional species that occur are unidentified, and six more species are listed but without a primary source for the data (plant species list provided by TSBR Secretariat 2005).

The swamp forest communities of the Tonle Sap floodplain appear to be unique both in structure and floristic composition, and contain a number of narrow endemics, e.g. *Samandura harmandii* (B. Rollet) (Simaroubaceae), which occurs in the Stung Sen Core Zone (McDonald *et al.* 1997). Some elements of the freshwater floodplain's flora show affinities with coastal mangrove habitats (Rundel 2000). For example, *Terminalia cambodiana* Gagnep. (Combretaceae) is endemic to the Tonle Sap and the southern coastal zone of Cambodia and adjacent Thailand; species relationships in the genera *Diospyros* and *Barringtonia* show similar patterns (Rundel 2000). McDonald *et al.* (1997) reported the collection of what appears to be an undescribed taxon of the mangrove *Lumnitzera* cf. *racemosa* (Combretaceae) in the outer Tonle Sap floodplain. Mekong Basin endemics including *Coccoceras anisopodum* Gagnep. (Euphorbiaceae), *Diospyros bejaudii* Lecomte and *D. cambodiana* H. Lec. (Ebenaceae), *Garcinia loureiri* Pierre (Guttiferae), *Acacia thailandica* Nielsen (Mimosoideae) and *Hydnocarpus saigonensis* Pierre (Flacourtiaceae) are well represented in the TSBR (Dy Phon 1982, McDonald *et al.* 1997, Rundel 2000). Most are locally distributed along river channels in relatively small and fragmented populations (Rundel 2000), for which the lower Steung Sen catchment is an important area (McDonald *et al.* 1997).

A complete list of plant species documented from the TSBR is presented in Annex1.

THE TERM "FLOODED FOREST"

The dominant wooded habitat of the floodplain is most often referred to as "flooded forest". However, the more descriptive "seasonally flooded freshwater swamp forest" is technically a more accurate term for these formations (e.g. Rundel 2000). Seasonally flooded freshwater swamp forest differs markedly from classic South-east Asian swamp forests in both structure and species composition, because it is flooded seasonally, and not permanently. For example, palms, often a characteristic component of typical swamp forests, are almost entirely absent from the Tonle Sap floodplain but for two or three rattan species (Rundel 2000), and pneumatophores, aerial roots and vascular epiphytes are all lacking (Rollet 1972).

The Tonle Sap's seasonally flooded freshwater swamp forests are adapted to withstand twice-annual fluctuations in water level of up to 10 m, and to cope with this stress, have developed some very distinctive physiological characteristics (McDonald *et al.* 1997, Rundel 2000):

- Most seasonally flooded swamp forest plants are "flood-deciduous", i.e. leaf fall occurs underwater, when the flood submerges the branches (leaf fall in most tropical forests coincides with dry season periods of insufficient water stress); the flush of new leaves occurs as receding waters (in November–December) expose the trees and shrubs to the air again;
- Flowering and fruit production is delayed for several months after the leaf flush, occurring during the late dry and early wet season, suggesting the possibility that fish may play a key role in seed dispersal.

FOREST ASSOCIATIONS

Two major forest associations are described for the extensive floodplain area of Tonle Sap: i) a variously termed gallery (e.g. McDonald *et al.* 1997) or swamp forest (e.g. Rundel 2000) formation around the lake itself, and along some of the lake's major tributaries (e.g. the Stung Sen

and Stung Sangkhe), and ii) a short-tree shrubland in the middle-outer floodplain (McDonald *et al.* 1997, Rundel 2000). In addition, an evergreen forest association with tropical rainforest affinities occurs locally in riverine locations (McDonald *et al.* 1997).

Swamp or gallery forest

This forest association receives inundation (of 4-6 m, locally up to 8 m) for up to eight months each year, and occurs around the dry-season shoreline of the lake itself and along the major river channels, as a mosaic of stands of large trees and open areas with floating aquatic vegetation typical of the lake itself (McDonald *et al.* 1997, Rundel 2000). The primary dominants are two rather stunted (7- 15 m tall) tree species, *Barringtonia acutangula* (L) Gaertn. (Lecythidaceae) and *Diospyros cambodiana*, which typically occur with a variety of woody lianas, including *Combretum trifoliatum* Vent. (Combretaceae), *Breynia rhamnoides* Arg. (Euphorbiaceae), *Tetracera sarmentosa* Vahl (Dilleniaceae) and *Acacia thailandica*. *Barringtonia acutangula* and *Combretum trifoliatum* both retain their leaves year-round (but flush new leaves contemporaneously with the deciduous species). A similar gallery forest association formerly occurred along channels of many major rivers in southern Cambodia (Rundel 2000). Other common tree species in this forest type noted by Rollet (1972) include *Barringtonia micrantha* (Lecythidaceae), *Coccoceras anisopodum*, *Elaeocarpus griffithii* Mast. and *E. madropetalus* Pierre (Elaeocarpaceae), *Hydnocarpus anthelmintica* Pierre and *H. saigonensis* (Flacourtiaceae), *Albizia lebbekoides* (A.P. DC.) Benth. (Mimosaceae), and *Cynometra* sp. (cf. *dongnaiensis*) (Caesalpiniaceae) and *Stephegyne* cf. *diversifolia* Rubiaceae (Naucleaceae).

Evergreen riverine forest

An evergreen riverine forest habitat identifiable by a tall and species-rich gallery forest is described along the Stung Sen embankments (McDonald *et al.* 1997). In addition to the typical swamp forest species (e.g. *Barringtonia acutangula*,

Coccoceras anisopodum, *Crataeva roxburghii* R.Br., *C. nurvala* Ham. (Capparidaceae), and *Terminalia cambodiana*), which tend to occur as co- or sub-dominant constituents with *Crudia chrysanthra*, Caesalpiniaceae, *Diospyros* and *Ficus* spp., *Garcinia loureiri*, *Elaeocarpus griffithii*, *Hydnocarpus anthelmintica* and *Samandura harmandii*, forming a more stratified vegetation cover including trees with trunks reaching 1-3 m in diameter and 15 m in height (McDonald *et al.* 1997). Also present in the stratified canopy of this forest are large lianas of the rattan *Calamus palustris* Griff. (Palmeae), as well as a diverse assemblage of typical swamp forest lianas including *Acacia thailandica*, *Breynia rhamnoides*, *Cissus hexangularis* Thorel (Vitaceae), and *Combretum trifoliatum*. The under storey of this community is occupied by a mixture of shrubs typical of the short-tree shrubland association including *Brownlowia paludosa* Kost. (Tiliaceae), *Cudrania cambodiana* Gagnep. (Moraceae), *Gmelina asiatica* L. (Verbenaceae), *Mallotus cochinchinensis* Lour. (Euphorbiaceae), *Phyllanthus* sp, *Vitex holaedenon* D.Dop (Verbenaceae) and four locally unique, unidentified species, and the under storey herb *Schummanianthus dichotomus* (Marantaceae) was only encountered in this habitat (McDonald *et al.* 1997).

This forest association contains a few species that do not delay flowering and fruit production: e.g. *Combretum trifoliatum*, *Crataeva nurvala* and *C. roxburghii*, and *Gmelina asiatica*.

Short-tree shrublands

This vegetation type consists of dense, fairly homogeneous stands of 2-4 m tall trees and scrub. The flora of the short-tree shrublands is dominated by species of Euphorbiaceae, Fabaceae and Combretaceae (McDonald *et al.* 1997). Widespread common and/or dominant species include *Acacia spiralis* (Mimosaceae), *Barringtonia acutangula* (Lecythidaceae), *Bridelia cambodiana* Gagnep. (Euphorbiaceae), *Brownlowia paludosa*, *Capparis micrantha*, *Cissus*

hexangularis, *Croton mekongensis* Gagnep. and *Croton krabas* Gagnep. (Euphorbiaceae), *Dalbergia pinnata* Pierre (Papilionaceae), *Gardenia cambodiana* Pitard (Rubiaceae), *Gmelina asiatica*, *Phyllanthus taxodiifolius* Beille (Euphorbiaceae), *Popowia diospyrifolia* Pierre (Annonaceae), *Quisqualis indica* L. (Combretaceae), *Stenocaulon kleinii* W. & Arn. (Asclepiadaceae), *Terminalia cambodiana* and *Vitex holoadenon*.

Several species (e.g. *Combretum trifoliatum*), which form woody lianas under wetter conditions, form extensive areas of scrub in the outer floodplain under the seasonal cycle of flooding and drought and disturbance. Herbaceous cover is largely lacking in these short-tree shrublands, but returns rapidly following clearance. Several alien woody species have now invaded this habitat and are greatly expanding their cover and dominance (McDonald *et al.* 1997). The giant mimosa, *Mimosa pigra* L. (Mimosaceae), currently presents the most serious problems (Jantunen 2003, Hellsten *et al.* 2003).

The low stature shrubland which dominates much of the Tonle Sap floodplain has led some authors to describe this vegetation formation as forest degraded by logging and other human activities (see Rundel 2000). The shrublands and swamp forests of the Tonle Sap floodplain have been modified by centuries of human activities (e.g. Chandler 2003), an impact that has certainly accelerated over the past decade. Although extensive areas now comprise short-tree shrublands, it is unclear whether or not these are secondary formations. McDonald *et al.* (1997) provide a compelling argument that these formations are essentially a climax vegetation, while others argue that it is more logically a result of repeated disturbance, especially burning, supported by the observation that gallery forest exists only on the wettest substrates, i.e. those where trees are safe from fire. While much disturbance has clearly taken place, the structure and composition of woody vegetation on the floodplain appears to be as much a function of the microhetero-

geneity of soil moisture conditions and seasonal flood dynamics as human disturbance (Rundel 2000).

AQUATIC HERBACEOUS COMMUNITIES

The shallow shoreline of Tonle Sap lake and patches within the gallery/swamp forests support dense mats of herbaceous vegetation, 1-3 m tall, that may be emergent from shallow water but are more typically floating (McDonald *et al.* 1997). True submerged species are lacking, but surface creepers capable of increasing their stem length with rising water are very common. These large, often clonal assemblages float freely over the lake, colonising large openings and gaps within the swamp forest. Extensive mats of the floating legume *Sesbania javanica* Miq. (Papilionaceae), the grass *Brachiaria muticus* Stapf., *Polygonum barbatum* L. (Polygonaceae) and the introduced *Eichhornia crassipes* (Martius) Solms (Pontederiaceae) occur, and along the Stung Sangkhe, *Achyranthes aquatica* R.Br. (Amaranthaceae) co-dominates with these species. Occasional widespread species include *Commelina salicifolia* Roxb. (Commelinaceae), *Ipomoea aquatica* Forsk. and *I. chrysioides* Ker.-Gawl. (Convolvulaceae), *Ludwigia adscendens* (L.) Hara. (Onagraceae), *Pistia stratiotes* L. (Araceae) and *Salvinia cucullata* Roxb. (Salviniaceae) (McDonald *et al.* 1997). Given the long history of human activities around the lake, the structure and diversity of the aquatic flora has likely altered from its original composition (Rundel 2000).

A notable floristic character of the aquatic flora of Tonle Sap is the paucity of families of rooted monocots and dicots that characterise similar habitats elsewhere in Asia (Rundel 2000). These families include the Hydrocharitaceae, Marantaceae, Najadaceae, Nymphaeaceae, Pontederiaceae and Potamogetonaceae (McDonald *et al.* 1997). The large seasonal change in water level of the lake and its strong turbidity are the likely causes for the absence of these groups. One rooted monocot, the grass *Phragmites*

karka Trin. (Poaceae), is a local dominant at the mouth of Tonle Sap and at other river inlets and exits.

A distinctive aquatic community occurs in isolated ponds in the outer floodplain, in which grasses and sedges are important, including *Cyperus pilosus*, *Rhynchospora* sp. and *Actinoscirpus grossus* (L.f.) Goetgh. & D.A. Simpson (Cyperaceae), as well as a group of dicot emergents, including *Aeschynomene indica* L. (Papilionaceae), *Impatiens* sp. (Balsaminaceae) and lotus *Nelumbo nucifera* (L) Gaertn. (Nelumbonaceae). Lamberts (2001) and Hellsten *et al.* (2003) note that *Nelumbo nucifera* is missing from the inner floodplain.

GRASSLANDS AND AGRO-ECOSYSTEMS

A wide variety of grassland types occur in the middle-outer floodplain. Their structure and species composition has largely been determined by a combination of physical factors (the inter-related seasonal inundation gradient, soil type and fertility) and land-use processes, deepwater (chiefly floating) rice cultivation, burning and grazing (Davidson 2004). Deepwater rice cultivation—in which seed is hand-broadcast onto areas that flood naturally, and grown with minimal chemical inputs (Catling 1992)—has modified the middle and outer floodplain areas for centuries, but has declined in extent by over 60% since the late 1960s (Catling 2001).

Examination of MRC/GTZ (1999) land-cover data and 2002 Landsat Thematic Mapper (TM) raw satellite imagery suggest that grassland areas within and around the Tonle Sap floodplain may cover more than 2,000 km² (Davidson 2004), quite possibly the largest extent of seasonally inundated grassland habitat anywhere in South-East Asia (Davidson *et al.* in prep.). Grasslands occur throughout the floodplain, especially in the middle and outer reaches which receive shorter duration inundations, and exhibit considerable diversity in both structure and community composition (Davidson 2004).

Oryza rufipogon Griff. (Poaceae) (wild

rice) is the dominant grassland type within the inundated forest-scrub of the inner and middle floodplain (e.g. Veal Srangai IBA where it is rather extensive), occurring in homogeneous dense mats mixed with *Leersia hexandra* Sw. (Poaceae) (Davidson 2004). Burning promotes species diversity in these grasslands: *Oryza* dominated swards burnt during the previous dry season often support a wider range of species, including the sedges *Cyperus digitatus* Roxb. and *C. iria* L. (Cyperaceae), *Aeschynomene indica*, and tall stands of *Panicum luzonense* J. Presl. (Poaceae) (Davidson 2004). Further from the lakeshore, *Oryza rufipogon* and *Leersia hexandra* become less common, merging into *Paspalum*-type grasslands including co-dominants *Paspalum scrobiculatum* L. (Poaceae) and other, unidentified rhizome-forming species. *Gmelina asiatica* scrub is a widespread dominant throughout these areas. Waterlogged substrates in the inner and middle floodplain support stands of *Phragmites* sp./spp. (especially in the Tonle Sap 'delta, e.g. McDonald *et al.* 1997), and (often extensive) *Actinoscirpus grossus* sedge beds and stands of *Sesbania javanica* (Davidson 2004).

Large homogeneous areas of apparent fire-climax communities, including a distinctive *Imperata-Arundinella-Eragrostis-Themeda* grass community, comprising dominant *Imperata cylindrica* (L.) P. Beauv. (Poaceae) and *Rhynchospora* sedge sp./spp. (including *Rhynchospora submarginata* Kuk. (Cyperaceae)) and, patchily co-dominant *Arundinella setosa* Trin., *Eragrostis atrovirens* (Desf.) Trin. and *E. brownii* (Kunth) Nees. (Poaceae), occur on impoverished soils subject to annual burning. These areas also support numerous tall stands of the *Saccharum*-like *Sclerostachya fusca* (Roxb.) A. Camus. and more patchy *Cymbopogon cambogien-sis* (Balansa) E.G & A. Camus, *Themeda arundinacea* (Roxb.) Ridl. (Poaceae) and the sedge *Fimbristylis dura* (Zoll. ex Maritz.) Merr. (Cyperaceae) (Davidson 2004).

In recent fallows, *Panicum repens* L. (Poaceae), *Eragrostis atrovirens* and other,

unidentified *Eragrostis* spp., dominate, with patchy *Desmostachya bipinnata* (L.) Stapf. (Poaceae), and short (15-20 cm) *Fimbristylis dichotoma* (L.) Vahl and *F. umbellaris* (Lam.) Vahl sedge swards. Tall *Chrysopogon festuoides* tussocks are widespread across drier and less recently cultivated substrates. On the outer edge of the floodplain, on very poor sandy soils, structurally simple, extensive sparse short grasslands occur, including *Fimbristylis* swards, with occasional tiny isolated clumps of the rattan *Calamus salicifolius* Becc. (Davidson 2004).

The wet-season floating ricefield agro-ecosystem near Roluos in Kompong Thom supports a community very similar to the floating aquatic vegetation mats of the open lake and gallery/swamp forest clearings described by McDonald *et al.* (1997), including *Sesbania javanica*, *Eichhornia crassipes* (introduced), *Ipomoea aquatica*, *Ludwigia adscendens* and *Pistia stratiotes*, together with *Polygonum tomentosum* Willd. (Polygonaceae), *Nelumbo nucifera*, *Limnophila geoffrayi* Bonati. (Scrophulariaceae), *Nymphae* sp., and *Trapa natans* L. (Trapaceae), the latter not noted by other authors, and perhaps a cultivar (Balzer *et al.* 2002).

Fig. 2. Vertical distribution of dominant plant species in the Tonle Sap floodplain (to 6m elevation), reproduced from Hellsten *et al.* (2003).

SITES WITH DISTINCTIVE VEGETATION

ASSEMBLAGES

Much of the seasonally inundated swamp forest and short-tree shrubland in the TSBR comprises a characteristic mix of the same dominant species. Particularly large tracts of this are found in the Prek Toal Core Area, which is notable for its common and large (10+ m tall)

Terminalia cambodiana trees, and in Boeng Chhma Core Area where there is a diversity of vegetation heights and structures, interspersed with patches of open water supporting extensive herbaceous hydrophytic flora (McDonald *et al.* 1997).

Stung Sen Core Area and river-mouth

Gallery forest along the Stung Sangkhe is the most species rich, tall forest encountered in the TSBR by McDonald *et al.* (1997), and includes the largest number of rare species. Common elements of the swamp or gallery forest formations typical of many parts of the floodplain are co- or subdominant to populations of *Hydnocarpus anthelminthica*, *Ficus* spp. (some very large examples), *Elaeocarpus griffithii*, *Garcinia loureiri*, *Crudia chrysantha* and *Samandura harmandii*.

Moat Khla area

Large and dense gallery forests developed along landlocked waterways between Peam Bang and Moat Khla are a mature and relatively undisturbed example of closed canopy inundated swamp forest. Generally very typical in overall species composition, there are examples of endemics in this formation, including the narrow endemic *Homalium brevidens* Gagnep. (Flacourtiaceae).

Outer floodplain north of Bak Prea

This is an exemplary area of "upland" vegetation on the Tonle Sap floodplain in terms of physiognomy and species composition. The relatively short stature vegetation supports emergent trees of up to 12m, and species diversity is higher than in formations associated with the lakeshore and riverways McDonald *et al.* (1997). Eight unidentified shrub species

were unique to the site in the McDonald *et al.* (1997) survey.

GLOBALLY THREATENED SPECIES

Only two of the plant species recorded thus far (Annex 1) are afforded a global threat status. However, the flora of the Tonle Sap floodplain is still rather poorly known, and its importance in a regional context is inadequately described. Research into the status of the substantial number of endemics reported from the Tonle Sap floodplain and adjacent areas (McDonald *et al.* 1997, Rundel 2000) may reveal that more species meet the global threat status criteria.

Cynometra (cf.) *inaequifolia* IUCN Vulnerable

Cynometra cf. *inaequifolia* was noted as a constituent species of the seasonally flooded freshwater swamp forest community of the Tonle Sap by Rollet (1972) but not by subsequent authors. It is unclear whether this is due to a misidentification by Rollet (1972), or it perhaps indicates a decline, natural scarcity or a localised distribution. This small-stature tree is known from Thailand, peninsular Malaysia, Malaysian Borneo and the Philippines, and has undergone a rapid decline due to ongoing clearance for agriculture and extraction for timber (IUCN 2004).

Dalbergia entadoides IUCN Data Deficient

This shrubby liana occurs commonly in the swamp or gallery forest formations of the Tonle Sap's seasonally flooded freshwater swamp forest community (Rollet, 1972, McDonald *et al.* 1997). Its known range covers Cambodia, Lao, Thailand and Vietnam (IUCN 2004).

MAMMALS

OVERVIEW

The mammals of the Tonle Sap have not yet been well studied, and no specific surveys have been conducted for any mammal species. Most field records are of incidental observations made during waterbird and reptile surveys, and by the Prek Toal Conservation Team rangers. The other main source of records is market specimens and captive animals.

Despite the almost total lack of specific historical information on mammals from the Tonle Sap floodplain, it is highly likely that it was seasonally important for a variety of large herbivores, when floodplain forests were connected to other major forest blocks to the north, east and southwest (e.g. McDonald *et al.* 1997). Kol (1987 cited in MoE 1994) mentions that the Tonle Sap forests “feature a range of wildlife including troupes of elephants (200-300 per troupe) wild buffalo and deer at certain times”. These may have included Eld’s Deer *Cervus eldi*, which still occurs in small populations just beyond the inundation zone (McShea *et al.* 2005 Seng *et al.* 2003) and the regionally extirpated Hog Deer *Axis porcinus*. Whatever their former status, however, wild large herbivores have now been extirpated from the TSBP. These extirpations may have occurred as recently as 10-20 years ago (McDonald *et al.* 1997, P.J.A.D. unpublished interview data). The most recent report of elephants was of a group seen crossing NR-6 in 1994 from the Tonle Sap floodplain travelling towards Boeng Per Wildlife Sanctuary (N. Thayer pers. comm. to D. Ashwell, 1994).

The TSBP does not support a particularly diverse mammal fauna, but several species that do still occur are listed as globally threatened (IUCN 2004), and may occur in

internationally significant numbers. It seems likely that one large mammal, the Irrawaddy Dolphin *Orcaella brevirostris*, was extirpated only very recently.

GLOBALLY THREATENED SPECIES

Loris sp. *Nycticebus* sp.

One loris was confiscated from a hunter within the Prek Toal Core Area in November 2000. The animal superficially resembled Northern Slow Loris *Nycticebus bengalensis* (IUCN Data Deficient), but the unlikely possibility of it being Pygmy Slow Loris *Nycticebus pygmaeus* (IUCN Vulnerable) could not be discounted (Goes and Hong 2002). Fishermen and hunters report that the species occurs in the Prek Toal Core Area (Sun Visal, WCS, verbally 2005).

Long-tailed Macaque *Macaca fascicularis* IUCN Near Threatened

This primate is still widespread and locally common in taller inundated forest-scrub within the TSBP, particularly around the lakeshore itself (e.g. Goes and Hong 2002). Large numbers (up to 170 individuals in one consignment) have been seized from hunters and traders, especially during the wet season, e.g. in Prek Toal (Goes and Hong 2002) and in Kompong Thom town (P.J.A.D. unpublished data). The population is likely to have declined as a result of hunting to supply captive breeding facilities in Cambodia, Vietnam and China (e.g. Goes 2002b). Captive individuals are frequently seen in many of the floating villages around the lake (Goes and Hong 2002).

It is common in Prek Toal Core Area (e.g. Goes and Hong 2002), where it is encountered on an estimated 70% of visits during

the wet season, when animals are more visible than during the dry season in the reduced area of available habitat (Sun Visal, WCS, verbally 2005). It also occurs in the Boeung Chhma Core Area (Goes and Hong 2002), the Stung Sen Core Area (Seng *et al.* 2003), and the Veal Srangai, Stung Sen-Santuk-Baray and Boeung Chhma Moat Khla IBAs (Seng *et al.* 2003).

Germain's Silver Leaf Monkey

Trachypithecus villosus germaini IUCN Data Deficient

This is the species referred to as Silvered Langur *Semnopithecus cristatus* by many previous authors. Recent taxonomic work first considered *T. v. germaini* a full species in its own right, Indochinese Lutung *Trachypithecus germaini* (Groves 2001), but this has since been rejected (Brandon-Jones *et al.* 2004). Nonetheless, given the uncertainties that remain over this species (and other primate)'s taxonomies, Brandon-Jones *et al.* (2004) urge that conservation measures be implemented for as many subspecies as possible. There are very few recent records of *T. v. germaini* from a large part of its range, which encompasses continental Thailand and parts of Myanmar, Lao PDR, Vietnam and Cambodia, prompting concern that it may qualify for the IUCN threat category Vulnerable, or possibly Endangered (J. Walston *in litt.* 2005).

Germain's Silver Leaf Monkey occurs in the Prek Toal and Boeung Chhma Core Zones (e.g. Seng *et al.* 2003), and Veal Srangai IBA (Goes *et al.* 2001). In Prek Toal Core Zone it is most regularly observed during the wet season, when animals become confined to discrete groups of trees by the flood waters (Sun Visal, WCS, verbally September 2005). Field observations suggest the species may be less well adapted to swimming long distances than Long-tailed Macaque *Macaca fascicularis* (Sun Visal, WCS, pers. obs.).

Recent surveys across Cambodia have revealed that *T. v. germaini* is relatively widespread, with post-2000 records from the Cardamom Mountains, the Northern Plains (Preah Vihear) and the north-east (Mondulkiri and Ratanakiri). The paucity of records from elsewhere within its range underscore the regional conservation importance of the Cambodian population. However, the relative significance of the Tonle Sap population within a national context cannot be assessed objectively at present.

Otters

Most otter records in Cambodia originate from markets or captivity, and specific locality data only exists for two species, Hairy-nosed Otter *Lutra sumatrana* and Smooth Otter *Lutrogale perspicillata*, both of which occur in areas of inundated forest and scrub within the TSBR (Poole 2003). Otters in Cambodia are trapped for their skins, which are used in Traditional Khmer Medicine to assist women during pregnancy and childbirth, and can fetch up to \$45/kg (Walston 2005). The relative lack of otter records from habitats where they would be expected to occur, combined with the demand for skins, make otters a high conservation priority in Cambodia. The seasonally inundated forest and scrub in the TSBR, which may hold globally significant populations of Hairy-nosed Otter, is the single most important priority area for otter surveys in Cambodia (Poole 2003).

Hairy-nosed Otter *Lutra sumatrana* IUCN Data Deficient

Two of the four confirmed records of this species from Cambodia come from the Tonle Sap: two captive individuals, which had reportedly been caught along the Prek Kantiel within the Prek Toal Core Area, were photographed in Prek Toal village in June 1998, and a young captive animal was photographed in Peam Bang village near the Boeng Chhma Core Area in December 1998 (Poole 2003). Villagers in Prek Toal considered the species may be

close to extinction in the Prek Toal area (Goes and Hong 2002). Hairy-nosed Otter was also reported to occur at Boeung Chhma (Doroshenko *et al.* 1998, Long 2003).

Smooth Otter *Lutrogale perspicillata*
IUCN Vulnerable

The only confirmed record of this species from the TSBR is of an individual caught by hunters in the inundated forest-scrub near Kbal Taol village south of the Prek Toal Core Area in mid 2002 (Poole 2003). This is the first time two otter species have been confirmed to co-exist at one site (Prek Toal) in Cambodia.

Unidentified otters

An unidentified otter was reported between Phnom Kraom and Prek Toal in October 2001 (Goes and Hong 2002). A group of four otters was seen along the Prek Preah Daem Chheu in March 2003 (Sun Visal, WCS, verbally September 2005). Prek Toal Conservation Team rangers report seeing otters annually, in groups of 4-8 individuals, and usually in the dry season (per Sun Visal, WCS, September 2005). Some stream owners complain that otters destroy fish traps (per Sun Visal, WCS, September 2005).

Fishing Cat *Prionailurus viverrinus*
IUCN Vulnerable

Frequently reported by local people, this elusive cat's occurrence in the TSBR was supported when tracks were measured and photographed by dried up pools in the outer floodplain part of the Prek Toal Core Zone in March/April 2002. Fresh tracks with measurements and a general impression matching that of Fishing Cat were seen in February 2002 in western Kruos Kraom (P.D. unpublished data).

Irrawaddy Dolphin *Orcaella brevirostris*
IUCN Data Deficient

Irrawaddy Dolphin formerly occurred in the Tonle Sap Lake, but may now be extirpated. The population was decimated in the 1970s by the Khmer Rouge, who hunted them for their oil, which was reportedly used as a petroleum substitute for motor-

cycles and motorboats (Baird and Beasley 2005). As of 1997, occasional dolphin sightings have been reported from the lake (Baird and Beasley 2005), but there have been no confirmed or published sightings since 1969 (Lloze 1973). In March 2004, 567 kilometres of boat-based surveys conducted over 40 hours by the Mekong Dolphin Conservation Project yielded no sightings. Interview surveys with 156 professional fishers confirmed that dolphins had not been seen in the lake since 1990 (I. Beasley unpublished data).

Additional notes on mammal species

Giant Flying Squirrel *Petaurista sp.*

Reported from the Prek Toal Core Area, where it is considered to be very rare (Sun Visal, WCS, verbally September 2005).

Asiatic Jackal *Canis aureus*

The only records reported by biologists are from the Kruos Kraom area within the Stung Sen-Santuk-Baray IBA, where it has been observed twice, in July 2000 (Goes *et al.* 2001) and March 2002 (P.D. unpublished data) in the outer floodplain grassland-scrub mosaic and deepwater rice agro-ecosystem. Farmers in the area report that jackals were formerly common, but have declined as a result of hunting for food (Goes *et al.* 2001).

Leopard Cat *Prionailurus bengalensis*

One captive individual, photographed in the Fisheries Office at Phet Sanday village, at the mouth of the Stung Sen in Kompong Thom province on 2 December 1998 (Goes and Hong 2002), was the only record traced, and the only evidence that the species may occur within the TSBR.

Small Asian Mongoose *Herpestes javanicus*

The few scattered records of this species (including from Prek Toal Core Area and the Siem Reap-Kompong Thom border region), suggest a widespread distribution (Goes and Hong 2002). This mammal is widespread in Cambodia, and seemingly relatively resilient to human disturbance in

the variety of landscapes it occurs in; as such it is not (currently) of conservation concern.

Variable Squirrel *Callosciurus finlaysonii*

The distinctive deep rufous-coloured morph of this squirrel is widespread in the forested areas of the floodplain (e.g. Bailleux 2003, P.J.A.D. unpublished data).

Bats

Lyle's or Large Flying-Fox *Pteropus lylei/vampyrus*

A roost of several thousand was photographed 8km south-west of Phnom Kraom, Siem Reap province, in August 1997 (Sam 1997 cited in Goes and Hong 2002). Approximately 1,000 roosted in trees at Dey Roneath in 2002 (month not given), but were disturbed regularly by fishermen and hunters, and did not return in 2003 (Sun Visal, WCS, verbally 2005). Roosts are occasionally reported in the Prek Toal Core Area, and residents of Kbal Taol village reported that there was a roost near the Pursat/Battambang border in 2004.

Small numbers of microchiropteran bats are regularly observed (perhaps more in the wet season) feeding over the lake surface, and roosts occur in pagodas around the fringes of the floodplain (Goes and Hong 2002, P.D. unpublished data).

Rodents

In 2003-4, studies of rats in ricefield habitats have been conducted in four provinces around the Tonle Sap, Kompong Chhnang, Siem Reap, Banteay Meanchey and Battambang. At least six species have been trapped within ricefield habitats, i.e. outside villages and the immediate commensal environments shared with human populations, and identified through molecular analysis of DNA and comparison with other specimens from the region (Frost *et al.* in prep.).

Bandicoot rat *Bandicota indica* is widespread in lowland rice growing areas, and is very common where conditions are

favourable. The Lesser Bandicoot Rat *B. savilei* has a more patchy distribution (within the TSBR, it has thus far only been recorded from Kompong Chhnang province), and is much less common. Field Rat *Rattus rattus*, which may comprise two distinct taxa, is widespread in most habitats and common in ricefields. Ricefield Rat *R. argentiventer* only occurs in the southern part of the TSBR, in Kompong Chhnang province; its distribution in Cambodia is restricted to the south-east of the country. Lesser Ricefield Rat *R. losea* is less common than *R. argentiventer*, but more widespread in the TSBR and locally common in Siem Reap, occurring in ricefield habitats in both the south-east and north-west. Field Mouse *Mus cervicolor* occurs in the north-west of the TSBR, and favours grassland habitats, including ricefields (Frost *et al.* in prep.).

Farmers interviewed by Frost *et al.* (in prep.) describe a strong link between the presence of seasonally inundated shrubland and high rodent rice crop damage: in areas where scrub and forest have been cleared, crop damage is significantly reduced, clearly indicating that short-tree shrubland is a key habitat for rodent populations, probably as shelter and nesting habitat during the inundation period. In Kompong Cham, interviewees report that the fields closest to the floodwaters generally have higher levels of crop damage from rodents than those further away Frost *et al.* (in prep.). These factors infer that the Tonle Sap inundation zone supports significant populations and/or high densities of several rodent species. Casual dry-season field observations in Kompong Thom confirm this, where the abundant rodent populations associated with deep-water rice cultivation provide an important prey base for substantial populations of birds of prey (P.J.A.D. unpublished data).

BIRDS

Birds are the best-studied faunal group within the TSBR, and consequently their status is better known than for any other faunal group. Two bird communities of great global significance have been the focus of WCS conservation and monitoring projects since 2001. Counts and protection of the large waterbird colonies have been conducted in Prek Toal Core Area since the late 1990s, and since 2003 have been the subject of an increasingly sophisticated monitoring system (Goes *et al.* 1998, Hong 1999, Goes and Hong 2002, Goes 2005). Bengal Florican *Houbaropsis bengalensis* and other species using the grasslands and agro-ecosystems of the floodplain in Kompong Thom and Siem Reap provinces have been the focus of monitoring and research since 2001 (Davidson 2004, Hong and Ro 2005, Davidson *et al.* in prep.). In addition, large areas of the Tonle Sap floodplain, especially north and east of the lake, were covered during the Important Bird Area identification process in 2000-2002 (Seng *et al.* 2002, 2003), and various ad hoc visits have been made to potentially interesting sites for birds at different times of year (Carr 1993, 1994, Mundkur *et al.* 1995, Parr *et al.* 1996, Goes and Hong 2002, Long and Sun 2002).

By June 2005, 210 bird species had been recorded in the TSBR (Annex 3), of which 17 are globally threatened or Near Threatened (BirdLife International 2004).

Breeding colonies of large waterbirds

Prek Toal Core Area

The TSBR supports the largest remaining fragment of a bird megafauna that was once widespread across much of South-east Asia (Davidson *et al.* 2001). The vast majority of these large waterbirds breed in the inundated forest and scrub of Prek Toal Core Area. Prek Toal represents either the largest or the only remaining nesting site in South-east Asia for seven Globally Threatened colonial large water-

birds, Greater Adjutant *Leptoptilos dubius* (Endangered), Lesser Adjutant *Leptoptilos javanicus*, Spot-billed Pelican *Pelecanus philippensis* and Milky Stork *Mycteria cinerea* (all Vulnerable), and the Near Threatened Painted Stork *Mycteria leucocephala*, Black-headed Ibis *Threskiornis melanocephalus* and Darter *Anhinga melanogaster* (BirdLife International 2001, 2003, Goes and Hong 2002, Goes in prep.). The site supports 10-30% of the global population of each of these species (except Milky Stork), totaling up to 5,000 breeding pairs. Prek Toal is the only site in South-east Asia where Black-necked Stork *Ephippiorhynchus asiaticus* (Near Threatened)—a solitary nester—has been confirmed to breed (Sun 2005). In addition, the Masked Finfoot *Heliopais personata* (Vulnerable) is an uncommon wet season breeding visitor to the inundated swamp forest of Prek Toal Core Area (Goes 2001, Goes and Hong 2002, Seng *et al.* 2003).

Internationally significant populations (> 1% of the Asian biogeographic population) of several other large waterbirds breed within the Prek Toal Core Area: Little Cormorant *Phalacrocorax niger*, Indian Cormorant *P. fuscicollis*, Great Egret *Casmerodius albus* and Asian Openbill *Anastomus oscitans* (Seng *et al.* 2003). An additional suite of large waterbird species, each of which is threatened as a breeding species, at least, in the adjacent countries of Thailand (Round 2000), Laos (Duckworth *et al.* 1999) and Vietnam (Safford and Buckton 2004), also occur in substantial numbers within the TSBR: Woolly-necked Stork *Ciconia episcopus*, Glossy Ibis *Plegadis falcinellus*, Grey Heron *Ardea cinerea*, Purple Heron *Ardea purpurea* and Great Cormorant *Phalacrocorax carbo*.

It is important to note that each large waterbird species only uses Prek Toal during its breeding season, and as such Prek Toal cannot be viewed in isolation when considering the conservation of large waterbirds in Indochina. After breeding, most individuals of all species disperse widely across Cambodia, using other parts

of the Tonle Sap floodplain (e.g. Boeng Tonle Chhma/Moat Khla and the Kompong Thom grasslands), and areas north-west of the TSBR (e.g. Ang Trapeang Thmor Sarus Crane Reserve) in particular, as well as the Mekong delta and Cambodia's northern plains (e.g. Davidson *et al.* 2001, Seng Kimhout *et al.* 2003). Small numbers range farther, into north-east and central Thailand, southern Lao PDR and southern Vietnam (Duckworth *et al.* 1999, BirdLife International 2004a, Buckton and Safford 2004).

Dei Roneath IBA

The seasonally inundated swamp forest along the shores of the lake in Pursat province may support a significant colony of Lesser Adjutants (100+ pairs reported in 2001) and Darters (1,000+ pairs reported in 2001), in addition to the largest known colony of Purple Heron *Ardea purpurea* in Cambodia, if not South-east Asia, comprising 1-10% of the Asian biogeographic population (Rose and Scott 1997, Goes 2001, Goes and Hong 2002). The current status of these colonies is unknown because they are not monitored annually.

Other significant swamp forest and permanent wetland sites for water-birds

Boeng Chhma Core Area and Moat Khla

The seasonally inundated swamp forests and short-tree shrublands of the Boeng Chhma Core Area are less well studied, but do support important post-breeding feeding concentrations (May-July) of Greater Adjutant and Spot-billed Pelican and the highest count of Black-necked Storks (6 in late June 1998) from the TSBR (Goes 2001, Seng *et al.* 2003), along with 3,500 Indian Cormorants and 200+ Great Cormorants *Phalacrocorax carbo*. The total population of Indian Cormorant in the TSBR is equivalent to 30% of the global population, with key concentrations occurring seasonally at Chhnuk Tru, Prek Toal and Boeng Chhma (Carr 1993, Rose and Scott 1997, Goes 2001).

This inland delta at the mouth of the lake, and area of extensive *Phragmites karka* beds and shallow water, where the Stung Sen River enters and the Tonle Sap River begins, seasonally supports 6,000+ Indian Cormorants (see above), 1,500 Purple Swampheens *Porphyrio porphyrio* (part of a regionally important population estimated at 10,000 birds in the TSBR), 500 Black-winged Stilts *Himantopus himantopus* (1-10% of the Asian biogeographic population) and large numbers of migratory shorebirds (March - May) that utilise the mudflats that are only exposed at the height of the dry season (Carr 1993, Rose and Scott 1997, Goes 2001).

Tonle Sap Lake

The open lake is an important feeding area for an estimated 2,000 Brown-headed Gulls *Larus brunnicephalus* (2% of the global population) and 10,000+ Whiskered Terns *Chlidonias hybridus* (perhaps the highest known concentration in South-east Asia) (Goes 2001, Davidson 2005).

Bird fauna of grassland and agro-ecosystems

A suite of globally threatened species and internationally significant populations seasonally utilise the grasslands and agricultural habitats of the middle and outer Tonle Sap floodplain. These habitats support the largest known breeding population of Bengal Floricans *Houbaropsis bengalensis* (Endangered) in South-east Asia, and perhaps the world (Davidson *et al.* in prep.). The floricans breed during the dry and early wet seasons, from January to July, when the rising flood forces them to migrate across the agricultural belt of land flanking NR-6 to patchy grasslands within open deciduous dipterocarp woodlands outside the inundation zone (Davidson 2004). The largest known breeding concentrations are in Veal Srangai, Stung Sen-Santuk-Baray and Stung-Chikreng-Kompong Svay IBAs in Kompong Thom and Siem Reap provinces, but large areas of grassland and agro-ecosystem have not been surveyed (Seng *et al.* 2003, Davidson 2004).

The many small wetlands scattered throughout the floodplain grassland and agricultural habitats are important feeding areas for large waterbirds, chiefly when the flood recedes during November-January and when the flood rises again in June-July, but also during periods of heavy rainfall mid dry season (P.D. unpublished data). Most important among these are the White-shouldered Ibis *Pseudibis davisoni* (Critically Endangered), which is infrequently recorded in very small numbers (Sam 1999, P.J.A.D. unpublished data), and large flocks of Greater Adjutant and Lesser Adjutant (maximum national counts of both come from the Tonle Sap floodplain grasslands). In addition, large flocks of Black-headed Ibis, Painted Stork and Asian Openbill, and smaller numbers of Woolly-necked and Black-necked Storks use these grasslands seasonally.

Flocks of Sarus Crane *Grus antigone* (Vulnerable) use the drier grasslands as migration staging posts, and in recent years a flock of up to 25 has spent the non-breeding season (December-April) in Stung-Chikreng-Kompong Svay IBA (Davidson 2005).

The abundant rodent populations associated with deepwater rice agro-ecosystems and grasslands (Jahn 1997) in Kompong Thom support internationally important populations of Greater Spotted Eagle *Aquila clanga* and a few Imperial Eagles *Aquila heliaca* (both Vulnerable) between December and April, during the boreal winter (P.J.A.D. unpublished data). Many other raptors exploit this rich prey base during the dry season, including large numbers of Eastern Marsh Harriers *Circus spilonotus*, and smaller numbers of Pied Harriers *Circus melanoleucos*, Black Kites *Milvus migrans*, Brahminy Kites *Haliastur indus*, which collectively must represent one of the most important raptor assemblages in South-east Asia.

The largest-known wintering population of Manchurian Reed-warbler *Acrocephalus tangorum* (Vulnerable) uses a variety of tall grass and scrub habitats, and Asian Golden Weaver *Ploceus hypoxanthus*

(Near Threatened) nests in riparian larger bushes and trees flanking some of the Tonle Sap's tributaries (Seng *et al.* 2003). Red Avadavat *Amandava amandava*

Grassland habitats in the outer floodplain (especially in Stung-Chikreng-Kompong Svay and Stung Sen-Santuk-Baray IBAs) support healthy dry season populations of several grassland/agro-ecosystem specialists that have undergone substantial declines in other parts of South-east Asia (e.g. Duckworth *et al.* 1999, Round 2000, 2002). These include Small Buttonquail *Turnix sylvatica*, Blue-breasted Quail *Coturnix chinensis*, Red Avadavat *Amandava amandava*, Striated Grassbird *Megalurus palustris*, Australasian Bushlark *Mirafra javanica* and Oriental Skylark *Alauda gulgula*.

Deepwater rice stubbles provide important food sources for large flocks of both granivorous species, especially Yellow-breasted Bunting *Emberiza aureola* (Near Threatened), which has undergone widespread declines at wintering sites across much of its range (BirdLife International 2004a), and insectivores, including Oriental Pratincole *Glareola maldivarum*, Black Drongo *Dicrurus macrocercus*, Bluethroat *Luscinia svecica*, Red-throated Pipit *Anthus cervinus* and Yellow Wagtail *Motacilla flava*. As the flood rises in the early wet season, deepwater rice fields are important feeding habitats for Javan Pond Heron *Ardeola speciosa*, Watercock *Gallicrex cinerea* and Purple Swamphen *Porphyrio porphyrio*, Cinnamon Ixobrychus *ixobrychus cinnamomeus* and Yellow Bitterns *Ixobrychus sinensis* (P.J.A.D. unpublished data).

Aerial insectivores occur in dense flocks over grassland and scrub mosaic habitats, including Red-rumped Swallow *Hirundo daurica* and Sand Martin *Riparia riparia* (P.J.A.D. unpublished data).

Bird communities of the swamp forest and short-tree shrublands

The inundated forest around the lake itself is rather species-poor in comparison with other forest types (evergreen, semi-

evergreen, deciduous and deciduous dipterocarp) in lowland Cambodia. Nonetheless, it supports some important populations of resident birds. Most notable is the Grey-headed Fish Eagle *Ichthyophaga ichthyaetus* (Near Threatened), which is widespread and may occur at higher densities around the Tonle Sap than in any other part of its wide Asian range. Estimates suggest that at least 15 pairs may breed in the Prek Toal Core Area, and the population around the lake as a whole may exceed 100 pairs (Goes 2001, Goes and Hong 2002). It is a dry season breeder in Boeung Chhma and Prek Toal Core Areas (Goes 2001), when adults are able to take advantage of the abundant fish build up behind fishing lot traps. One other notable element to the resident swamp forest bird fauna is that it supports one of very few inland populations of Mangrove Whistler *Pachycephala grisola*, perhaps a remnant associated with elements the floodplain flora that show affinities with coastal mangrove habitats.

Short-tree shrublands provide important roosting, loafing and cover habitats for species feeding in the more productive adjacent grassland and wetlands. Populations of many species for which the TSBR is internationally important use this habitat, including all stork species, cormorants and darters, herons and egrets, most birds of prey and Manchurian Reed Warbler. No bird species occurs exclusively in this habitat, however.

Globally important bird population statistics and ecological notes

Estimating numbers of breeding large waterbirds at the colonies in the Prek Toal Core Area is complex and potentially prone to large variances, largely due to the logistical difficulty of viewing the colonies. Only conspicuous tree-nesters can be counted at the colonies; this immediately rules out ibises, which nest out of sight, low down in scrub. Storks, pelicans, Darters and cormorants are tree-nesters, and can be counted from the network of 7-10 observation platforms. These species may occupy 690-880 trees each year, of which almost 250 are not visible from any

observation platform, and at least 27 are visible from more than one platform. The potential margin of error in estimating numbers is therefore considerable in a year when large numbers of birds chose to nest in trees that are not visible from observation platforms: there exists potential to underestimate numbers by up to 35%. Counts made elsewhere (along the lakeshore and at post-breeding dispersal sites) provide useful comparatives to the colony counts, and a means of assessing numbers for species that cannot be counted at colonies, e.g. ibises.

The monitoring programme is undergoing continual improvements, to provide a simple and sustainable method to generate annual population estimates. Nonetheless, the current platform-based monitoring system has already proved invaluable in a) enabling numerical assessments of the conservation significance of the Prek Toal colonies, b) providing an extremely effective tool for managing the Prek Toal colonies, including protection, enforcement, tourism and colony demarcation, c) evaluating the success of conservation activities, and d) detecting threats elsewhere in the landscape.

For each of the species of global significance, the following summary accounts give minimum population estimates for Prek Toal Core Area within a global context, highlighting aspects of the species ecology that are important to their conservation.

Greater Adjutant *Leptoptilos dubius* IUCN Endangered

The Prek Toal Core Area population numbered a minimum of 51 breeding pairs in 2003-4 (WCS unpublished data), making it the second largest colony in the world, and representing just over 10% of the global population (BirdLife International 2004a). This number may indeed be higher, because colonies are not always visible from the counting platforms (Goes 2005). Greater Adjutant was also reported to breed in the Boeung Chhma/Moat Khla and Stung Sen Core Areas, but follow-up field surveys only found empty, collected nests

(Goes and Hong 2002). Up to 82 birds have been counted along the Prek Toal Core Area lakeshore (Goes 2005), and post-breeding flocks of at least 85 have been counted on feeding grounds in inundated grasslands in Stung Sen-Santuk-Baray IBA in Kompong Thom province in June-July (e.g. Goes 2001).

This stork, and its congener the Lesser Adjutant, also breeds in Cambodia's Northern Plains; twenty-one Greater Adjutant nests were counted in two Northern Plains colonies in 2004-5 (Tan *et al.* 2005). Adjutants in the Northern Plains breed during the wet season and/or early dry season (between August and February), a little earlier, but in some cases overlapping with, the breeding period for adjutants in Prek Toal (December-May). This implies that they comprise at least partially separate breeding populations. Further research is required to better understand seasonal movements and any linkages between these populations, which disperse widely across Cambodia during non-breeding periods.

Lesser Adjutant *Leptoptilos javanicus* IUCN Vulnerable

A minimum number of 209 nesting pairs was counted in the Prek Toal Core Area in 2004-5, an increase from 149 pairs in 2003-4 (WCS unpublished data). This is the largest known breeding population in South-east Asia, representing approximately 10% of the global population (BirdLife International 2004a). Other (much smaller) colonies were reported in Dei Roneat IBA in 2000-2001, and Boeung Chhma/Moat Khla and Stung Sen Core Areas in 2001 (Goes and Hong 2002). The highest count (168) of the species anywhere in Cambodia in recent decades, perhaps a post-breeding aggregation, was made in Veal Srangai IBA in April 2002 (Goes and Davidson 2002), when only 40 pairs were estimated to breed in the Prek Toal Core Area (Goes and Hong 2002). Understanding the conservation requirements of the Cambodian population of this species will require research into the seasonal movements and any linkages between the Tonle Sap and

the Northern Plains breeding populations (see Greater Adjutant).

Spot-billed Pelican *Pelecanus philippensis* IUCN Vulnerable

Prek Toal Core Area supports the largest single colony of this pelican in the world, estimated to number 900-1,100 pairs in 2005 (Goes 2005, WCS unpublished data), representing approximately 20% of the global population (BirdLife International 2004a). Although pelicans disperse widely across Cambodia and beyond post-breeding, the species is better adapted to remain in deeply flooded habitats than any other large waterbird species, and as such a proportionately larger number may remain in the flooded habitats of the TSBR during the wet season.

Milky Stork *Mycteria leucura* IUCN Vulnerable

Up to ten pairs are estimated to breed with the Painted Stork colonies in the Prek Toal Core Area. This number is rather insignificant in a global context, but this is the only known inland breeding population in mainland South-east Asia; the species breeds primarily in mangroves elsewhere (BirdLife International 2001). The Cambodian population may soon be the only population in South-east Asia, with only 10 birds remaining in Malaysia (Malayan Nature Society *in litt.* to C. Shepherd, September 2005).

Painted Stork *Mycteria leucocephala* IUCN Near Threatened

The Prek Toal Core Area supports a breeding population in the region of 1,000 pairs (Goes and Hong 2002), equivalent to 20% of the global population. Accurate population estimates for this species are hampered by the large proportion of birds that nest out of view of platforms each year.

Darter *Anhinga melanogaster* IUCN Near Threatened

This species has increased dramatically since monitoring began in 2001, when 280 nests were counted; in 2004-5, that total had risen to 1,870, a factor of eight increase over four years, or a doubling of

the population annually. If this exponential increase continues (a similar pattern has been shown by cormorants also), it will present management problems through potential occupancy of nesting trees required by other species that breed later in the season, and with protection.

White Shouldered Ibis *Pseudibis davisoni* IUCN Critical

Historically the species was described as a common bird in Cambodia in 1924 (Delacour and Jabouille 1925), or less numerous than Woolly-necked Stork, but nevertheless very abundant in the region of Siem Reap and Angkor (Delacour 1924). Other historical records and accounts, in the Tonle Sap region include; Kompong Thom, common in this province during the 1920's, (although the only specific record given is of five resting in a marsh near Kompong Thom, April 1924) (Delacour and Jabouille 1925); one seen at Angkor Wat roosting on a temple in 1924 (Delacour and Jabouille 1925); large numbers seen between Kompong Thom and Siem Reap in December 1927 and January 1928 (Delacour 1929), at Siem Reap many observed in the 1920's around Boeng Tonle Sap (Delacour 1928); two collected at Siem Reap in August 1938 (Eames and Ericson 1996).

This Critically Endangered species is now very rare with populations persisting only in Indochina and on Borneo. The most important populations in Indochina now are found in Cambodia, with birds concentrated in four main areas.

In the Tonle Sap region in contrast to the species historical abundance the only recent record come from two relatively small areas of the southeastern floodplain in Khompong Thom Thom Province, where up to 20 birds have been sighted on a number of occasions between 1999 and 2004. Despite extensive survey work for Bengal Floricans in similar areas of the eastern and northern floodplain there have been no other survey records. Also the species has never been observed in the northwest in the extensive areas of scrub, forest, watercourses and pools around the colonies of large waterbirds in the Prek Toal area of the inner floodplain of the

lake. However the western extremity of these same 'flooded forests' which abut agricultural lands on the western floodplain, and where White-shouldered Ibis might be most likely found, has never been well surveyed, most survey work having been focused on the 'eastern' lake-side.

Black-headed Ibis *Threskiornis melanocephalus* IUCN Near Threatened
Prek Toal Core Area supports the largest breeding colony of the species in South-east Asia (e.g. Goes 2001), but numbers cannot be reliably counted there because they nest out of sight in thick shrubland. Post-breeding counts from Ang Trapeang Thmor Sarus Crane Reserve in Banteay Meanchey province peaked at 1,600 in 2003 (Goes 2005). If only half of these were breeding adults, 400 pairs are equivalent to 8-15% of the global population (Goes and Hong 2002).

Bengal Florican *Houbaropsis bengalensis* IUCN Endangered

Counts of displaying males at three sites monitored from 2002-4 gave an estimate of 64-122 at three sites covering a combined area of 170km² (Davidson *et al.* in prep.). Examination of MRC/GTZ (1999) land-cover data and 2002 Landsat Thematic Mapper (TM) raw satellite imagery suggest that additional grassland areas within and around the Tonle Sap floodplain may cover more than 2,000 km² (Davidson 2004), almost ten times the area surveyed. It is therefore possible that the total number of Bengal Floricans in and around the Tonle Sap floodplain will be found to equal or exceed the total number (530; BirdLife International 2004a) thought to exist in the only other population, in the Indian subcontinent (Davidson *et al.* in prep.). Breeding male floricans display in a variety of grassland landscapes, which are maintained by various combinations of cultivation and fallowing, burning and livestock grazing land-uses. At a landscape scale, territorial males aggregate in larger areas of short grassland for displaying, but tolerate a broad range of structural habitat composition and land-use within their individual territories (Davidson 2004).

Much still needs to be learnt about the florican: it appears to have an exploded lek mating system, in which female breeding requirements may not be well reflected by male habitat associations; annual productivity is not known and urgently requires detailed study. Floricans breeding within the floodplain make short-distance migrations across a 15-30km wide agricultural belt to open woodland mixed with patchy grasslands. The florican's non-breeding (wet-season) distribution, habitat preferences and threats are poorly understood, and are a priority for further research (Davidson 2004).

Sarus Crane *Grus antigone* IUCN Vulnerable

The outer floodplain grasslands in Stung Sen-Santuk-Baray IBA regularly host flocks of up to 30 Sarus Cranes (e.g. Goes and Davidson 2002) migrating between their breeding grounds in the northern and north-eastern plains of Cambodia (e.g. Davidson *et al.* 2001) and non-breeding congregations at Ang Trapeang Thmor Sarus Crane Reserve just north-west of the Tonle Sap floodplain in Banteay Meanchey province (Goes 2004, Hong and Goes 2001). Since 2002, a steadily growing non-breeding population of Sarus Cranes have been spending the dry season (December to April) in the Prolay grassland of Stung District, Kompong Thom province; by February 2005 this population numbered 30+ (Davidson 2005), the only known non-breeding congregation of this bird in the TSBR.

Greater Spotted Eagle *Aquila clanga* IUCN Vulnerable

Historical evidence indicates that Cambodia once supported a regionally significant wintering population of Greater Spotted Eagle (e.g. Thomas and Poole 2003). Up to six are recorded each winter (January-April) in the 120km² of grassland-scrub-agricultural landscape in the Kruos Kraom area of Kompong Thom province (e.g. Davidson 2001, Goes and Davidson 2001, Goes *et al.* 2004), and a single day-count at the site in March 2004

produced 6-10 birds. Smaller numbers are recorded at other outer floodplain sites (e.g. in Stung-Chikreng-Kompong Svay IBA; Seng *et al.* 2003). Greater Spotted Eagles, together with occasional Imperial Eagles *Aquila heliaca* (also IUCN Vulnerable), congregate in the cultivated parts of the floodplain to exploit the high densities of rodents. Given the extent of suitable habitat, the population using the Tonle Sap floodplain's agro-ecosystems is potentially larger than the population wintering in Thailand, estimated at 60-100 birds (Mallalieu in prep.).

Manchurian Reed Warbler *Acrocephalus tangorum* IUCN Vulnerable

Since the discovery of a wintering population of Manchurian Reed Warblers (present from at least December to early May) in the Tonle Sap floodplain in 2001 (Davidson 2001), the species has been proven locally common in a variety of habitats in the middle and outer floodplain, including tall, dry grassland and dry shrubland edge and freshly burnt tall grass and scrub habitats, as well as sedge beds, *Phragmites* stands and lotus swamps (Goes and Davidson 2003, P.J.A.D. unpublished data). There is so much habitat that superficially seems suitable for it in the TSBR, that if it occurs across much of the floodplain at the densities we know it to occur in at one or two localities, it will very likely prove to be too numerous to be considered IUCN Vulnerable under small population criteria. Plans to survey representative habitats in different parts of the floodplain are being made for early 2006. Only one other site, in Thailand, is currently known to regularly support significant numbers (tens of birds) in winter (Round 1994), where a close association with *Phragmites* beds (now a scarce habitat in Thailand) has been demonstrated (Round and Rumsey in prep.).

Yellow-breasted Bunting *Emberiza aureola* IUCN Near Threatened

This small passerine, known in Khmer as *Chap Prey Veng* ("the sparrow of Prey

Veng”) on account of its former abundance, has undergone widespread declines at wintering sites across much of its range (BirdLife International 2004a). Large numbers still occur in the TSBR: flocks numbering 5,000 birds have been noted as recently as 2000 (Goes 2000, P.J.A.D. unpublished data). The traditional floating rice agro-ecosystems of the Tonle Sap floodplain are crucial wintering habitat for the species now that much of this habitat in its former strongholds in the Mekong Delta (e.g. Prey Veng; Thomas and Poole 2003) and similar habitats in Thailand (Round 2002) have been converted to intensive rice cultivation.

Locally extinct large waterbirds

One large waterbird species has been extirpated from the Tonle Sap (and with it South-east Asia as a whole), the Greater Flamingo *Phoenicopterus ruber*, which was last recorded in 1935 (Delacour and Jabouille 1931, Thomas and Poole 2003). One more large waterbird, the Great White Pelican *Pelecanus onocrotalus* was formerly numerous (Thomas and Poole 2003), but is now on the brink of extirpation, with just two recent records, one reported from Boeng Chhma in January 1996 (Edwards 1999), and one photographed near Prek Toal on 25 March 2001 (Goes and Falise 2001). Black-faced Spoonbill *Platalea minor* (IUCN Endangered) was described by Delacour (1929) as “seen in some numbers near Kompong Thom”. There have been no recent records, and in the absence of specimen evidence, the species’s occurrence is best treated as unconfirmed due to potential confusion with Eurasian Spoonbill *P. leucorodia*, which was recorded for the first time in Cambodia at Prek Toal in March 2004 (Goes *et al.* 2004).

REPTILES

The Tonle Sap is perhaps the single most important wetland for reptile conservation in Southeast Asia (Goes 2005). The enormous extent of wetland habitat formerly supported an abundant reptile fauna (e.g. Zhou 2002), which has been subject to sustained high levels of exploitation for over a decade (Bailleux 2003). Nonetheless, the TSBR is still believed to support internationally significant populations of at least eight globally threatened reptile species, including the Critically Endangered Siamese Crocodile *Crocodylus siamensis*, at least six species of freshwater turtle, including the Endangered Yellow-headed Temple Turtle *Hieremys annandalii*, and Burmese Python *Python molurus* (Near Threatened). Relatively little herpetofaunal survey work has been conducted, and many reptiles are now difficult to observe in the field because their populations have been reduced to very low densities, thus recent status assessments are generally based more on surveys of markets than animals observed in the wild. The following accounts focus on the key species.

Globally threatened species

Siamese Crocodile *Crocodylus siamensis*

The Siamese Crocodile was once abundant and widespread in the TSBR (e.g. Nao and Touch 1994), but wild populations have plummeted in recent decades due largely to chronic over-harvesting of eggs, young and adults to stock crocodile farms (Anon. 2004, Platt *et al.* 2004). Since 2000, wild crocodiles have continued to be widely reported in the TSBR, and at least 105 wild crocodiles were collected in the Tonle Sap region between 1998 and 2002 (Anon. 2004).

Widespread, dedicated crocodile interview, field sign and spotlight surveys were conducted in the TSBR from June 2000 to September 2001 (Platt *et al.* 2004). However, these spotlight surveys along almost 170km of waterways in the Prek Toal, Boeng Chhma-Moat Khla and Stung

Sen Core Areas did not yield any crocodile sightings, and no crocodile signs were encountered during daylight surveys (Long 2002, Platt *et al.* 2004).

Interview reports indicate that very small numbers of Siamese Crocodiles persist in several areas of TSB: the three core areas, Dei Roneat, Fishing Lot no.6 and inundated forest in Battambang province adjacent to the Prek Toal Core Area (Platt *et al.* 2004). Reported collection of hatchlings from Boeng Chhma-Moat Khla and Prek Toal Core Areas, inundated forest adjacent to the Prek Toal Core Area, and the Dei Roneath wetlands indicates that reproduction was occurring in these areas (Platt *et al.* 2004). However, densities are probably so low that their viability may be questionable (Platt *et al.* 2004), and the total population may not exceed a few pairs (Long 2002).

In 2005, two wild Siamese Crocodiles (one female and one male) were caught in Fishing Lot no. 1 by fishermen from nearby Kbal Taol village, and taken to Pursat Provincial Department of Fisheries, for future tag and release back into the same Fishing Lot (Heng Sovannara and Sun Visal, WCS, verbally, September 2005). One adult Siamese Crocodile was discovered dead following a fire in inundated forest-scrub habitat at Moat Khla in March 2005, and a wild crocodile sighting was reported from an area north of Boeng Chhma Core Area by the Kompong Kleang fishing community in June-July 2005 (Heng Sovannara, WCS, verbally September 2005).

Platt *et al.* (2004) found no evidence to suggest that crocodilians other than *C. siamensis* currently inhabit the TSB. However, there is the possibility that some of the "wild" crocodiles present around the Tonle Sap now may be animals that have escaped or been released from farms (Long 2002), and there are reports from 2003-4 that captive crocodiles (of unknown genetic stock) have escaped from Prek Toal (Sun Visal, WCS, verbally September 2005). This is a major concern because of the presence of Cuban Crocodile *C. rhombifer* and hybrid *C. sia-*

mensis x *C. rhombifer* in farms in Siem Reap (Platt *et al.* 2004). The existence of a large, unregulated crocodile farming industry in Cambodia is still the primary threat to wild crocodiles in the TSB, providing strong incentives for villagers to harvest the last remaining wild individuals.

Habitat loss and degradation appears to have contributed little to their decline: significant areas of suitable but unoccupied crocodile habitat remains (Platt *et al.* 2004). The TSB probably retains the single most extensive contiguous tract of suitable habitat for Siamese Crocodiles in Cambodia. If adequate *in situ* protection of wild crocodile populations can be achieved through enlisting the cooperation of fishing lot owners and fishermen, conservation management prospects for the Tonle Sap Siamese Crocodile population would significantly improve, and reintroduction into secure areas of the TSB could be warranted, alongside rigorous monitoring to evaluate recovery efforts and detect future population trends (Platt *et al.* 2004).

Estuarine Crocodile *Crocodylus porosus* Historical Occurrence

There is strong anecdotal evidence that Estuarine Crocodile *C. porosus*—which is not globally threatened—formerly occurred in the Tonle Sap, based on verbal reports and bas-reliefs of very large, aggressive (human-attacking) crocodiles (Platt in prep.). The measurements of a crocodile mandible collected in swamp forest along the northern shore of the lake provide the first compelling physical evidence that Estuarine Crocodile formerly occurred sympatrically *C. siamensis* in the Tonle Sap ecosystem, as it does with other congeners elsewhere (Platt in prep.). Recent interview survey data indicate that *C. porosus* was extirpated from the lake 30 to 50 years ago (Platt *et al.* 2004). Its large size and aggressive behaviour would have made it especially vulnerable to heavy persecution (Platt in prep.).

Freshwater turtles

Turtle populations in lowland wetland habitats throughout Cambodia have plum-

meted as a result of over-harvesting, chiefly for both legal and illegal export to China and Vietnam, for use in traditional medicine and as food (e.g. Walston 2005), and also for domestic consumption (Touch *et al.* 2000). The TSBR is no exception: turtles here have sustained heavy harvesting pressure since the early 1980s (Keng 2000, 2003). Most recent turtle records derive from markets and captive individuals, few of which have verifiable locality data. Eight species are reported or known to occur in the TSBR, all of which are globally threatened. More detailed information on the individual threatened species is given below.

Inundated forest-scrub with numerous pools is considered the most important habitat for turtles during the dry season (Long 2003), particularly in areas with high numbers of fruiting trees (Sun Visal, WCS, verbally September 2005). Most turtle species are thought to breed in the dry season, when human disturbance and the risk of fire are highest; indeed, use of fire is reported as a method for hunting turtles in forest habitats in the floodplain during the dry season (Balzer *et al.* 2002). Some species lay eggs in submerged substrates within ponds that later dry-out, others spend the dry season partially or wholly submerged in mud at the bottom of ponds that dry out. Both are susceptible to collection by professional hunters with dogs. Turtle nests have a variety of natural predators, including the macaques (locally numerous), rats (abundant) and some birds (e.g. coucals and corvids, both locally common).

River Terrapin *Batagur baska* Critically Endangered

The discovery of two complete shells of this species, found buried in lake sediments in 1985, confirmed the historical occurrence of the "Royal Terrapin" (Cambodia's national reptile) in the Tonle Sap Lake (Platt *et al.* 2003). Elderly residents reported that small numbers were present in the early 1900s. Surveys in 2000-2001 found no evidence of the species continued existence and it is considered almost certainly extirpated from the TSBR (Platt *et al.* 2003).

Asian Box Turtle *Cuora amboinensis* IUCN Vulnerable

Considered to be the second most numerous turtle in the TSBR after *Malayemys subtrijuga*, but it is now considered uncommon in the TSBR, which is considered to support a small population, and becoming harder to find in the wild (Long 2003). Recently recorded from Prek Toal Core Area and a captive individual was photographed in Sary village near Kompong Thom town (Stuart and Platt 2004). This turtle occurs in lowlands throughout Cambodia, and its global range extends from north-east India to the Philippines and Indonesia (Stuart *et al.* 2001). It is believed to still be widespread in the lowlands of Cambodia, which probably support the largest population of the species in Indochina (Touch Saeng Tana *et al.* 2000, Stuart *et al.* 2001).

Black Marsh Turtle *Siebenrockiella crassicollis* IUCN Vulnerable

This species tends to occur more commonly in floodplain ponds away from the Great Lake itself, where it is considered rare, but is not favoured for its meat, which is considered by many to be either foul-smelling or even inedible (Holloway *et al.* 2000). This turtle ranges from Myanmar to Indonesia; the Cambodian population is potentially large and may be the most important population in the region (Touch Saeng Tana *et al.* 2000).

Yellow-headed Temple Turtle *Hieremys annandalii* IUCN Endangered

Considered the third most common species in the TSBR within Kompong Chhnang province, based on interview surveys there in 2000 (Holloway *et al.* 2000), and known from the Prek Toal area (Stuart and Platt 2004). Cambodia is probably the most important country in Indochina (including Thailand) for the conservation of this species (Touch *et al.* 2000), and the TSBR may be the most important area for its conservation in Cambodia (Holloway *et al.* 2000). It is known to occur in Prek Toal Core Area (Stuart and Platt 2004), has been recorded in markets at Chong Kneas, Kompong

Thom town (Stuart and Platt 2004), and was reported by hunters in Kompong Leng Commune, Chornouk Village and Kompong Chhnang town (all Kompong Chhnang Province).

Giant Asian Pond Turtle *Heosemys grandis* IUCN Vulnerable

Reported from the TSBR within Kompong Chhnang province (under the name Orange-headed Temple Turtle), based on interview surveys there in 2000, and is thought to be scarce (Holloway *et al.* 2000). This species half-buries itself in muddy substrates in ponds that subsequently dry out during the dry season.

Malayan Snail-eating Turtle *Malayemys subtrijuga* IUCN Vulnerable

Known colloquially as the “ricefield turtle”, this species is reportedly the most numerous turtle around the Tonle Sap Lake (Holloway *et al.* 2000, Keng 2003). It is favoured for its meat and is also used in traditional medicine (Balzer *et al.* 2002). It occurs in floating ricefields in Kompong Thom province between August and December; outside this period it is considered by local people to inhabit inundated forest habitats (Balzer *et al.* 2002). It occurs in flooded ricefields as well as natural wetland habitats, and is declining across its range, which stretches from Thailand and Indochina to Indonesia (Stuart *et al.* 2001).

Asiatic Softshell Turtle *Amyda cartilaginea* IUCN Vulnerable

Strongly favoured for its meat, it is variously regarded as common, in the Tonle Sap Lake, although has undergone a serious decline (Keng 2003), and quite rare, in Kompong Chhnang (Holloway *et al.* 2000). This turtle is also widespread in Asia, occurring from Myanmar to Indonesia, and inhabits various wetland habitats from estuaries to montane streams (Touch *et al.* 2000, Stuart *et al.* 2001).

Asian Giant Softshell Turtle *Pelochelys cantorii* IUCN Endangered

This enigmatic species has often been

reported from the TSBR, but there are no confirmed specimens or photographs. It was reported during interview surveys in 1998 (Doroshenko *et al.* 1998), and there continue to be unconfirmed reports (D. Emmett, Conservation International and Sun Visal, WCS, *in litt.* 2005), although it was not recognised during interviews in Kompong Chhnang province in 2000 (Holloway *et al.* 2000). Despite very few confirmed recent records, Cambodia is suspected to support a regionally important population, perhaps the most important in South-East Asia (Touch *et al.* 2000).

Elongated Tortoise *Indotestudo elongata* (IUCN Endangered)

This species has been recorded in markets in Kompong Chhnang (e.g. Holloway *et al.* 2000), but its occurrence within the TSBR has not been confirmed with either specimen or photographic evidence.

Pythons

Burmese Python *Python molurus* IUCN Near Threatened

The Stung Sen and Boeung Chhma Core Areas are reportedly important areas for both Burmese and Reticulated Pythons *Python reticulatus* (Long 2003). Pythons are hunted heavily in both areas (Long 2003), for their skins, meat and blood to serve both domestic and international markets. Some fishermen in the Prek Toal Core Area use specific net types to try and catch pythons (Sun Visal, WCS, verbally September 2005) while others catch them by hand. Immature individuals are occasionally caught in gillnets set by fishers targeting fish or water snakes. Female pythons make their nests within dense scrub, on the ground, during the dry season, typically laying 20-30 eggs. In May 2005, three dead pythons were discovered curled around their eggs in the Prek Toal Core Area, following forest fires (Sun Visal, WCS, verbally September 2005).

Although Burmese and Reticulated Pythons clearly occur sympatrically in the TSBR, it is not clear what their relative

statuses are, or whether any ecological segregation exists. Reticulated Python is not IUCN Red-Listed (IUCN 2004).

Selected additional reptile species accounts

Watersnakes

The abundance of reptiles within the TSBR is perhaps best illustrated by what is the largest exploitation of any single snake assemblage in the world (Stuart *et al.* 2000): an estimated 3.8 million snakes were harvested between June 2004 and January 2005 (Brooks *et al.* 2005). This harvest principally targets species in the sub-family Homalopsinae (Homalopsine watersnakes). The rainbow Watersnake *E. enhydris* is the most abundant species caught, accounting for 72-ca.80% of the number of individuals in the overall catch (Stuart *et al.* 2000, Brooks *et al.* 2005). The Tonle Sap Watersnake *E. longicauda* is the second-most abundant species, and accounts for almost 50% of the total caught in the southern TSBR (Brooks *et al.* 2005). This poorly known species is endemic to the Tonle Sap Lake and River, and is Cambodia's only known endemic reptile. As such, it is of special conservation interest, and is a focus of the Cambodian Snake Trade Project, (Brooks *et al.* 2005). Other species targeted (in addition to pythons – see above) include Puff-faced Watersnake *Homalopsis buccata* and Bocourt's Watersnake *Enhydris bocourti*, both of which have been collected over several decades for their skins, which are exported to Thailand, Vietnam and China (Stuart *et al.* 2000, Long 2003, Brookes *et al.* 2005). The Bocourt's water snake is also traded alive for its meat, supplying restaurants locally and regionally. Long (2003) considers Bocourt's Watersnake to be locally rare as a result of over-exploitation. Other species that occur in the harvest include *Cylindrophis ruffus*, *Xenochrophis piscator*, *Erpeton tentaculatum*, *Enhydris plumbea*, *Enhydris subtaeniata* (misidentified as *Enhydris jagorii* in Stuart *et al.* 2000), *Boiga occellata*, *Boiga cyanea*, *Naja* spp. and *Ptyas korros*.

The enormous scale of this snake harvest is a very recent phenomenon. Since the late-1990s, snakes have become one of the main protein sources for captive-bred crocodiles in the burgeoning number of crocodile farms around the lake. In addition to the species also targeted for their skins, a proportion of the catch of several species is also used for human consumption (Stuart *et al.* 2000, Brooks *et al.* 2005). The watersnake harvest has two peaks, between July and August (wet season), and again in November-December (early dry season) (S. Brooks verbally September 2005). The first and largest peak of the harvest coincides with the breeding of *E. enhydris* (Brooks *et al.* 2005) and the second peak occurs just prior to the breeding seasons of many of the other species, as the water starts to recede (S. Brookes verbally September 2005). It is not known what effect this has on recruitment.

The seasonal distribution and habitat use of watersnakes in the Tonle Sap is still very poorly understood. The highest catch success is achieved by hunting in the shallow edge of the lake, which can move up to several kilometres back and forth each year (Brooks *et al.* 2005). Although factors affecting catchability cannot be separated from density effects, this observation is corroborated by research elsewhere, which has shown that some of these species are closely associated to shallow-water edge habitats and mud-root tangle (Voris and Karns 1996, Murphy *et al.* 1999, both cited in Brooks *et al.* 2005). Water snakes are not caught in open water at the height of the dry season, when water has receded from the forest (in March-April). This indicates that the snakes may remain in the forest; both *E. enhydris* and *H. buccata* have been found aestivating in the dry floodplain of the lake during this period (Brookes *et al.* 2005), inferring a close year-round association with forest habitats.

Additionally during the dry season other aquatic snakes are caught as a fisheries by-catch in the open water of the lake. Species so far recorded are the granulated

file snake, *Acrochordus granulatus* and a sea snake, *Enhydrina spp*, yet to be fully identified. These species do not occur in the large scale harvest occurring in the inundated forest and are therefore likely to be associated with the deep water habitat.

AMPHIBIANS

This is the least-studied of the vertebrate groups; almost no information exists on amphibians in the TSBR. Two species occur in the deepwater rice agro-ecosystem in Kompong Thom province, the frog *Hoplobatrachus rugulosus* and the toad *Bufo melanostictus* (Balzer *et al.* 2002). Each is reportedly abundant, particularly between June and September. The frog is a local delicacy and is commonly seen in Kompong Thom markets. The toad is used as an anthelmintic for cattle, is also eaten, and is sometimes exported to China (Balzer *et al.* 2002). McDonald *et al.* (1997) report seeing a medium-sized tree frog inhabiting the thatched roof of a floating home in Moat Khla; this was the only amphibian observed in the wild during one month of dry season field surveys in the seasonally inundated swamp forests and short-tree shrublands.

It is likely that the amphibian fauna of the TSBR exhibits close affinities with that in the adjacent lowlands. A collection of 18 amphibian species was recently made in the vicinity of the Angkor Wat temple complex; a number of these would be expected to occur in the TSBR (B. Stuart *in litt.* 2005).

FISH

Overview of the Lower Mekong Basin and Tonle Sap fish fauna

Fish are the largest vertebrate group in the Tonle Sap ecosystem, both in terms of number of species as well as biomass (Lamberts 2001). The Mekong Basin as a whole supports an exceptional freshwater fish diversity, numbering between 1,200 and 1,700 species (Coates *et al.* 2003), and in terms of overall biodiversity the Mekong River is among the top three rivers in the world, after the Amazon and the Zaire (Dudgeon 2000). About 500 species have been described for the Mekong system in Cambodia, which includes the Tonle Sap ecosystem (Rainboth 1996), but the precise number of species that occur in the Tonle Sap is simply not known. Fisheries data tends to underestimate the number of species, due to uncertainty over identifications and the use of local names that often cover multiple biological species. The lack of a practical, comprehensive fish species identification guide for use in the field by local data collectors contributes to this uncertainty (Lamberts 2001). The Tonle Sap ecosystem is expected to lack localised endemism (Rainboth 1996).

In terms of fish biomass, the Tonle Sap is widely believed to be one of the most productive (and most heavily harvested) freshwater ecosystems in the world. Annual inland fish production in the lake between 1994 and 1999 was estimated at 179,500-246,000 tons, which in terms of yield per hectare per year is equal to or greater than that in Amazonian, Bangladeshi, Indonesian and Thai floodplain ecosystems (Lieng and Van Zalinge 2001, also presented in Baran 2004).

Fish migration and life cycle patterns

The Tonle Sap fish fauna is characterised by extensive and diverse migration patterns, both within the Tonle Sap ecosystem itself, and between the Tonle Sap and the Mekong. A chiefly passive annual migration of large numbers of eggs, fry, juvenile and adult fish into the Tonle Sap

Lake begins as the flow in the Tonle Sap River reverses with the onset of the wet season. This migration, of fish at different stages of development, is for many species very important, as it determines the initial stock levels and therefore the potential final production (Lamberts 2001). Migration out of the Tonle Sap ecosystem is also essential for many species (simply for survival), and minimum levels of fish migrating into and out of the ecosystem are another essential parameter determining the lake's productivity (Lamberts 2001). Fish migrations are generally classified as either lateral (from main water–floodplain) or longitudinal (from lake–channel–Mekong River).

Most descriptions of the fish fauna of the Lower Mekong Basin generally differentiate two classes, black fish and white fish, based on life cycles, water quality requirements and migratory behaviour/distribution patterns, which in turn are very closely linked to the seasonal fluctuations in hydrology (e.g. Lamberts 2001, Baran 2004, Hurtle *et al.* 2004). Two further categories can usefully be added to this simplistic overview, opportunists and mainstream associates (Mekong Secretariat 1992 cited in Lamberts 2001).

Black fish are chiefly residents in the Tonle Sap, inhabiting relatively clear-water swamps and plains year round and make limited lateral migrations. The waters they inhabit are tea-coloured by chemicals dissolved from floodplain vegetation, the decomposition of which increases acidity and depletes oxygen, stresses to which black fish are adapted (Hurtle *et al.* 2004). Most species are specifically adapted to such conditions, and can breathe air, are able to move overland in search of fresh waterbodies, and some can survive out of water for long periods (Hurtle *et al.* 2004). Black fish are mostly carnivorous and detritus feeders, and include the Channidae (Snakeheads), Clariidae, Bagridae (*Mystus* spp.) and Anabantidae (Baran 2004).

White fish are mainly associated with the main channels and streams, and exhibit strong lateral and longitudinal migrations, including into floodplains. They move into the Tonle Sap as the flood rises in the early wet season (from May), remaining there to feed and reproduce, until the waters begin to recede (from November), when they return to the turbid (“white”) waters of the Tonle Sap and Mekong Rivers, where they spend the majority of each annual cycle (e.g. Nao 1997, Hurtle *et al.* 2004). The white fish includes many cyprinids (*Cirrhinus microlepis*, *Hampala macrolepidota*, *Barbodes altus*, *Leptobarbus hoeveni*, *Osteochilus melanopleura*, *Morulus chrysophekadion*), various *Pangasius* sp., Siluridae (e.g. *Wallago attu*, *Micronema apogon*) and Notopteridae (e.g. *Notopterus chitala* and *N. notopterus*) (Baran 2004).

Opportunists are small, fast-growing species, able to make maximum use of the flood period for prolific reproduction and/or growth. This group (which are also classified as white fish by some authors) comprises mainly cyprinids (e.g. *Henicorhynchus siamensis*, *Thynnichthys thynnoides*, *Dangila spilopleura*), which are harvested in large quantities for the manufacture of *prahoc*, fish sauce and feed for caged fish. “*Trey Riel*” *Henicorhynchus* spp. are the most common and account for the largest catch by weight of any genera in Cambodia (van Zalinge *et al.* 2000).

Mainstream associates are only a marginal group in the catches of the Tonle Sap ecosystem, primarily occurring in main channels of larger rivers. The group includes clupeids, sciaenids and soleids.

Complex variations exist in the migration strategies adopted by white and black fish. Most respond to hydrological changes and use hydrological events as cues for the timing of their migration (e.g. Poulsen *et al.* 2002). Many longer-distance migratory fish species move into Tonle Sap at the beginning of the annual flood (May-June) and return to the Tonle Sap and Mekong River systems at the end

of the flood (October-November), producing two peak migration periods. The Tonle Sap Lake forms part of the Lower Mekong Migration System, and is a key site for both lateral (from floodplain to river channel) and longitudinal (up and down the Mekong) migrating species, including several globally and regionally threatened fishes. Many fish species that are resident in the TSBR make short-distance movements each year in response to the flood-pulse, to utilise the different floodplain habitats.

Rises in water levels in the early wet season trigger most migratory species to move down the Mekong and into the Tonle Sap, spending the flood season feeding in the fertile floodplain habitats, particularly the inundated swamp forest and short-tree shrublands, which provide key breeding, nesting, spawning, feeding and nursery areas for many fish species fish (and their predators, e.g. waterbirds), and are consequently essential for fisheries productivity (Lieng and van Zalinge 2001, Poulsen *et al.* 2002). Shrub habitats on the Tonle Sap floodplain are key for these life cycle stages in many fish species. Throughout Cambodia a four-month fishing ban is instituted to coincide with the main fish breeding period, in order to promote the sustainable development and use of fishery resources. In the TSBR, this ban falls between June 1st and October 31st (Baran 2004).

Fish population trends

As early as 1959, local fish catch declines around the Tonle Sap were being reported by fishermen (Bardach 1959). It is widely perceived that total catches on The Tonle Sap are now close to a maximum (e.g. van Zalinge and Touch Seang Tana 1996, Baran *et al.* 2001, Baran 2004). The abundant observational evidence for this includes:

- An overall decrease in average fish size,
- An increase in the proportion of small fish in catches,
- A decrease in the catch of medium sized fish,

- Sharp declines in the catch of larger and more valuable fish, and
- Decreasing mean catch per capita and unit effort

Each of these features is characteristic of proven declines in freshwater fisheries elsewhere (Welcomme 1995). Standardised long-term and large-scale monitoring data are required for fish populations in the TSBR to statistically prove these observed declines, however. Several fish species that occur in the Tonle Sap are globally threatened. Several others are of conservation concern.

Fish diversity, distribution and habitat associations

One hundred and forty-three fish species were identified from five sources (Lim *et al.* 1999 van Zalinge *et al.* 1999, Lamberts 2001, Neou *et al.* 2001, Balzer *et al.* 2002) as having been recorded in the Tonle Sap Great Lake and its floodplain, the Tonle Sap River and the transitional zone between the two (the principal channel, old channel and ox-bow lakes around the mouth of the lake) since 1995 (Annex 2). A further 14 potentially different taxa were not conclusively identified to species level.

Lim *et al.* (1999) compared 1995-7 fisheries catch data with previous studies (1936-1976), and found that only 54% of species that had been caught historically (based on Chevey 1936, Bardach 1959, Fily and d'Aubenton 1966, Rainboth 1996) were still present. This indicates a potentially substantial loss in fish species richness within the TSBR, but differences in fishing techniques employed and the areas being compared (e.g. previous studies appeared to include data from the Mekong River) were not accounted for in the analysis.

Sampled catches from four locations in the Tonle Sap Lake, one in the Tonle Sap River and one in the intermediate zone, were dominated by fish species belonging to three orders, the Cypriniformes (chiefly carps and minnows), Siluriformes (catfishes) and Perciformes (perch-like fishes) (Lim

et al. 1999). Cyprinidae was the dominant family, represented by 40 species. The Tonle Sap River and intermediate zone supported more species than the lake itself, although this may simply reflect the timing of fishing activity from which the data was taken (November–April, peaking in December–February) falling outside the main period that longer-distance migratory fishes are using the Tonle Sap lake and floodplain.

The Tonle Sap River fish fauna is dominated by the genera *Thynnichthys*, *Puntioplites*, *Dangila* (Cyprinidae) and *Pristolepis* (Nandidae); the transitional zone is characterised by the genera *Cyclocheilichthys*, *Cirrhinus*, *Leptobarbus*, *Osteocheilus* and *Morulus* (Cyprinidae); and the lake itself is inhabited by *Barbodes*, *Hampala* (Cyprinidae), *Micronema* (Siluridae), *Pangasius* (Pangasiidae), *Trichogaster* (Belontiidae) and *Channa* (Channidae) (Lim *et al.* 1999).

Species diversity is generally higher in the floodplain and inundated forest during the flood, but higher in the braided, deltaic mouth of the Tonle Sap (transitional zone) during the migration period (Lim *et al.* 1999). Ricefields in the middle-outer floodplain support at least 60 fish species (Balzer *et al.* 2002). Fish species inhabiting floodplain and riparian forest mainly spawn between May and August (Lim *et al.* 1999), except some Cypriniformes and Clupeiformes (includes shads and sardines), the Pleuronectiformes (flatfishes) and some Tetraodontiformes (triggerfishes and boxfishes). Local people report the eggs of four species from ricefield habitats in Kompong Thom: two catfish, *Clarias macrocephalus* and *C. batrachus*, *Channa striata* (Chevron Snakehead) and *Anabas testudineus* (Climbing Perch) (Balzer *et al.* 2002). The areas and dates of spawning for some families, including Engraulidae, Belonidae, Mastacembelidae, Soleidae and Cynglossidae, are still unknown (Lim *et al.* 1999). The transitional zone is also considered important fish spawning and nursery habitat (Lim *et al.* 1999). Growth studies showed that the floodplain and lake habitats sustained more rapid growth

of some Cyprinidae (in the genera *Cyclocheilichthys*, *Leptobarbus*, *Hampala* and *Labeo*) than the Tonle Sap River (Chevey 1936 in Lim *et al.* 1999).

Globally Threatened Fish Species

Mekong Giant Catfish *Pangasianodon gigas* (IUCN Critically Endangered; CITES Appendix I)

The Mekong Giant Catfish *Pangasianodon gigas* is one of the largest and rarest freshwater fish in the world. It is endemic to the Mekong River, with a historical range encompassing the Tonle Sap Lake and River, and the Mekong River from southern China south to Vietnam. It measures up to three metres in length and can weigh in excess of 300 kg. It is most easily differentiated from other species by its size, lack of teeth and barbels (in individuals over 50cm), and eight or nine pelvic fin rays. It has a broader head and mouth than its close relative *P. hypophthalmus* (Roberts and Vidthayanon 1991).

Fisheries in the Upper Mekong Basin began targeting the species as early as 1890, when Pavie reported harvests of 6,000 fish from Luang Prabang (Roberts and Vidthayanon 1991). By 1935 fishermen were targeting the species throughout the Mekong Basin (Giles 1935), and it has since disappeared from Luang Prabang and north-east Thailand fisheries (Smith 1945, Phukasawan 1968, Mengumpun 2000), and has been declining in fisheries in far northern Thailand since at least 1990 (Mengumpun 2000). In 2003, its global threat status was elevated to Critically Endangered (IUCN 2004), on account of an estimated rate of decline—based on annual catch data (used as a proxy for population size)—of more than 80% in two decades in the Mekong River Basin area prior to the late 1990s (Hogan 1998). It has been listed on CITES Appendix I since 1975.

Knowledge of the species ecology is scant, and very little data exists on its natural migratory or spawning behaviour. The Tonle Sap Lake and Tonle Sap River appear to provide important habitat for the species, especially Fishing Lot #2, which

may be an important nursery area, sustaining a significant population of young (rearing) fish, while the Tonle Sap River is a migratory corridor for mature fish moving to the Mekong River (Hogan *et al.* 2001, Zeb Hogan *in litt.* 2005).

The population status of the Mekong Giant Catfish is unclear. Catches have been monitored from the Tonle Sap River dai fishery since 1999, since when between four and 11 fish have been caught annually (Hogan *et al.* 2001). As water levels begin to drop in October and November, Mekong Giant Catfish move out of the Tonle Sap Lake and into the main Mekong River channel. They inhabit the deep pools of the Mekong River during the dry season, and probably spawn in the Mekong River either in the Stung Treng area or in the upper Mekong near Chiang Khong (north Thailand).

Fishing-induced mortality represents the most immediate threat to the Mekong Giant Catfish. A fundamental problem is that fishermen continue to catch and sell the fish despite its conservation status (Sretthachuea 1995), although in Cambodia an ongoing purchase and release initiative was launched in 2000 (Hogan *et al.* 2001). This problem is further complicated by the difficulty of monitoring commercial and subsistence fisheries; catches of Mekong Giant Catfish often go unreported. Other potential threats to the species include waterway modification, clearance of inundated swamp forest and water pollution.

Leaping Barb *Chela caeruleostigmata*
(IUCN Critically Endangered)

Not recorded from the Tonle Sap Lake, but it could occur given its Cambodian range, the fact that it appears to make migratory movements back into large rivers at the end of the flood cycle in March or April, and its preference for the surface waters of large rivers and inundated swamp forests (Fishbase 2005). It is probably used to make prahoc and is occasionally seen in the aquarium trade.

Jullien's Golden Carp *Probarbus jullieni*
(IUCN Endangered; CITES Appendix I)

This distinctive fish, also known as the Seven-line Barb, can weigh over 70kg, although 5-20kg individuals are more common now (Roberts and Baird 1995). It is distributed in several major South-east Asian rivers, chiefly inhabiting mainstream channels, where it occurs in deep, slow reaches, with sand or gravel substrates, and abundant mollusc populations (Roberts and Warren 1994, Rainboth 1996). In the Mekong basin, it performs spawning and trophic (feeding) migrations, and has been recorded in the Tonle Sap Lake (Poulsen *et al.* 2004). Known upstream spawning migrations take place between October and February from Kompong Cham in central Cambodia to Chiang Khong in northern Thailand, where it spawns between late December and early February. Trophic migrations occur throughout the Mekong, take place mainly at the onset of the flood season (May-June), and are mainly undertaken by juveniles and subadults, which take several years to mature (Sokheng *et al.* 1999, Poulsen *et al.* 2004).

Jullien's Golden Carp is undergoing a serious long-term decline and the most obvious (but not necessarily only) cause is over-fishing with gillnets during the reproductive migrations and spawning periods (Roberts and Warren 1994), especially the November-January spawning migration (Roberts and Baird 1995).

Laotian Shad *Tenuulosa thibaudeaui*
(IUCN Endangered)

This rather small fish species (most large, spawning fish weigh 400-500g) is endemic to the Mekong basin, and its main area of occurrence appears to be from the Tonle Sap north. It is migratory, moving downstream into Cambodia from the middle Mekong in Thailand/Laos in July. It may follow the turbid floodwaters all the way to the Tonle Sap, probably moving into the Great Lake as it fills with water from the Mekong. As water levels in the Great Lake fall, it migrates back down the Tonle Sap to the Mekong (Rainboth 1996). In the mid-1900s it was abundant, one of

the principal species caught in the Tonle Sap fishery (Bardach 1959), but the last recorded large scale migrations were in 1984. This drastic decline is probably due to several factors, including dam construction and over-fishing in southern Laos (Roberts 1993).

Tricolor (or Bala) Sharkminnow

Balantiocheilos melanopterus IUCN
Endangered

This rather small Cyprinid inhabits the Mekong and Chao Phraya basins, the Malay Peninsula, Sumatra and Borneo, but is becoming rare or extinct in many river basins, and is commercially important in both aquaculture and the aquarium trade (Fishbase 2005). It formerly occurred in the TSBR (e.g. Rainboth 1996), but is now rare and was not taken in fish 1995-97 fish catches analysed by Lim *et al.* (1999); it is depicted on the Department of Fisheries *Endangered Fishes of Cambodia* poster.

Asian Bonytongue/Asian Arowana

Scleropages formosus IUCN Endangered;
CITES Appendix I

This familiar fish is threatened throughout its range (Indonesia, Malaysia, Thailand, Cambodia and Vietnam) by demand for the aquarium trade and to a lesser extent its meat, which commands a moderate price (Fishbase 2005). It inhabits tannin stained blackwater streams (Rainboth 1996). It is unclear whether it occurs in the TSBR.

Thicklip Barb *Probarbus labeamajor* IUCN
Data Deficient

At least one other *Probarbus* species, Thicklip Barb *Probarbus labeamajor*, and perhaps the Thinlip Barb *P. labeaminor* (also IUCN Data Deficient), both of which are very similar in appearance to *P. jullieni*, has been recorded in the Tonle Sap, based on Local Ecological Knowledge (Poulsen *et al.* 2004). Little is known about either due to confusion with *P. jullieni*, but each apparently migrate together with *P. jullieni*, and the population of *P. labeamajor* has been decimated by an intensive gillnet fishery which targets the species in southern Laos (Roberts and

Warren 1994). Further investigation is needed to find out whether it shares spawning grounds, general distribution and migration periods with *P. jullieni* (Roberts and Warren 1994).

Giant Pangasius *Pangasius sanitwongsei*
(IUCN Data Deficient)

This large Pangasid is endemic to the Lower Mekong and Chao Phraya river basins, and although listed as common by Rainboth (1996), it is becoming increasingly rare throughout its range (Poulsen *et al.* 2004). Little information is available on its ecology and distribution (www.fishbase.org), but it spawns just prior to the rainy season (Rainboth 1996). It has been reported during local knowledge surveys at the southern end of the Tonle Sap Lake (Poulsen *et al.* 2004), but it is unclear whether there are specimens from the Tonle Sap.

Additional fish species of conservation concern

Giant Barb *Catlocarpio siamensis*

Catlocarpio siamensis is endemic to the middle and lower Mekong River (from Thailand-Laos to Vietnam), and is considered one of the world's largest cyprinid fish, measuring up to 3m and weighing up to 200kg, although fish weighing more than 50 kg are rarely caught today (Rainboth 1996, Mattson *et al.* 2002). Adults prefer large, deep pools in the Mekong for at least part of the year, but juveniles are mostly seen in swamps and small tributaries (Sokheng *et al.* 1999). It is a migratory species, but its movements appear to be poorly understood (Mattson *et al.* 2002). Giant Barb is caught incidentally in the Tonle Sap *dai* fishery, especially *dai* #2 where the river is deepest and narrowest and the current is swiftest, making escape difficult (Hogan *et al.* 2001b). Its numbers have declined drastically: in Cambodia, the total catch of Giant Barb declined from 200 tonnes in 1964, to 50 individual fishes in 1980, and just 10 fishes in 2000 (Mattson *et al.* 2002). Individuals rarely survive to reach reproductive maturity, and its catch needs to be strictly regulated by size (Rainboth 1996). It is an urgent candidate for an

IUCN Red List evaluation and immediate conservation attention (Hogan *et al.* 2001b).

Puntioplites bulu (no English name)

This fish was formerly common, but has recently become very rare (Rainboth 1996); it is depicted on the Department of Fisheries *Endangered Fishes of Cambodia* poster. It occurs from Indonesia to peninsular Thailand and Cambodia, inhabiting midwater to bottom depths in large low-land rivers and lakes, and moves into inundated forest habitats when water levels rise (Fishbase 2005). These habits suggest it may occur in the TSBR.

Sabretoothed Thryssa *Lycothrissa crocodilus*

A relatively small (<30 cm) anchovy, which is distributed from the Lower Mekong Basin and parts of Thailand to western Indonesia and Borneo (Poulsen *et al.* 2004). It is depicted on the Department of Fisheries *Endangered Fishes of Cambodia* poster, but is common from the Mekong Delta north into the TSBR, into which it performs migrations in response to wet season floods, and spawns in the TSBR's floodplain habitats (Poulsen *et al.* 2004).

Four-barred Tigerfish *Datnioides quadri-fasciatus*

This small (<30cm) but strikingly marked Perciforme is widely distributed from India to Indonesia and New Guinea, which occurs in brackish waters and inland lakes. It is unclear whether it occurs in the TSBR, but it is depicted on the Department of Fisheries *Endangered Fishes of Cambodia* poster.

Wallago leeri

This catfish occurs from Thailand to Indonesia, inhabiting large rivers and entering inundated forest (Roberts 1993, Rainboth 1996). It is unclear whether it occurs in the TSBR, but it is depicted on the Department of Fisheries *Endangered Fishes of Cambodia* poster, and is of commercial importance (Fishbase 2005).

Albulichthys albuloides

This relatively small Cyprinid occurs in the Mekong, Chao Phraya and Mae Khlong basins and Borneo (Fishbase 2005), and is depicted on the Department of Fisheries *Endangered Fishes of Cambodia* poster. Adults are common in the Tonle Sap Lake, where it is of commercial value when sold fresh (Fishbase 2005).

Elephant-ear Gourami *Oxonedus exodon*

This medium sized (<60 cm) Mekong Basin endemic inhabits pools of large rivers and inundated forests during the rainy season. It reproduces in non-flowing waters near the river shore during lowest water levels (Rainboth 1996) and undertakes lateral migrations into floodplain areas during the flood season, returning to the Mekong River or other permanent water bodies during the dry season, triggered by changes in water levels (Sokheng *et al.* 1999). It is unclear whether it occurs in the TSBR, but it is depicted on the Department of Fisheries *Endangered Fishes of Cambodia* poster.

Botia genus

Several species in this genus were recorded in the Tonle Sap during the first half of the 20th Century (*Botia hymenophysa* and *B. modesta*; Bardach 1959), but there have been no recent records (E. Baran verbally 2005). Each of these species is therefore of conservation concern.

Key areas of conservation importance for fish

There are three well-known key areas of conservation importance for fish, each of which seasonally supports significant concentrations of fish:

- 1) Prek Toal Core Area (Fishing Lot #2) – the most productive fishery on the Tonle Sap;
- 2) Boeng Chhma Core Area (Fishing Lots #5, 6 & 7) – supports the highest diversity of fish habitats;
- 3) Rivermouths (e.g. Stung Sen river mouth and the Pi Stuong Fish Sanctuary) – these areas concentrate nutrients, which in turn support rich feeding aggregations of fish.

Other important habitats must include permanent wetlands in the floodplain (e.g. in Veal Srangai IBA). These are a high priority for research because there is currently no information on them.

Although it is often stated that the inundated forest is a rich feeding and spawning ground for many species during the flood season (e.g. Lieng and van Zalinge 2001), no studies have been conducted on the importance or ecological role of the floodplain habitats to overall fish species richness and diversity, or indeed to any individual species (E. Baran verbally 2005). This is a key area for research.

Research into fish abundance and species composition in the eight Fish Sanctuaries began in April 2005 (Cheng Phen verbally 2005). Only two of the eight fish sanctuaries are clearly of elevated importance to fish in comparison to other (superficially very similar) parts of the Tonle Sap. One, Pi Stuong, at the mouth of the Stung Sen River, contains a deepwater area (average dry season depth is 4-5m), with a rocky bottom (sediments are apparently flushed through by the river current), and incorporates a narrow belt of inundated forest along the lakeshore. It supports large fish aggregations. The other, Kompong Phluk, is apparently a slightly deeper water area than most of the lake. The other six fish sanctuaries are located in the open water column, and none appear to support particular concentrations of fish. The experimental protection of two fish sanctuaries (Pi Stuong and Ba Lat) using concrete tubes has two functions, the primary purpose being protection from fishing of the lower water column, the other being creation of shelter for brood stock and spawning habitat for some species (Cheng Phen verbally 2005).

The most suitable locations for fish sanctuaries in the Tonle Sap Lake, River and adjacent floodplains will be determined, new large scale fish sanctuaries established by the Department of Fisheries as recommended, and existing fish sanctuaries situated in unsuitable locations will be decommissioned (Anon. 2003). Additional

fish sanctuaries to the existing eight are also planned under Community Fisheries agreements (Cheng Phen verbally 2005). Whatever the approach to revising and expanding fish conservation areas, it will be imperative to have a clear understanding of the biophysical features that are important for the selection and designation of new sanctuary areas and the excision of any inappropriate areas. This understanding does not currently exist.

Conservation of the many migratory fish populations utilising the Tonle Sap is dependent on factors operating elsewhere in the Mekong Basin. Many species only use the Tonle Sap seasonally (most if not all long-distance migratory forms only occur during the wet season). The Mekong mainstream in the Lower Mekong Basin, anywhere from the Mekong Delta up to the Chinese border is where many species spend the dry season. Deepwater pools in the Mekong are key dry season refuge habitats for some (Poulsen *et al.* 2002), e.g. the Mekong Giant Catfish. Migratory fish departing the lake before the flood has receded very far often return to the Mekong via a route other than the Tonle Sap River. These fish are heavily exploited at various locations, including under the NR-6 bridges in Kompong Cham (E. Baran verbally 2005).

The invertebrate fauna of the Tonle Sap is little studied and consequently poorly known, although a preliminary collection made on 27-28 May 2003 in Prek Toal using sweep nets and light traps (Constant and Grootaert 2003), yielded 218 species, not including Diptera (true flies, gnats, mosquitoes and crane flies), Lepidoptera (butterflies and moths) and Odonata (dragonflies). These 218 species comprised five Blattoptera (cockroaches), 81 Coleoptera (beetles and weevils), 26 Heteroptera (true bugs, a suborder of Hemiptera), 29 Homoptera (a group including cicadas, plant hoppers, treehoppers, spittlebugs, aphids, mealybugs, whiteflies and scale insects), 46 Hymenoptera (ants, bees, sawflies, and wasps) and 31 Orthoptera (crickets, grasshoppers, katydids, mantids, and walking sticks).

At least two species of Diptera, of the family Dolichopodidae, collected in Prek Toal during 2003 were previously undescribed (Constant and Grootaert 2003). Constant and Grootaert (2003) predict that a low invertebrate species richness is expected from the Prek Toal area, comprising chiefly aquatic and semi-aquatic species. Nothing is known of how these insects spend the flood season, whether it is as larvae, pupae, or adults in the emergent trees, or whether perhaps the floodplain is colonised annually from outside the inundation zone.

Insects must form a key component of the ecosystem food chain's lower trophic levels, and may be a particularly important resource during drought years when fish becomes scarce (MRC 2003). Two distinctive aquatic insects that are common to abundant in the ricefield ecosystem of Kompong Thom, a giant water bug *Lethocerus* sp. and a water beetle probably from either the Dytiscidae or the Hydrophilidae (Balzer *et al.* 2002), form important food items in the local human diet.

Studies of insects resumed in September 2005 in and around the Prek Toal Core Area, with funding and technical assistance from the Royal Belgian Institute of Natural Sciences, in collaboration with the Sam Veasna Centre for Conservation in Siem Reap.

Odonata (dragonflies)

Eight dragonfly species were identified during a visit to Prek Toal on 7 February 2003 (P.K. Batchelor *in litt.* to Sam Veasna Centre for Wildlife Conservation, 2003): *Pseudagrion rubriceps*; *Brachythemis contaminata*; *Crociothemis servilia*; *Orthetrum safina*; *Rhyothemis phyllis*; *Rhyothemis variegata*; *Tholymis tillarga* and *Trithemis pallidinervis*.

Apis (honeybees)

Three of the four species of honeybee known from Cambodia (*Apis dorsata*, *A. cerana*, *A. florea* and *A. andreniformis*) were identified during interviews with Prek Toal villagers in 2003 to occur, or to have occurred, in the Tonle Sap floodplain (Petersen 2003). *Apis dorsata* and *Apis florea* reportedly still occur in the area. One person reported that *Apis cerana* existed in the area prior to 1995, but forest fires and wood cutting activities since then had destroyed most suitable nesting sites, large cavities (minimum volume 15-20 liters) in trees (Petersen 2003). *Apis andreniformis* was not recognized by the respondents and may not exist in the TSBR.

A. dorsata appears to be a year-round resident of swamp forest and short-tree shrubland habitats. It nests in the open in large, prominent colonies that are easy to collect. All respondents reported that over-harvesting, forest fires and cutting for timber and firewood had contributed to a steep decline of *A. dorsata* populations since 1995 (Petersen 2003). *A. florea*

prefers low, dense shrub for nesting, and makes small nests that yield low returns per unit harvesting effort; they do not appear to be at risk in the TSBR (Petersen 2003).

Crustacea (crabs and shrimps)

At least one crab, and one shrimp species occurs in ricefield habitats in Kompong Thom (Balzer *et al.* 2002). Five morphologically distinct forms of crab are distinguishable in these ricefield agro-ecosystems (all but one of which is abundant), indicating as many as five species may occur; van Amerongen (1999 cited in Balzer *et al.* 2002) suggests that all ricefield crabs in the Tonle Sap belong to the genus *Somanniathelphusa*.

Somanniathelphusa crabs are generally considered rice pests (Balzer *et al.* 2002), and as such are collected from June to December, but only eaten in times of food scarcity.

The shrimp species, identified as *Macrobrachium lanchesteri* (Mogensen in Balzer *et al.* 2002), is abundant between September and December, when it is harvested for food. McDonald *et al.* (1997) mention that local informants report two species of shrimp, which are commercially exploited from the deeper waters of the lake itself.

Mollusca (snails and mussels)

The Mekong Basin, including in the Tonle Sap, exhibits an extremely high diversity of molluscs (snails and mussels) (Rainboth 1996). For example, the stenothyrid and pomatiopsid snails (gastropods) include over 120 species, at least 111 of which are endemic to the river (Davis 1979 cited in MRC 2003), the greatest known biodiversity of snails in a freshwater system in the world (MRC 2003). Twenty-nine species of mollusc (comprising over 50% of all species present) were identified in the zoobenthos of "the Mekong, the Tonle

Sap channel and the floodplains", and made up 85% of the zoobenthos by weight (Nguyen and Nguyen 1991 cited in Lamberts 2001). The remainder of 57 identified zoobenthic species included 15 insects, eight oligochaete worms and five crustaceans (Nguyen and Nguyen 1991 cited in Lamberts 2001). One species of ampullarid snail, probably in the genus *Pila*, was found in the ricefield ecosystem in Kompong Thom (Balzer *et al.* 2002). Other, unidentified snails and snail shells were collected from the rivers and the lakes nearby.

ZOOPLANKTON

The zooplankton of the Tonle Sap ecosystem was partly described from work conducted in the late 1980s (Nguyen and Nguyen 1991 cited in Lamberts 2001). Of the 46 species identified, half are rotifers, about one third are cladocerans and the remaining seven species are copepods. As with phytoplankton, the number of species in the flooded areas is higher than in the river, the composition of the zooplankton communities varies throughout the year, and zooplankton density (in the Tonle Sap channel) increases by a factor greater than 100 during the dry season. In the flood season, zooplankton density in the flooded areas is almost one hundred times higher than in the river (Nguyen and Nguyen 1991 cited in Lamberts 2001).

With approximately 470,000 people living within the inundation zone and over 1 million in all parts of the floodplain including adjacent urban centres, coupled with the highest incidence of poverty in Cambodia (Keskinen 2003), pressure on natural resources is high. Access to natural resources is very unequal, land tenure is insufficient and many areas are effectively common land, which is driving increasing competition for resources, and with it a cycle of overexploitation and degradation.

Over-exploitation of animals

- Populations of some species have indisputably declined to the verge of extirpation from the TSBR as a result of chronic over-harvesting (e.g. Siamese Crocodile, Platt *et al.* 2004). Similar declines are suspected for other reptiles, especially turtle species (e.g. Holloway *et al.* 2000). Hunting of Irrawaddy Dolphin has probably driven the species to extinction in the TSBR (Baird and Beasley 2005).
- Over-fishing through inappropriate practices (e.g. use of mosquito netting, Troeng 2000) is a major concern for some fish, particularly the larger and more valuable species, e.g. Mekong Giant Catfish, Giant, Thicklip and Thinlip Barbs and Jullien's Golden (or Seven-line) Barb. Suspending fishing operations at dai #2 in the Tonle Sap River would decrease the chance of capture of the large endangered fishes (Hogan *et al.* 2001). Identifying the source area(s) where over harvesting occurs is not always straightforward, however, and for some or many species, it may be occurring in areas outside the TSBR (e.g. Laotian Shad; Roberts 1993).
- All major migratory routes used by fish to depart the Tonle Sap Lake and floodplain (the Tonle Sap River, and, before the flood has receded very far, flooded 'overland' routes, e.g. under the NR-6 bridges in Kompong Cham (E. Baran verbally 2005) are heavily over-fished. Lamberts (2001) notes concern within the Department of Fisheries over the collection of large quantities of fry in the Mekong, the possible impact of heavy and noisy boat traffic along migration paths, and the use of illegal fishing methods (e.g. brush parks) along migration corridors.
- The recent watersnake harvest, probably the largest exploitation of a snake assemblage anywhere in the world, may well be unsustainable, and declines in several species (particularly *Enhydryis bocourti*) are reported by local fishermen (Stuart *et al.* 2000, Brooks *et al.* 2005).
- Unsustainable harvesting of eggs and chicks from breeding colonies was the primary threat to large waterbirds until very recently (Parr *et al.* 1996, Ear-Dupuy *et al.* 1997, Goes and Hong 2002). This threat has been minimised within the Prek Toal Core Area since permanent ranger presence at population monitoring platforms through the breeding season (Goes 2005), but remains a problem in colonies elsewhere that are not currently monitored or afforded protection, e.g. Beong Chhma-Moat Khla and Dei Roneath (Seng *et al.* 2003).
- Bengal Florican was heavily hunted prior to conservation in parts of Kompong Thom province (Goes *et al.* 2001), and is probably still threatened by hunting away from conservation areas (Seng *et al.* 2003).

Habitat Loss and Degradation

Inundated Forest-scrub

Significant areas of inundated forest-scrub, a critical fish habitat (e.g. Lieng and van Zalinge 2001), have been destroyed through clearance and conversion to rice cultivation, burning, harvesting for fuelwood and construction materials and collection for firing brick kilns (Giesen 1998, Troeung 2001, Baran 2004).

- In the 1930's, an estimated 1 million ha of natural vegetation around the Tonle Sap declined to approximately 564,000 ha in the 1980's (Woodsworth 1995).
- By the late 1990's, approximately 361,000 ha of natural forest and 157,000 ha of degraded forest were estimated extant (Giesen 1998).
- In 2002, the floodplain supported approximately 22,000 ha of forest, 448,000 ha of shrub and almost 730,000 ha of grassland (Keskinen and Huon 2002, cited in Baran 2004).

It is very likely that each of these estimates was based on a different dataset and different interpretation processes, but the overall impression is clear: the area of forested habitat in the TSBR has declined over the past five decades. Forest cover at a local scale has been monitored more consistently: close to 30% of the inundated forest in Battambang province was cleared between 1965 and 1992, including 10,688 ha in Fishing Lot no.2 (the Prek Toal Core Area) (Troeung 2001). Firewood collectors are relatively unselective, but *Hymenocardia wallichii*, *Lumnitzera* aff. *racemosa*, *Terminalia cambodiana*, *Barringtonia acutangula*, *Coccocera anisopodum* and *Vitex holodenon* are preferred, and *Diospyros*

cambodiana is the preferred tree species for construction (Gum 1998, Rundel 2000).

Land-use conversion

Grasslands and agro-ecosystems

These multiple-use landscapes have poorly developed regulatory and protection mechanisms, hence are vulnerable to rapid changes in agricultural practice, either through intensification or abandonment. Episodic cultivation of deepwater rice has created a mosaic landscape of great biodiversity importance in parts of the floodplain, and has probably been instrumental in the creation and maintenance of grasslands in the floodplain (Davidson 2004, Evans *et al.* 2005). Abandonment of deepwater rice cultivation and reversion to tall scrub due to low economic returns from deepwater rice harvests represents a substantial concern. However, agricultural intensification poses a more urgent threat. Intensification is a major cause of biodiversity loss in Thailand and Vietnam (Tran Triet *et al.* 2000; Round 2002; Buckton & Safford 2004), particularly conversion to irrigated rice production with associated high levels of chemical inputs and the loss of dry season stubble and fallow habitats. Rapid expansion of dry-season irrigated rice now presents a serious and immediate threat to landscapes of the outer Tonle Sap floodplain. In 2004–5, at least 15 dams were constructed to irrigate over 60 km² for intensive rice production within and surrounding two sites in Kompong Thom covering approximately 200km² (Evans *et al.* 2005). This is expected to greatly reduce habitat suitability for grassland dependent species due to reduced structural diversity, high pesticide inputs and greatly reduced opportunities for non-crop species to survive, as well as reduce open access resource availability (e.g.

grazing, fishing) to local communities (Evans *et al.* 2005).

Only 5% of the grasslands inside the country's Important Bird Areas are represented within Cambodia's protected-areas network (Seng Kim Hout *et al.* 2003). Development of Cambodia's agricultural sector is a key objective of the government's poverty reduction strategy, of which irrigation projects form an important component. Urgent priority should therefore be given to mitigating agricultural intensification, through research into agro-ecosystem biodiversity, the incorporation of grasslands and agro-ecosystems within biosphere core areas and/or the integration of conservation priorities into land-use management strategies for multiple-use zones supporting grasslands and agro-ecosystems (Davidson *et al.* in prep.).

Pollution

Agro-chemical

Increasing use of agro-chemicals, especially pesticides, has been highlighted as a major concern in the TSBR and Cambodia as a whole (Yang *et al.* 2001, EJV 2002, CEDAC 2004). Approximately one third (ca.80) of 241 pesticides on the market in 2000 were classified by the World Health Organisation as hazardous or very hazardous (Yang *et al.* 2001). These include endosulfan, monocrotophos, DDT, brodifacoum, cypermethrin, diazinon, carbofuran and phosphamidon, all of which are known to have caused mass wildlife mortalities in other countries (EJV 2002). It is suggested that the use of these agro-chemicals will have a relatively limited effect on overall fisheries productivity due to the size and hydrology of the ecosystem (Lamberts 2001), but impacts to biodiversity and human populations at the local level can be considerable (EJV 2002, CEDAC 2004).

Urban and domestic

The potential impact of untreated urban and domestic solid and liquid waste, which is discharged directly into TSBR waterbodies (especially from floating villages), is large, particularly if fish migration routes become polluted (Lamberts 2001). Impacts on water quality are most severe during the dry season when shallow waters quickly become stagnant and temperatures can be high.

Petro-chemical and Noise

Oils spills pose a threat to waterways and associated habitats around ports (e.g. Chhlong Kneas) and waste oil, sludge and bilge are often discarded into the water in these locations. There is concern about the impact of persistent noise pollution from motorised boat traffic along the main Tonle Sap channel on migration of fish (e.g. Lamberts 2001). There have also been fears that oil exploration may begin on the Tonle Sap (Goes 2002); it is not clear whether these remain.

Mekong Basin-wide threats

The predicted effects of damming of the upper Mekong River in China include reductions in sediment deposition, soil fertility and biological productivity within the Tonle Sap floodplain, and alterations to the chronology of the wet-season flood regime (Kummu *et al.* 2005, in press a & b). Any combination of these could have serious long-term consequences, and alter the current seasonal cycle of processes that maintains the ecosystem's exceptional productivity and its key populations of animals and plants.

Introduction of exotic (non-native) species can cause irreversible alterations to the ecology of aquatic and terrestrial environments, through competition, predation or transmission of diseases, and is a key threat theme that requires addressing in the TSBR.

Fish

About 17 exotic fish species have established wild populations in the Lower Mekong Basin (Welcomme and Vidthayanon 2003), most of which originated from aquaculture. No specific information could be traced on their effects on the fish fauna of the Tonle Sap.

Cambodia's DoF recently prohibited aquaculture of one exotic species, the red-bellied pacu *Piaractus brachypomus*, a member of the Piranha family from South America (Hortle *et al.* 2004).

Invertebrates

The inappropriate introduction of European honeybees (*Apis mellifera*) poses a serious threat through disease introduction, chemical pesticide dependence (mites and foul-brood control) and disruption of ecosystem processes. Introduction has occurred near Siem Reap but is being contained (D. Jump *in litt.* October 2005). Further introductions of *A. mellifera* as part of bee-keeping schemes should be vigorously discouraged by donors and other agencies (Petersen 2003).

Pomacea gigas (Apple Snail), which feeds on the growing basal stems of aquatic plants, has had a major impact on aquatic habitats and agro-ecosystems in Thailand, degrading natural vegetation and severely reducing rice yields (Round 2002, Welcomme and Vidayathon 2003). Affected habitats become denuded of their fish populations, and the introduced snails compete with native species such as *Pila*

spp., which specialize in feeding on already moribund plants. Confirmed evidence of the occurrence of *Pomacea gigas* in the TSBR could not be traced, but given how widespread it is in Thailand, there is a high possibility it could enter the Tonle Sap ecosystem if it hasn't already. It is a favoured prey of Asian Openbill, the population of which has increased rapidly in Thailand's central plains potentially as a result of the abundance of *P. gigas* (Round 2002). Toxic agro-chemicals are used to eradicate the snail, which can then accumulate in species higher up the food chain. The case of the apple snail is an example of the disastrous consequences that can follow from an inappropriate introduction (Welcomme and Vidayathon 2003).

Plants

A variety of exotic plant species have become established in the TSBR. Two major invasives present the greatest known problems: Water Hyacinth *Eichornia crassipes* and Giant Mimosa *Mimosa pigra*.

Water hyacinth *Eichornia crassipes*, a native of South America, reported present since the 1980s at least (Hellsten *et al.* 2003), appears to be increasing greatly in abundance along the shore of Tonle Sap, as it has in many tropical river systems in Southeast Asia (McDonald *et al.* 1997). Water hyacinth is most apparent along waterways with slow moving currents and in pools and ditches. While this species has some economic value as a pig fodder and in fish baits, and has some local uses, e.g. edible flowers, fertilizer and as rope (McDonald and Veasna 1996), its negative qualities greatly outweigh any economic value. Water hyacinth has a remarkably high rate of growth, and quickly forms dense mats of vegetation that deoxy-

genate water. It competes strongly with native aquatic species and impacts on fish production through lowered water quality (McDonald *et al.* 1997).

Several alien woody species occur in the floodplain, some of which are greatly expanding their cover and dominance. The Giant Mimosa *Mimosa pigra*, also a native of South America, reported present since at least 1990 (Hellsten *et al.* 2003), currently presents the most serious problems. Giant Mimosa is already a serious pest in other parts of Asia and northern Australia (e.g. Jantunen 2003). This aggressive plant rapidly invades fallow fields and heavily disturbed shrubland and swamp forest habitats after clearance or burning. Once established, it forms dense impenetrable thickets of spiny growth that choke out other native species, provides very little value as wildlife habitat, and is detrimental to fisheries (Goes 2005). The largest patches occur in abandoned fields in the south-western part of the TSBR, especially in Pursat province. There are also substantial thickets in the delta area and around Siem Reap (Hellsten *et al.* 2003). Two other alien *Mimosa* species, *M. invisa* and *M. pudica*, are also established around Tonle Sap but have been less aggressive (Rundel 2000 citing McDonald *et al.* 1997).

Two grass species have also widely invaded wetland margins of Tonle Sap. *Brachiaria mutica* and *Echinochloa stagnina* were introduced at some time in the past from Africa (Rundel 2000) as high quality species for grazing, and have become dominant species in many areas of the lake. Their ecological effects in the TSBR are undocumented.

The TSBR is one of the most productive freshwater ecosystems in the world. It supports unique floral and faunal assemblages characterised by a high relative abundance and adaptations to seasonally exploit specific components of an ecosystem that experiences extreme stresses during the course of its annual cycle of flooding and drought-like conditions. It is one of the most important wetlands for biodiversity conservation in Southeast Asia, supporting numerous narrowly or regionally endemic plant species, and an exceptional number of internationally important populations of globally threatened, Near Threatened and Data Deficient animal species.

Biodiversity within the TSBR is not extensively documented and is rather poorly understood. A great deal remains to be learned about the status, distribution and ecology of most individual species, ecological relationships within and between individual species and whole assemblages, and patterns of seasonal migrations, changes in abundance and habitat use. The following breakdown by taxonomic group attempts to highlight both a) the key known facts about the TSBR fauna and flora, and b) species or taxonomic groups that are potential conservation priorities but for which there is insufficient information.

MAMMALS

Relatively few mammal species occur in the TSBR for a tropical lowland ecosystem. These include six IUCN Red Listed species, each of which inhabits the seasonally inundated swamp forests and short-tree shrublands. Populations that are potentially of global or regional conservation significance are:

Long-tailed Macaque

(widespread and locally common, probably one of the larger populations in South-east Asia)

Germain's Silver Leaf Monkey

(poorly known but certainly important globally)

Smooth and Hairy-nosed Otters

(both poorly known but potentially important in South-east Asia)

Fishing Cat

(very poorly known but potentially important in South-east Asia)

The key conservation research priorities for mammals are:

- Further surveys to assess the status, distribution and conservation significance of the Germain's Silver Leaf Monkey population
- Further surveys to assess the status, distribution and conservation significance of Smooth and Hairy-nosed Otter populations
- Further surveys to assess the status, distribution and conservation significance of the Fishing Cat population
- Any significant populations of these species warrants follow-up conservation measures

BIRDS

Birds have been more extensively studied than any other group, 210 species have been recorded, and globally and/or Asia-regionally significant populations of over 25 species occur, 17 of which are IUCN Red-Listed. These most significant habitats, species and populations are:

- Globally significant colonies of **Greater and Lesser Adjutants, Spot-billed Pelican, Painted and Milky Storks, Black-headed Ibis, Darter and Indian Cormorant** that breed in seasonally inundated swamp forest in the Prek Toal Core Area;
- Probably one of the largest known breeding populations of **Grey-headed**

Fish Eagle;

- A unique bird community in perhaps the largest remnant tract of seasonally inundated grasslands and agro-ecosystems in South-east Asia, including during the dry season, probably the world's largest breeding population of **Bengal Florican**, the largest known wintering population of **Manchurian Reed Warbler**, very small numbers of **White-shouldered Ibis** and Asia-regionally important populations of **Greater Spotted and Imperial Eagles**, and in the wet season post-breeding aggregations of **Greater and Lesser Adjutants and Black-headed Ibis**.

The key conservation research priorities for birds are:

- Further develop monitoring systems of large waterbird populations to improve understanding of precise numbers, dispersal and interchange with other populations in Cambodia to facilitate conservation planning;
- Further surveys of potentially suitable seasonally inundated swamp forest habitat for breeding large waterbird colonies;
- An assessment of grassland extent and quality within the TSBR, and the status and distribution of Bengal Florican within remaining grasslands, in western Siem Reap, Banteay Meanchey, Battambang, Pursat, southern Kompong Thom and north-eastern

Kompong Chhnang provinces (Davidson 2004), coupled with continuing detailed studies of florican ecology and behaviour to better understand its conservation requirements;

- Conduct more widespread wet-season surveys in seasonally inundated swamp forest to assess status and distribution and conservation significance of breeding Masked Finfoot populations;
- Conduct wide-ranging dry season surveys of seasonally inundated swamp forest to assess status and distribution and conservation significance of breeding Grey-headed Fish Eagle populations;
- Conduct mist-netting surveys in grassland, short-tree shrubland and wetland habitats to assess distribution, habitat use and population size of wintering Manchurian Reed Warbler in dry season;
- Survey *Aquila* eagle roosts in outer floodplain grassland and short-tree shrubland habitats during the dry season to assess the size of the wintering population.

At least eight, perhaps ten globally threatened and Near Threatened reptile species occur in the TSB, but all species are poorly known and difficult to survey in the wild.

- Siamese Crocodiles probably still occur in several localities but in very small numbers, at least some populations may not be viable
- The largest known harvest of a snake assemblage in the world (chiefly of six species of watersnake) occurs in the seasonally inundated forests and short-tree shrublands during the wet season and into the early dry season
- An exceptional freshwater turtle assemblage has been reduced to small but nonetheless globally or regionally significant populations of at least six globally threatened species, the most significant being Yellow-headed Temple Turtle and perhaps Asian Giant Softshell Turtle, with key populations of Black Marsh Turtle, Asian Box Turtle, Malayan Snail-eating Turtle and Asiatic Softshell Turtle
- Large populations of Burmese and Reticulated Pythons have been reported from Boeng Chhma Core Area and adjacent Moat Khla, and Stung Sen Core Area
- The amphibian fauna is undocumented

Key conservation research priorities for herpetofauna are:

- Investigate potential to re-introduce wild Siamese Crocodiles to secure sites
- Monitor watersnake harvests and conduct field studies to assess sustainability and conservation requirements
- Manage key sites (e.g. Prek Toal and Boeng Chhma Core Areas) to minimise or remove exploitation and monitor recovery of crocodile, turtle and snake populations

- Conduct amphibian surveys to establish baseline data on species diversity, distribution and abundance

FISH

Fish catch data spans a longer period than for any other taxonomic group, but despite the enormous economic importance of the Tonle Sap fishery to Cambodia as a whole, fish ecology in the TSB is remarkably poorly understood. Many fish species that occur in the TSB are endemic to the Mekong Basin itself, or the Mekong Basin and one or two other South-east Asian catchments.

- At least five globally threatened fish occur in the Tonle Sap, including Mekong Giant Catfish, for which Fishing Lot #2 may seasonally be of great global conservation importance
- Several other species are of conservation concern based on apparent sharp declines
- Most fish species migrate in response to the highly seasonal fluctuations in hydrology, but these movements are poorly understood beyond some general basic principles
- Seasonally inundated swamp forest and short-tree shrubland habitats provide key nesting, spawning and rearing habitats for many species, but the relative importance of specific habitats to specific species and basic understanding of ecological requirements and precise movements for almost all species is lacking
- General trends apparent from fish catch data are that there have been sharp declines in the catch of large, rare fish species, the proportion of small fish caught is increasing as average fish size decreases, and mean catch per capita and unit effort is decreasing

- Only two of the eight designated Fish Sanctuaries appear to support significant concentrations of fish

Key conservation research priorities for fish are:

- Conduct detailed ecological studies of the globally threatened species and other species of conservation concern to assess their status and establish sustainable fishing practices to allow populations to recover, including a dedicated study of the Mekong Giant Catfish population in Fishing Lot #2 (Prek Toal Core Area)
- Conduct detailed studies of the seasonal use by fish communities of permanent wetlands in the middle and outer floodplain, on which there is currently no information, to assess their conservation importance to “black fish”
- Develop and implement a standardised monitoring programme to annually assess the status of fish populations in the main fisheries in the TSBR
- Pursue international collaboration, data sharing and fisheries management development for key populations of long distance migratory “white fish” utilising the Tonle Sap seasonally, but which are affected by factors operating elsewhere in the Mekong Basin, particularly the Mekong mainstream between the Mekong Delta and the Chinese border, where many species spend the dry season.

INVERTEBRATES

The invertebrate fauna is only now beginning to be studied. The first collection, made over two days in late May 2003 at Prek Toal, has so far yielded 218 identified species (excluding one large order and two smaller orders), including new species

and perhaps genera to science. Clearly, further collections are required in all major habitat types to establish a baseline of data. Too little is currently known to assess the conservation status of individual species or taxonomic groups.

FLORA

Knowledge of the TSBR flora is based on historical studies and one month-long survey in 1997. From these, we know that:

- The TSBR supports the largest remnant tract of a unique seasonally inundated freshwater swamp forest formation, which although relatively species poor is highly distinctive and rich in both regional and narrow endemics.
- This swamp or gallery forest has an understorey of lianas, made up of a group of species that form their own distinctive formation – short-tree shrublands – in the absence of the larger species in the middle floodplain.
- Exceptional examples of these occur in Prek Toal, Boeng Chhma (and adjacent Moat Khla) and Stung Sen Core Areas
- The TSBR supports what may be the largest remaining area of seasonally inundated grasslands (of diverse structure and community composition) in South-east Asia

Key conservation research priorities for flora are:

- Further surveys to assess distribution and conservation status of regional and narrow endemic species, and identify important examples of each for conservation action
- Detailed study of grassland species to assess grassland community uniqueness and their regional conservation significance

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ANNEX 1. PLANT SPECIES RECORDED IN THE TSBR

Dominant or locally common species in each broad vegetation formation are indicated with an *

Family	Scientific Name	Seasonally inundated swamp forest, tropical evergreen forest and short-tree shrublands	Aquatic herbaceous communities	Grasslands and agro- ecosystems	Outer floodplai n pools and ricefields	Source (s)
Alangiaceae	<i>Alangium ridleyi</i> King ¹	*				1,7,4
Alismataceae	<i>Ottelia alismoides</i> Pers.					1
	<i>Sagittaria sagittifolia</i> Lour					1
Amaranthaceae	<i>Achyranthes aquatica</i> R.Br.		*			1
	<i>Alternanthera sessilis</i> (L.) DC.			*		1,2
	<i>Centrostachys aquatica</i> Wall.					1
Annonaceae	<i>Gagnep.</i>	*				1,2
	<i>Popowia diospyrifolia</i> Pierre	*				1,2
	<i>Uncaria homomalla</i>	*				4
	<i>Uvaria pierrie</i> Finet & Gagnep.	*				1,4
Apocynaceae	<i>Parameria glandulifera</i> Benth.	*				1,4
	<i>Thevetia nereifolia</i> Juss. ex Steudl					1
Araceae	<i>Pistia stratiotes</i> L.		*		*	1,2
Asclepiadaceae	<i>Stenocaulon kleinii</i> W. & Arn.	*				1,2
	unidentified sp.					1
Asteraceae	<i>Eclipta alba</i> (L.) Hassk.				*	1,2
	<i>Grangea maderaspatana</i> (L.) Poir.			*	*	1,2
Balsaminaceae	<i>Impatiens</i> sp.				*	1,2
Barraginaceae	<i>Cordia</i> sp.	*				4
Bombaceae	<i>Ceiba pentandra</i> Gaertn.					1
Boraginaceae	<i>Coldenia procumbens</i> L.			*		1,2
	<i>Heliotropium indicum</i> L.			*	*	1,2
Caesalpiniaceae	<i>Crudia chrysantha</i>	*				1,4
	<i>Cynometra cf. dongnaiensis</i>	*				4
	<i>Cynometra cf. inaequifolia</i>	*				4
	<i>Cynometra ramiflora</i>	*				4
	<i>Cynometra</i> sp.					1
	<i>dasyrrachis</i>	*				1
	<i>Shorea cochinchinensis</i> Lam.					1
	<i>Tamarindus indicus</i> L.					1
Campanulaceae	<i>Sphenoclea zeylanica</i> Gaertn.					1
Capparidaceae	<i>Capparis micrantha</i> DC.					1
	<i>Crataeva nurvala</i> Ham.	*				1,4
	<i>Crataeva roxburghii</i> R.Br.	*				1
	<i>Maerua decandra</i> Gagnep.	*				1
Celastraceae	<i>Lophotatum wightianum</i> Arn.					1
	<i>Lophotatum fimbriatum</i>	*				4
Combretaceae	<i>Calycopteris floribunda</i> Lam.	*				1,4
	<i>Combretum deciduum</i> Coll. & Hemsl.	*				2
	<i>Combretum trifoliatum</i> Vent.	*				1,2,4
	<i>Combretum quadrangulare</i> Kurz.	*				1
	<i>Lumnitzera aff. racemosa</i> Willd.	*				1,2
	<i>Quisqualis indica</i> L.	*				1
	<i>Quisqualis densiflora</i> ^	*				4
	<i>Terminalia cambodiana</i> Gagnep.	*				1,2,4
Commelinaceae	<i>Commelina salicifolia</i> Roxb.		*			1
Connaraceae	<i>Connarus semidecandrus</i> Jack					1
Convolvulaceae	<i>Ipomoea aquatica</i> Forsk.	*	*			1,4
	<i>Ipomoea chrysioides</i> Ker.-Gawl.	*	*			1,4
	<i>Ipomoea obscura</i> Ker.-Gawl.		*			1
	<i>Merremia hederacea</i> (Burm.f.) Hall.f.					1
Cucurbitaceae	<i>Trichosanthes</i> sp.			*		1,2

Family	Scientific Name	Seasonally inundated swamp forest, tropical evergreen forest and short-tree shrublands	Aquatic herbaceous communities	Grasslands and agro- ecosystems	Outer floodplai n pools and ricefields	Source (s)
Cyperaceae	<i>Actinoscirpus grossus</i> (L.f.) Goetgh. & D.A. Smpson			*	*	1,2,3
	<i>Cyperus digitatus</i> Roxb.					3
	<i>Cyperus iria</i> L.					3
	<i>Cyperus aff. pilosus</i> Vahl			*	*	1,2
	<i>Fimbristylis dichotoma</i> (L.) Vahl					3
	<i>Fimbristylis dura</i> (Zoll. ex Maritz.) Merr.					3
	<i>Fimbristylis umbellaris</i> (Lam.) Vahl					3
	<i>Rhynchospora submarginata</i> Kuk.					3
	<i>Rhynchospora</i> sp.				*	1,2,3
	<i>Scleria</i> sp.					1
Dilleniaceae	<i>Tetracera sarmientosa</i> Vahl	*				1
Droceraceae	<i>Drosera burmannii</i> Vahl					1
	<i>Drosera indica</i> L.					1
Ebenaceae	<i>Diospyros bejardii</i> Lecomte	*				4
	<i>Diospyros cambodiana</i> H. Lec.	*				1
	<i>Diospyros sylvatica</i> Roxb.					1,4
	<i>Diospyros</i> sp.	*				4
Elaeocarpaceae	<i>Elaeocarpus griffithii</i> Mast.	*				1,4
	<i>Elaeocarpus lacunosus</i> Wall.	*				1
	<i>Elaeocarpus madopetalus</i> Pierre	*				1,4
	<i>Elaeocarpus</i> sp.	*				1
Euphorbiaceae	<i>Antidesma ghaesemibilla</i> Gaertn.	*				1,4
	<i>Breynia rhamnoides</i> Arg.	*				1,4
	<i>Bridelia cambodiana</i> Gagnep.	*		*		1,2
	<i>Coccoceras anisopodum</i> Gagnep.	*				1,4
	<i>Croton caudatus</i> Gagnep.	*				1,4
	<i>Croton krabas</i> Gagnep.	*		*		1,2,4
	<i>Croton mekongensis</i> Gagnep.	*				1,2
	<i>Homonoia riparia</i> Lour.	*				1,4
	<i>Hymenocardium wallichii</i> Tul.	*				1,2,4
	<i>Jatropha curcas</i> L.					1
	<i>Mallotus cochinchinensis</i> Lour.	*				1,4
	<i>Melanolepis vitifolia</i> Gagnep.					1
	<i>Phyllanthus julienii</i> Beille	*				1
	<i>Phyllanthus reticulatus</i> Poir.	*				1
	<i>Phyllanthus taxodiifolius</i> Beille	*				1,4
	<i>Phyllanthus</i> sp.	*		*		1,2,4
Flacourtiaceae	<i>Homalium brevidens</i> Gagnep.	*				1,4
	<i>Homalium dasyanthum</i>					1
	<i>Homalium griffithianum</i>	*				4
	<i>Hydnocarpus antheimintica</i> Pierre	*				1,4
	<i>Hydnocarpus saigonensis</i> Pierre	*				1,4
Guttiferae	<i>Calophyllum</i> sp.					1
	<i>Cratoxylum prunifera</i> Dyer.					1
	<i>Garcinia loureirii</i> Pierre	*				1,4
Hippocrataceae	<i>Salacia verrucosa</i> Wight					1
Hydrocharitaceae	<i>Ebdena canadense</i> Michx.				*	2
	<i>Hydrocharis dubia</i> (Bl.) Blak.					1
Lauraceae	<i>Cryptocarya oblongifolia</i> Bl.	*				1,4
Lecythidaceae	<i>Barringtonia acutangula</i> (L.) Gaertn.	*		*		1,2,4
	<i>Barringtonia micrantha</i>	*				4
	<i>Careya arborea</i>	*				4

Family	Scientific Name	Seasonally inundated swamp forest, tropical evergreen forest and short-tree shrublands	Aquatic herbaceous communities	Grasslands and agro- ecosystems	Outer floodplai n pools and ricefields	Source (s)
	Careya sp.					1
Lemnaceae	Lemna minor L.				*	1,2
Lentibulariaceae	Utricularia aurea Lour.		*		*	1,2
Lythraceae	Lagerstroemia sp.	*				1,4
	Ammannia baccifera Pollini					1
Malphiaceae	Hiptage triacantha	*				1,4
Marsiliaceae	Marsilea quadrifolia L.					1
Marantaceae	Schummanianthus dichotomus	*				1
Melicaceae ?	Dysoxylum procerum					1
Menyanthaceae	Nymphoides indica (Thwaites) Kuntze					1
Mimosaceae	Acacia spiralis	*				4
	Acacia thailandica Nielson	*		*		1,2
	Albizia lebeckoides (A.P. DC.) Benth.	*				1,4
	Enterolobium saman (Jacq.) Prain.					1
	Mimosa invisa ?					5
	Mimosa pigra L.					1
	Mimosa pudica ?					5
	Nepenthes oleracea Lour.					1
Moraceae	Capparis microcantha	*				4
	Cudrania cambodiana Gagnep.	*				1,4
	Ficus heterophylla Lf.	*				1,4
	Ficus sp.	*				1
Myrtaceae	Syzygium cinereum Wall.	*				1
	Syzygium sterrophyllum	*				1
Nelumbonaceae	Nelumbo nucifera (L.) Gaertn.				*	1,2
Nymphaeaceae	Nymphaea nouchali Burm.f.					1
Onagraceae	Jussiaea linifolia Vahl				*	2
	Ludwigia adscendens (L.) Hara.		*		*	1,2
	Ludwigia hyssopifolia (G. Don) Exell		*		*	1,2
Palmeae	Calamus godefroyi	*				4
	Calamus pulcherrimus Griff.	*				1
	Calamus salicifolius Becc.			*		1
Papilionaceae	Aeschynomene indica L.			*	*	1,2,3
	Butea frondosa Roxb. (monosperma) (Lam.) Taubert					1,4
	Dalbergia entadoides Pierre	*				1,2,4
	Dalbergia pinnaia Pierre	*				1,2
	Dendrobium lanceolatum (Dunn) Schindler					1
	Derris laotica Gagnep.	*		*		1,2
	Sesbania paludosa Prain (Sesbania javanica)	*	*			1,4
Poaceae	Arundinella setosa Trin.					3
	Bambusa arundinacea Ait.	*				1,4
	Brachiaria mutica Stapf.		*			1
	Chamaeraphis minuta Mez.					1
	Chrysopogon festucoides (J. Presl) Veldk.					3
	Cymbopogon cambogiensis (Balansa) E.G. & A. Camus					3
	Desmostachya bipinnata (L.) Stapf.					3
	Echinochloa stagnina (Retz.) Beauv.				*	1,2
	Eragrostis atrovirens (Desf.) Trin.					3
	Eragrostis brownii (Kunth) Nees.					3
	Imperata cylindrica (L.) P. Beauv.					3
	Leersia hexandra Sw.					1,3
	Lepidochloa sinensis Nees.					1

Family	Scientific Name	Seasonally inundated swamp forest, tropical evergreen forest and short-tree shrublands	Aquatic herbaceous communities	Grasslands and agro- ecosystems	Outer floodplai n pools and ricefields	Source (s)
	<i>Oryza rufipogon</i> Griff.					3
	<i>Oryza sativa</i> L.				*	1,2
	<i>Panicum luzonense</i> J. Presl.					3
	<i>Panicum repens</i> L.					3
	<i>Paspalum scrobiculatum</i> L.					1,3
	<i>Phragmites karka</i> Trin.		*	*		1,3
	<i>Pseudovossia cam bogensis</i> (Bal.) Camus.			*		1,2
	<i>Saccharum spontaneum</i> L.	*				1,4
	<i>Sacciolepis interrupta</i> A. Chase					1
	<i>Sacciolepis mysuroides</i> A. Chase					1
	<i>Sclerostachya fusca</i> (Roxb.) A. Camus.					1,3
	<i>Setaria pallida-fusca</i> Stapf.	*				1,2
	<i>Sorghum nitidum</i> (Vahl) Pers.					3
	<i>Themeda arundinacea</i> (Roxb.) Ridl.					3
	<i>Vossia cuspidata</i> Griff.					1
Podostemonaceae	<i>Dalzellia carinata</i>					1
Polygonaceae	<i>Polygonum barbatum</i> L.		*			1
	<i>Polygonum tomentosum</i> Willd.		*		*	2
Pontederiaceae	<i>Eichhornia crassipes</i> (Martius) Solms		*		*	1,2
	<i>Monochoria hastata</i> Solms					1
	<i>Monochoria vaginalis</i> Presl.					1
Potamogetonaceae	<i>Potamogeton</i> sp.					1
Rhamnaceae	<i>Zizyphus jujube</i>					1
	<i>Zizyphus</i> sp.					1
Rubiaceae (Naucleaceae)	<i>Antocephalus indicus</i> A. Rich.					1
	<i>Gardenia cambojana</i> Pitard.	*				1
	<i>Morinda persicae</i> folia Ham.	*		*		1,2,4
	<i>Mitragyna</i> cf. <i>diversifolia</i>	*				4
	<i>Randia longifolia</i> Benth.	*				1,2
	<i>Randia</i> sp.	*				1
	<i>Stephegyne</i> cf. <i>diversifolia</i>	*				4
	<i>Stephegyne parviflora</i> Korth.	*				1,4
	<i>Uncaria</i> sp.					1
Rutaceae	<i>Feronia lucida</i> Teijs. & Binn.					1
Salicaceae	<i>Salix tetrasperma</i> Roxb.					1
Salvinaceae	<i>Salvinia cucullata</i> Roxb.		*		*	1,2
Sapindaceae	<i>Cardiospermum halicababum</i> L.			*		1,2
	<i>Schleichera oleosa</i> (Lour.) Oken					1
Sapotaceae	<i>Mimusops elengi</i> L.	*				1,4
Scrophulariaceae	<i>Bacopa</i> sp.			*		1,2
	<i>Limnophila geoffrayi</i> Bonati.					1
	<i>Limnophila repens</i> Benth.					1
Simaroubaceae	<i>Saman dura</i> Harmandii Perre.	*				1
Sterculiaceae	<i>Buettneria pilosa</i> Roxb.	*				1,4
	<i>Melochia corchorifolia</i> L.				*	1,2
Trapaceae	<i>Trapa bicornis</i> Osbeck				*	1,2
	<i>Trapa natans</i> L.				*	5
Tiliaceae	<i>Grewia sinuata</i> Wall.	*				1,4
	<i>Brownlowia paludosa</i> Kost.	*		*		1,2
	<i>Siregodefroyana</i> ^	*				1,4
Verbenaceae	<i>Gmelina asiatica</i> L.	*		*		1,2
	<i>Vitex holodendron</i> D.Dop	*		*		1,2,4

Family	Scientific Name	Seasonally inundated swamp forest, tropical evergreen forest and short-tree shrublands	Aquatic herbaceous communities	Grasslands and agro- ecosystems	Outer floodplai n pools and ricefields	Source (s)
	<i>Vitex negundo</i> L.					1
Vitaceae	<i>Cissus hexangularis</i> Thorel	*				1,2
Xanthophyllaceae	<i>Xanthophyllum glaucum</i> Wall.	*				1,4
Xyridaceae	<i>Xyris compacta</i> R. Br.					1
	<i>Xyris indica</i> L.					1
	<i>Xyris intersita</i>					1
	<i>Xyris pauciflora</i> Willd.					1
	<i>Pentapetes phoenicea</i>	*				4
Unknown family	<i>Drypetes thorelii</i>	*				4
	<i>Styxis harmandiana</i>	*				4
	<i>Strychnos</i> sp.	*				4
	<i>Desmodium</i> sp.	*				4
	<i>Glossocarya siamensis</i> Craib.	*				4

Sources:

1 = McDonald et al. (1997)

2 = Lamberts (2001)

3 = Davidson (2004)

4 = Rollet (1972)

5 = Rundel (2000)

¹ Rollet (1972) mentions *Alangium* cf. *costatum*, a synonym for *A. ridleyi*

² ?Rollet (1972) may have mistaken for *Q. indica*

³ ?Rollet (1972) may have mistaken for *A. thailandica*; Khmer names very similar

⁴ Listed by Rundel (2000) citing McDonald et al. (1997), but not traced in copy of McDonald et al. (1997) viewed.

⁵ Rollet (1972) gives genus as *Schoutenia*

ANNEX 2. FISH SPECIES RECORDED IN THE TSBR

Family	Species	Global threat status	Spawning habitat ²	Tonle Sap River and Delta ²	Tonle Sap Lake ²	Inundated forest ²	Ricefield agro-ecosystems ⁴	Refs
Anabantidae	<i>Anabas testudineus</i>		floodplain		*		*	1,2,4
Anguillidae	<i>Anguilla bicolor</i>						*	4
Ariidae	<i>Arius spp./Hemipimelodus</i>							1
Ariidae	<i>Arius stormi</i>		Mekong	*				2
Ariidae	<i>Arius truncatus</i>							3
Ariidae	<i>Hemipimelodus borneensis</i>							3
Bagridae	<i>Hemibagrus spilopterus</i>						*	4
Bagridae	<i>Heterobagrus bocourti</i>							3
Bagridae	<i>Mystus albolineatus</i>		floodplain	*			*	2,4,5
Bagridae	<i>Mystus atrifasciatus</i>		floodplain	*	*			2
Bagridae	<i>Mystus filamentus</i>		floodplain	*	*			1,2,3
Bagridae	<i>Mystus multiradiatus</i>		floodplain	*	*			2,3
Bagridae	<i>Mystus mysticetus</i>		floodplain	*	*		*	2,3,4
Bagridae	<i>Mystus nemurus</i>		floodplain	*	*			1,2
Bagridae	<i>Mystus singaringan</i>		floodplain	*	*			2
Bagridae	<i>Mystus wicki</i>		floodplain	*	*			2
Bagridae	<i>Mystus wolffi</i>		floodplain	*	*			2
Bagridae	<i>Mystus wyckioides</i>		floodplain	*	*			2,5
Bagridae	<i>Pseudomystus siamensis</i>						*	4
Belontiidae	<i>Xenentodon cancila</i>		unknown	*	*		*	1?,2,3,4
Belontiidae	<i>Xenentodon cancilooides</i>		unknown	*	*			2
Belontiidae	<i>Trichogaster pectoralis</i>		floodplain		*		*	1,2,3,4
Belontiidae	<i>Trichogaster sp.</i>						*	4
Belontiidae	<i>Trichogaster trichopterus</i>						*	3,4
Belontiidae	<i>Trichogaster microlepis</i>		floodplain	*	*			1,2,3,7,4
Belontiidae	<i>Trichopsis schalleri</i>						*	4
Belontiidae	<i>Trichopsis vittata</i>						*	4
Chandidae	<i>Parambassis apogonioides</i>							1
Chandidae	<i>Parambassis notatus / siamensis</i>						*	4
Chandidae	<i>Parambassis wolffi</i>		floodplain	*	*		*	1,2,4
Chandidae	<i>Pseudambassis notatus</i>							3
Channidae	<i>Channa lucius</i>		floodplain		*		*	1,2,4
Channidae	<i>Channa micropeltes</i>		floodplain		*		*	1,2,4
Channidae	<i>Channa orientalis</i>							1
Channidae	<i>Channa striata</i>		floodplain		*		*	1,2,4
Clariidae	<i>Clarias batrachus</i>		floodplain	*	*		*	1?,2,4
Clariidae	<i>Clarias macrocephalus</i>		floodplain	*	*		*	1?,2,4
Clupeidae	<i>Clupeichthys aesarnensis</i>		Tonle Sap River	*				2,7,4
Clupeidae	<i>Clupeichthys goniognathus</i>		Tonle Sap River	*				1,2,7,4
Clupeidae	<i>Clupeoides borneensis</i>		Tonle Sap River	*				2
Clupeidae	<i>Tenuulosa thibaudeaui</i>	EN	Tonle Sap River	*	*			1,2
Clupeidae	<i>Tenuulosa toli</i>		Tonle Sap River	*				2
Cobitidae	<i>Acantopsis sp.</i>						*	4
Cobitidae	<i>Botia helodes</i>		floodplain	*	*		*	?1,2,4
Cobitidae	<i>Botia lecontei</i>		floodplain	*	*			?1,2,
Cobitidae	<i>Botia modesta</i>		floodplain	*	*		*	?1,2,4
Cynoglossidae	<i>Cynoglossus cynoglossus</i>		estuaries?	*				2
Cynoglossidae	<i>Cynoglossus feldmanti</i>		estuaries?	*				2
Cyprinidae	<i>Albulichthys albuloides</i>		inundated land	*	*			1,2
Cyprinidae	<i>Amblyrhynchichthys truncatus</i>		inundated land	*	*			2
Cyprinidae	<i>Barbodes altus</i>		rivers and floodplain	*	*		*	1,2,4
Cyprinidae	<i>Barbodes gonionotus</i>		rivers and floodplain	*	*		*	1,2,3,4
Cyprinidae	<i>Balantiocheilos melanopterus</i>	EN						7
Cyprinidae	<i>Catlocarpio siamensis</i>		?floodplain	*	*			1,2

Family	Species	Global threat status	Spawning habitat ²	Tonle Sap River and Delta ²	Tonle Sap Lake ²	Inundated forest ²	Ricefield agro-ecosystems ⁴	Refs
Cyprinidae	<i>Cirrhinus microlepis</i>		floodplain	*	*		*	1,3,4
Cyprinidae	<i>Cirrhinus molitorella</i>		floodplain	*	*			2
Cyprinidae	<i>Cosmochilus harmandi</i>		inundated land	*	*			1,2
Cyprinidae	<i>Crossocheilus reticulatus</i>							3
Cyprinidae	<i>Cyclocheilichthys apogon</i>							1,3,4?
Cyprinidae	<i>Cyclocheilichthys armatus</i>		inundated land	*	*			1,2,4?
Cyprinidae	<i>Cyclocheilichthys enoplos</i>		inundated land	*	*			1,2,3
Cyprinidae	<i>Cyclocheilichthys lagleri</i>		inundated land	*	*			2
Cyprinidae	<i>Cyprinus carpio</i>		unknown	*				1,2
Cyprinidae	<i>Dangila cf. cuvieri</i>		floodplain	*	*			1?,2
Cyprinidae	<i>Dangila kuhli</i>		floodplain	*	*			1?,2
Cyprinidae	<i>Dangila lineata</i>		floodplain	*	*			1?,2,3
Cyprinidae	<i>Dangila spilopleura</i>		floodplain	*	*			1,2,3
Cyprinidae	<i>Danio aequipinnatus</i>							1
Cyprinidae	<i>Esomus longimanus</i>							3
Cyprinidae	<i>Esomus metallicus</i>						*	3,4
Cyprinidae	<i>Hampala dispar</i>		inundated land	*	*			1,2,3
Cyprinidae	<i>Hampala macrolepidota</i>		inundated land	*	*		*	2,3,4
Cyprinidae	<i>Henicorhynchus caudimaculatus</i>		rivers and floodplain	*	*			?1,2
Cyprinidae	<i>Henicorhynchus cryptopogon</i>		rivers and floodplain	*	*			?1,2
Cyprinidae	<i>Henicorhynchus siamensis</i>		rivers and floodplain	*	*		*	?1,2,3,4
Cyprinidae	<i>Hypsibarbus lageri</i>							3
Cyprinidae	<i>Labeo erythropterus</i>							3
Cyprinidae	<i>Labiobarbus siamensis</i>						*	4
Cyprinidae	<i>Leptobarbus hoevenii</i>		floodplain	*			*	1,2,3,4
Cyprinidae	<i>Lobocheilos melanotaenia</i>		floodplain	*	*			2
Cyprinidae	<i>Luciosoma bleekeri</i>						*	3,4
Cyprinidae	<i>Luciosoma setigerum</i>		floodplain	*	*			1,2
Cyprinidae	<i>Morulius chrysophekadion</i>		rivers	*	*			1,2,3
Cyprinidae	<i>Opsarus koratensis</i>		rivers?	*				2
Cyprinidae	<i>Opsarus pulchellus</i>		rivers?	*				2
Cyprinidae	<i>Osteochilus hasselti</i>		floodplain	*	*		*	1,2,3,4
Cyprinidae	<i>Osteochilus melanopleurus</i>		floodplain	*	*		*	1,2,3,4
Cyprinidae	<i>Osteochilus microcephalus</i>							3
Cyprinidae	<i>Osteochilus schlegelii</i>		floodplain	*	*			1,2
Cyprinidae	<i>Parachela maculicanda</i>		floodplain	*	*			2
Cyprinidae	<i>Parachela siamensis</i>						*	1,3,4
Cyprinidae	<i>Paralauca typus</i>		unknown	*	*		*	1,2,3,4
Cyprinidae	<i>Probarbus jullieni</i>	EN	rivers and floodplain	*	*			1,2
Cyprinidae	<i>Probarbus labeamajor</i>	DD						8
Cyprinidae	<i>Puntioplites bulu</i>		inundated land	*	*			1,2
Cyprinidae	<i>Puntioplites proctozysion</i>		inundated land	*	*		*	1,2,4
Cyprinidae	<i>Puntius brevis</i>		inundated land	*	*		*	1,2,3,4
Cyprinidae	<i>Puntius masyai</i>		inundated land	*	*			2
Cyprinidae	<i>Rasbora aurotaenia</i>		rivers and ponds	*				1,2,3
Cyprinidae	<i>Rasbora borapetensis</i>						*	4
Cyprinidae	<i>Rasbora caudimaculata</i>							3
Cyprinidae	<i>Rasbora daniconius</i>		rivers and ponds	*			*	2,4
Cyprinidae	<i>Rasbora hobelmani</i>		rivers and ponds	*				2
Cyprinidae	<i>Rasbora pausisquamis</i>		rivers and ponds	*				2
Cyprinidae	<i>Rasbora paviei</i>		rivers and ponds	*				2
Cyprinidae	<i>Rasbora tornieri</i>		rivers and ponds	*			*	2,4
Cyprinidae	<i>Rasbora trilineata</i>						*	4
Cyprinidae	<i>Sikukia gudgeri</i>							1

Family	Species	Global threat status	Spawning habitat ²	Tonle Sap River and Delta ²	Tonle Sap Lake ²	Inundated forest ²	Ricefield agro-ecosystems ⁴	Refs
Cyprinidae	<i>Systomus orphoides</i>		rivers and floodplain	*	*			1,2,3
Cyprinidae	<i>Systomus partipentazona</i>						*	4
Cyprinidae	<i>Thynnichthys thynnoides</i>		floodplain	*	*		*	1,2,3,4
Datnioididae	<i>Datnioides microlepis</i>							1
Eleotridae	<i>Oxyeleotris marmorata</i>		floodplain		*		*	1,2,4
Engraulidae	<i>Coilia lindmani</i>		Tonle Sap River	*	*			?1,2,3
Engraulidae	<i>Coilia macrognathos</i>		Tonle Sap River	*	*			?1,2
Engraulidae	<i>Lycotrisa crocodilus</i>		unknown	*	*			2,3
Engraulidae	<i>Macrochirichthys macrochirus</i>		unknown	*	*			1,2
Engraulidae	<i>Setipinna melanochir</i>		unknown	*				1,2
Gobiidae	<i>Glossogobius aureus</i>		floodplain	*	*			2
Gyrinocheilidae	<i>Gyrinocheilus aymonieri</i>							5
Hemiramphidae	<i>Hyporhamphus limbatus</i>		unknown		*			1,2,3
Mastacembelidae	<i>Macrognathus maculatus</i>		unknown	*				2
Mastacembelidae	<i>Macrognathus siamensis</i>		unknown				*	1,2,?3,4
Mastacembelidae	<i>Macrognathus taeniagaster</i>		unknown	*			*	2,4,?3
Mastacembelidae	<i>Mastacembelus favus</i>		unknown	*	*		*	1,2,4
Nandidae	<i>Nandus nandus</i>						*	4
Nandidae	<i>Pristolepis fasciata</i>		floodplain	*	*		*	1,2,3,4
Notopteridae	<i>Chitala blanci</i>		inundated forest	*	*	*		2
Notopteridae	<i>Chitala ornata</i>		inundated forest	*	*	*	*	1,2,4
Notopteridae	<i>Notopterus notopterus</i>		inundated forest			*	*	1,2,4
Pangasiidae	<i>Pangasionodon gigas</i>	CR		*		*		6
Pangasiidae	<i>Pangasionodon hypophthalmus</i>							1,3
Pangasiidae	<i>Pangasius bocourti</i>							5
Pangasiidae	<i>Pangasius conchophilus</i>						*	4
Pangasiidae	<i>Pangasius djambal</i>							5
Pangasiidae	<i>Pangasius krempfi</i>							5
Pangasiidae	<i>Pangasius larnaudii</i>		floodplain	*	*			1,2,3,5
Pangasiidae	<i>Pangasius siamensis</i>		floodplain	*	*			1,2
Polynemidae	<i>Polynemus borneensis</i>		unknown	*				2
Polynemidae	<i>Polynemus longipectoralis</i>							3
Polynemidae	<i>Polynemus mutifilis</i>							1
Sciacnidae	<i>Boesemania microlepis</i>		unknown	*				1,2
Siluridae	<i>Belodontichthys dinema</i>		floodplain	*	*			1,2,3
Siluridae	<i>Kryptopterus cheveyi</i>							3
Siluridae	<i>Kryptopterus cryptopterus</i>		river	*	*			1,2,3
Siluridae	<i>Kryptopterus schilbeides</i>							3
Siluridae	<i>Micronema apogon</i>		floodplain	*	*			1?,2,3
Siluridae	<i>Micronema bleekeri</i>		floodplain	*	*			1?,2,5
Siluridae	<i>Micronema micronema</i>		floodplain	*	*		*	1?,2,4,5
Siluridae	<i>Ompok bimaculatus</i>		floodplain?	*	*		*	2,4,5
Siluridae	<i>Ompok hypophthalmus</i>		floodplain?	*	*		*	1,2,4
Siluridae	<i>Ompok</i> sp. cf. <i>eugeniatius</i>		floodplain?	*	*			2
Siluridae	<i>Wallago attu</i>		floodplain?	*	*		*	1,2,4
Siluridae	<i>Wallago leeri</i>		floodplain?	*	*			2
Sisoridae	<i>Bagarius/Glyphthorax</i> spp.							1
Soleidae	<i>Achiroides leucorhynchus</i>							1
Soleidae	<i>Euryglossa harmandi</i>		large rivers?	*				2
Soleidae	<i>Euryglossa orientalis</i>		estuaries?	*				2
Soleidae	<i>Euryglossa panoides</i>		estuaries?	*				2
Synbranchidae	<i>Monopterus albus</i>						*	4,5
Syngnathidae	<i>Doryichthys boaja</i>						*	4
Tetraodontidae	<i>Chelonodon fluvialilis</i>		estuaries	*				2

Family	Species	Global	Spawning habitat ²	Tonle Sap River and Delta ²	Tonle Sap Lake ²	Inundated forest ²	Ricefield agro- ecosyste ms ⁴	Refs
Tetraodontidae	<i>Chelonodon nigroviridis</i>		estuaries	*	*			2
Tetraodontidae	<i>Monotreta cambodgiensis</i>						*	1,3,4
Toxotidae	<i>Toxotes chatareus</i>		floodplain	*				1,2,3
Toxotidae	<i>Toxotes microlepis</i>		floodplain					2

References:

1 = van Zalinge et al. 1999

2 = Lim et al. 1999

3 = Lamberts 2001

4 = Balzer et al. 2003

5 = Neou et al. 2003

6 = Hogan et al. 2001

7 = Rainboth 1996

8 = Poulsen et al. 2004

ANNEX 3. BIRD SPECIES RECORDED IN THE TSBR

English Name (<i>sensu</i> Robson 2000)	Scientific Name	Global Threat Status	TS Status	Open water (lake, lakeshore and major tributaries)	Seasonally inundated swamp forest and short-tree shrublands	Grasslands and agro-ecosystems	Herbaceous wetlands (including sedge beds)
Rain Quail	<i>Coturnix coromandelica</i>					*	
Blue-breasted Quail	<i>Coturnix chinensis</i>					*	
Lesser Whistling-duck	<i>Dendrocygna javanica</i>				*	*	*
Comb Duck	<i>Sarkidiornis melanotos</i>				*	*	*
Cotton Pygmy-goose	<i>Nettapus coromandelianus</i>					*	*
Spot-billed Duck	<i>Anas poecilorhyncha</i>				*	*	*
Small Buttonquail	<i>Turnix sylvatica</i>					*	
Barred Buttonquail	<i>Turnix suscitator</i>					*	
Fulvous-breasted Woodpecker	<i>Dendrocopos macei</i>					*	
Rufous Woodpecker	<i>Celeus brachyurus</i>				*		
Laced Woodpecker	<i>Picus vittatus</i>				*		
Common Flameback	<i>Dinopium javanense</i>				*		
Indian Roller	<i>Coracias benghalensis</i>					*	
Common Kingfisher	<i>Alcedo atthis</i>				*	*	*
Stork-billed Kingfisher	<i>Halcyon capensis</i>			*	*		
White-throated Kingfisher	<i>Halcyon smyrnensis</i>			*	*		*
Black-capped Kingfisher	<i>Halcyon pileata</i>			*	*		*
Collared Kingfisher	<i>Todiramphus chloris</i>			*			*
Pied Kingfisher	<i>Ceryle rudis</i>			*			*
Blue-tailed Bee-eater	<i>Merops philippinus</i>			*	*	*	*
Chestnut-winged Cuckoo	<i>Clamator coromandus</i>				*		
Large Hawk Cuckoo	<i>Hierococcyx sparveroides</i>				*		
Indian Cuckoo	<i>Cuculus micropterus</i>				*		
Oriental Cuckoo	<i>Cuculus saturatus</i>				*		
Plaintive Cuckoo	<i>Cacomantis merulinus</i>					*	
Drongo Cuckoo	<i>Surniculus lugubris</i>				*		
Green-billed Malkoha	<i>Phaenicophaeus tristis</i>				*		
Greater Coucal	<i>Centropus sinensis</i>				*	*	*
Lesser Coucal	<i>Centropus bengalensis</i>				*	*	*
Red-breasted Parakeet	<i>Psittacula alexandri</i>				*		
Silver-backed Needletail	<i>Hirundapus cochinchinensis</i>			*	*		
Brown-backed Needletail	<i>Hirundapus giganteus</i>			*	*		
Asian Palm Swift	<i>Cypsiurus balasiensis</i>					*	
Fork-tailed Swift	<i>Apus pacificus</i>					*	
Barn Owl	<i>Tyto alba</i>					*	
Spotted Wood Owl	<i>Strix seloputo</i>				*		
Spotted Owlet	<i>Athene brama</i>					*	
Large-tailed Nightjar	<i>Caprimulgus macrurus</i>					*	
Rock Pigeon	<i>Columba livia</i>					*	
Spotted Dove	<i>Streptopelia chinensis</i>					*	
Red Collared Dove	<i>Streptopelia tranquebarica</i>					*	
Peaceful Dove	<i>Geopelia striata</i>					*	
Bengal Florican	<i>Houbaropsis bengalensis</i>	EN				*	
Sarus Crane	<i>Grus antigone</i>	VU				*	
Masked Finfoot	<i>Heliopais personata</i>	VU			*		
Slaty-breasted Rail	<i>Gallirallus striatus</i>					*	*
White-breasted Waterhen	<i>Amauromis phoenicurus</i>					*	*
Baillon's Crake	<i>Porzana pusilla</i>						*
Ruddy-breasted Crake	<i>Porzana fusca</i>					*	
White-browed Crake	<i>Porzana cinerea</i>					*	*
Watercock	<i>Gallicrex cinerea</i>			*		*	
Purple Swamphen	<i>Porphyrio porphyrio</i>			*		*	*
Common Moorhen	<i>Gallinula chloropus</i>			*		*	
Pintail Snipe	<i>Gallinago stenura</i>			*		*	

English Name (<i>sensu</i> Robson 2000)	Scientific Name	Global Threat Status	Open water (lake, lakeshore and major tributaries)	Seasonally inundated swamp forest and short-tree shrublands	Grasslands and agro-ecosystems	Herbaceous wetlands (including sedge beds)
Black-tailed Godwit	<i>Limosa limosa</i>		*		*	
Whimbrel	<i>Numenius phaeopus</i>		*		*	
Spotted Redshank	<i>Tringa erythropus</i>		*		*	
Common Redshank	<i>Tringa totanus</i>		*		*	
Marsh Sandpiper	<i>Tringa stagnatilis</i>		*		*	
Common Greenshank	<i>Tringa nebularia</i>		*		*	
Green Sandpiper	<i>Tringa ochropus</i>				*	
Wood Sandpiper	<i>Tringa glareola</i>				*	
Common Sandpiper	<i>Actitis hypoleucos</i>				*	
Red-necked Stint	<i>Calidris ruficollis</i>		*			
Temminck's Stint	<i>Calidris temminckii</i>		*		*	
Long-toed Stint	<i>Calidris subminuta</i>		*			
Curlew Sandpiper	<i>Calidris ferruginea</i>		*			
Broad-billed Sandpiper	<i>Limicola falcinellus</i>		*			
Ruff	<i>Philomachus pugnax</i>		*			
Red-necked Phalarope	<i>Phalaropus lobatus</i>		*			
Greater Painted-snipe	<i>Rostratula benghalensis</i>				*	
Pheasant-tailed Jacana	<i>Hydrophasianus chirurgus</i>		*		*	*
Bronze-winged Jacana	<i>Metopidius indicus</i>		*		*	*
Eurasian Thick-knee	<i>Burhinus oedicephalus</i>				*	
Black-winged Stilt	<i>Himantopus himantopus</i>		*		*	
Pacific Golden Plover	<i>Pluvialis fulva</i>				*	
Grey Plover	<i>Pluvialis squatarola</i>				*	
Little Ringed Plover	<i>Charadrius dubius</i>				*	
Oriental Plover	<i>Charadrius veredus</i>				*	
Grey-headed Lapwing	<i>Vanellus cinereus</i>				*	*
Red-wattled Lapwing	<i>Vanellus indicus</i>				*	
Oriental Pratincole	<i>Glareola maldivarum</i>				*	
Brown-headed Gull	<i>Larus brunnicephalus</i>		*			
Black-headed Gull	<i>Larus ridibundus</i>		*			
Caspian Tern	<i>Sterna caspia</i>		*			
Whiskered Tern	<i>Chlidonias hybridus</i>		*		*	*
White-winged Tern	<i>Chlidonias leucopterus</i>		*			
Osprey	<i>Pandion haliaetus</i>		*	*		*
Black Kite	<i>Milvus migrans</i>				*	
Brahminy Kite	<i>Haliaeetus indus</i>		*	*	*	*
White-bellied Sea Eagle	<i>Haliaeetus leucogaster</i>		*	*		
Grey-headed Fish Eagle	<i>Ichthyophaga ichthyaetus</i>	NT	*	*		
Short-toed Snake Eagle	<i>Circus gallicus</i>				*	
Pied Harrier	<i>Circus melanoleucos</i>				*	
Shikra	<i>Accipiter badius</i>				*	
Japanese Sparrowhawk	<i>Accipiter gularis</i>				*	
Greater Spotted Eagle	<i>Aquila clanga</i>	VU			*	
Imperial Eagle	<i>Aquila heliaca</i>	VU			*	
Common Kestrel	<i>Falco tinnunculus</i>				*	
Peregrine Falcon	<i>Falco peregrinus</i>		*	*	*	
Little Grebe	<i>Tachybaptus ruficollis</i>		*			
Darter	<i>Anhinga melanogaster</i>	NT	*	*		*
Little Cormorant	<i>Phalacrocorax niger</i>		*	*		*
Indian Cormorant	<i>Phalacrocorax fuscicollis</i>		*	*		*
Great Cormorant	<i>Phalacrocorax carbo</i>		*	*		*
Little Egret	<i>Egretta garzetta</i>		*	*	*	*
Grey Heron	<i>Ardea cinerea</i>		*	*	*	*
Purple Heron	<i>Ardea purpurea</i>		*	*	*	*
Great Egret	<i>Casmerodius albus</i>		*	*	*	*

English Name (<i>sensu</i> Robson 2000)	Scientific Name	Global Threat Status	Open water (lake, lakeshore and major tributaries)	Seasonally inundated swamp forest and short-tree shrublands	Grasslands and agro- ecosystems	Herbaceous wetlands (including sedge beds)
Intermediate Egret	<i>Mesophoyx intermedia</i>		*	*	*	*
Cattle Egret	<i>Bubulcus ibis</i>		*		*	*
Chinese Pond Heron	<i>Ardeola bacchus</i>		*	*	*	*
Javan Pond Heron	<i>Ardeola speciosa</i>		*		*	*
Little Heron	<i>Butorides striatus</i>			*		
Black-crowned Night Heron	<i>Nycticorax nycticorax</i>			*		
Yellow Bittern	<i>Ixobrychus sinensis</i>		*		*	*
Cinnamon Bittern	<i>Ixobrychus cinnamomeus</i>		*		*	*
Black Bittern	<i>Dupetor flavicollis</i>		*		*	*
Greater Flamingo	<i>Phoenicopterus ruber</i>					
Glossy Ibis	<i>Plegadis falcinellus</i>			*	*	
Black-headed Ibis	<i>Threskiornis melanocephalus</i>	NT		*	*	
White-shouldered Ibis	<i>Pseudibis davisoni</i>	CR		*	*	
Eurasian Spoonbill	<i>Platalea leucorodia</i>			*		
Great White Pelican	<i>Pelecanus onocrotalus</i>		*			
Spot-billed Pelican	<i>Pelecanus philippensis</i>	VU	*	*		*
Milky Stork	<i>Mycteria cinerea</i>	VU	*	*	*	
Painted Stork	<i>Mycteria leucocephala</i>	NT	*	*	*	
Asian Openbill	<i>Anastomus oscitans</i>		*	*	*	
Woolly-necked Stork	<i>Ciconia episcopus</i>			*	*	
Black-necked Stork	<i>Ephippiorhynchus asiaticus</i>	NT		*	*	
Lesser Adjutant	<i>Leptoptilos javanicus</i>	VU	*	*	*	
Greater Adjutant	<i>Leptoptilos dubius</i>	EN	*	*	*	
Blue-winged Pitta	<i>Pitta moluccensis</i>			*		
Black-and-red Broadbill	<i>Cymbirhynchus macrorhynchos</i>			*		
Brown Shrike	<i>Lanius cristatus</i>				*	
Mangrove Whistler	<i>Pachycephala grisola</i>			*		
Racket-tailed Treepie	<i>Crypsirina temia</i>			*	*	
Large-billed Crow	<i>Corvus macrorhynchos</i>			*	*	
Ashy Minivet	<i>Pericrocotus divaricatus</i>			*		
Pied Fantail	<i>Rhipidura javanica</i>			*		
Black Drongo	<i>Dicrurus macrocercus</i>				*	
Ashy Drongo	<i>Dicrurus leucophaeus</i>			*		
Black-naped Monarch	<i>Hypothymis azurea</i>			*		
Asian Paradise-flycatcher	<i>Terpsiphone paradisi</i>			*		
Common Iora	<i>Aegithina tiphia</i>			*		
Blue Rock Thrush	<i>Monticola solitarius</i>		*		*	
Asian Brown Flycatcher	<i>Muscicapa dauurica</i>			*	*	
Tickell's Blue Flycatcher	<i>Cyornis tickelliae</i>			*		
Siberian Rubythroat	<i>Luscinia calliope</i>				*	
Bluethroat	<i>Luscinia svecica</i>				*	
Oriental Magpie Robin	<i>Copsychus saularis</i>				*	
Common Stonechat	<i>Saxicola torquata</i>				*	
Pied Bushchat	<i>Saxicola caprata</i>				*	
White-shouldered Starling	<i>Sturnus sinensis</i>			*	*	
Asian Pied Starling	<i>Sturnus contra</i>				*	
Common Myna	<i>Acridotheres tristis</i>			*	*	
White-vented Myna	<i>Acridotheres grandis</i>			*	*	
Sand Martin	<i>Riparia riparia</i>		*		*	
Barn Swallow	<i>Hirundo rustica</i>		*		*	
Red-rumped Swallow	<i>Hirundo daurica</i>		*		*	
Asian House Martin	<i>Delichon dasypus</i>		*	*		
Yellow-vented Bulbul	<i>Pycnonotus goiavier</i>			*		
Streak-eared Bulbul	<i>Pycnonotus blanfordi</i>			*		
Zitting Cisticola	<i>Cisticola juncidis</i>				*	

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Bright-headed Cisticola	<i>Cisticola exilis</i>				*	
Yellow-bellied Prinia	<i>Prinia flaviventris</i>				*	
Plain Prinia	<i>Prinia inornata</i>			*	*	
[Spotted Bush Warbler]	<i>Bradypterus thoracicus</i>				*	
Lanceolated Warbler	<i>Locustella lanceolata</i>				*	
Rusty-rumped Warbler	<i>Locustella certhiola</i>			*	*	
Black-browed Reed Warbler	<i>Acrocephalus bistrigiceps</i>			*	*	*
Manchurian Reed Warbler	<i>Acrocephalus tangorum</i>	VU		*	*	*
Blunt-winged Warbler	<i>Acrocephalus concinens</i>					*
Oriental Reed Warbler	<i>Acrocephalus orientalis</i>				*	*
Thick-billed Warbler	<i>Acrocephalus aedon</i>				*	
Dusky Warbler	<i>Phylloscopus fuscatus</i>			*	*	
Radde's Warbler	<i>Phylloscopus schwarzi</i>			*		
Yellow-browed Warbler	<i>Phylloscopus inornatus</i>			*		
Striated Grassbird	<i>Megalurus palustris</i>				*	
White-crested Laughingthrush	<i>Garrulax leucolophus</i>			*		
Striped Tit Babbler	<i>Macronous gularis</i>			*		
Australasian Bushlark	<i>Mirafrja javanica</i>				*	
Oriental Skylark	<i>Alauda gulgula</i>				*	
Scarlet-backed Flowerpecker	<i>Dicaeum cruentatum</i>			*		
Ruby-cheeked Sunbird	<i>Anthreptes singalensis</i>			*		
Purple-throated Sunbird	<i>Nectarinia sperata</i>			*		
Olive-backed Sunbird	<i>Nectarinia jugularis</i>			*		
House Sparrow	<i>Passer domesticus</i>				*	
Plain-backed Sparrow	<i>Passer flaveolus</i>				*	
Eurasian Tree Sparrow	<i>Passer montanus</i>				*	
White Wagtail	<i>Motacilla alba</i>				*	*
Yellow Wagtail	<i>Motacilla flava</i>		*		*	*
Richard's Pipit	<i>Anthus richardi</i>				*	
Paddyfield Pipit	<i>Anthus rufulus</i>				*	
Red-throated Pipit	<i>Anthus cervinus</i>				*	
Streaked Weaver	<i>Ploceus manyar</i>		*			
Baya Weaver	<i>Ploceus philippinus</i>		*			
Asian Golden Weaver	<i>Ploceus hypoxanthus</i>	NT	*			
Red Avadavat	<i>Amandava amandava</i>				*	
Scaly-breasted Munia	<i>Lonchura punctulata</i>				*	
Yellow-breasted Bunting	<i>Emberiza aureola</i>	NT			*	

This species list has been compiled from records published in Recent Sightings in *Cambodia Bird News* nos.1-13, Goes 2001 and other articles in *Cambodia Bird News* 8, and Goes and Hong 2002.

ANNEX 4. MAMMAL SPECIES RECORDED IN THE TSBR

English Name	Scientific Name	Global Threat Status	Seasonally inundated swamp forest and short-tree shrublands	Grasslands and agro-ecosystems
Loris sp.	<i>Nycticebus sp.</i>	?	*	
Long-tailed Macaque	<i>Macaca fascicularis</i>	NT	*	
Germain's Silver Leaf Monkey	<i>Trachypithecus villosus germaini</i>	DD	*	
Hairy-nosed Otter	<i>Lutra sumatrana</i>	DD	*	
Smooth Otter	<i>Lutrogale perspicillata</i>	VU	*	
Asiatic Jackal	<i>Canis aureus</i>			*
Fishing Cat	<i>Prionailurus viverrinus</i>	VU	*	
Leopard Cat	<i>Prionailurus bengalensis</i>		?	
Small Asian Mongoose	<i>Herpestes javanicus</i>			*
Giant Flying Squirrel	<i>Petuarista sp.</i>		*	
Variable Squirrel	<i>Callosciurus finlaysonii</i>		*	
Lyle's or Large Flying Fox	<i>Pteropus lylei/vampyrus</i>		*	
Bandicoot Rat	<i>Bandicota indica</i>			*
Lesser Bandicoot Rat	<i>Bandicota savilei</i>			*
Field Rat	<i>Rattus rattus</i>			*
Ricefield Rat	<i>Rattus argentiventer</i>			*
Lesser Ricefield Rat	<i>Rattus losea</i>			*
Field Mouse	<i>Mus cervicolor</i>			*