3 Ecological character

The ecological character of a wetland is defined by its components and process which, through their interactions, provide benefits and services. Figure 19 illustrates the links between the ecological components and processes of Towra Point.

Critical ecosystem services are listed in Table 4.

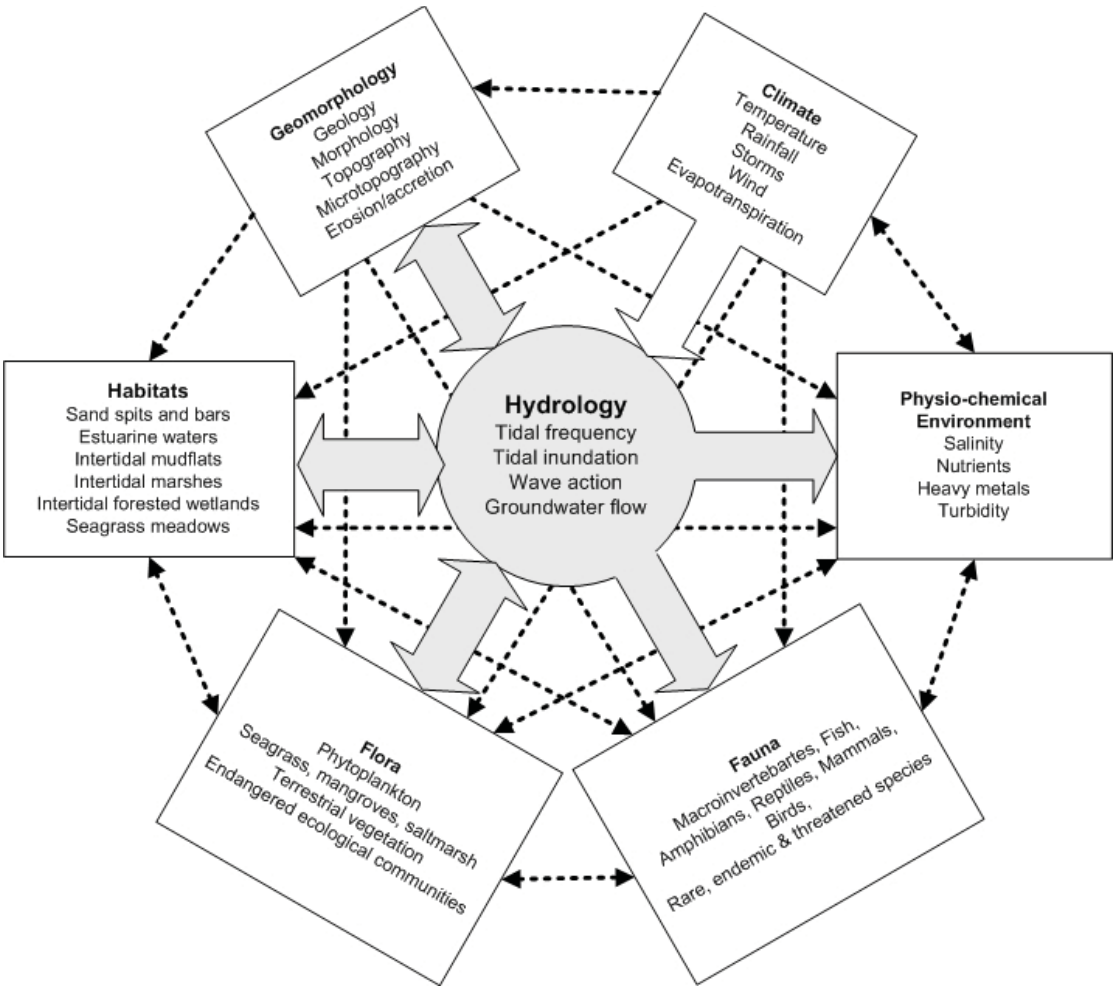


Figure 19: General conceptual model for components and processes at Towra Point

Table 4: Critical ecosystem services of Towra Point Nature Reserve

Ecosystem service		Service relating to the Ramsar site	Ramsar criteria
Provisioning	Fisheries production	Nursery habitat for commercial fish species and for commercial oyster cultivation.	3, 4, 8
	Trophic relay	Extensive food web provides numerous biological interactions and allows transfer of energy and nutrients throughout estuary.	
Regulating	Maintenance of hydrological regimes	Tidal cycle allows crabs to release larvae, which are a reliable food source for many fish and birds	1
		Retention and retardation of excess water flows, preventing flooding	
	Shoreline stabilisation and protection	Vegetation prevents erosion of marine and fluvial sands, especially in areas of site affected by tides, storms and high rainfall	1
	Pollution control	Mangroves and other vegetation types filter and trap sediments through a combination of biological activity and physical adsorption onto soil particles, preventing the flow of contaminants directly into the site's hydrological system.	1
	Science and education	As the largest wetland of its type in Sydney, Towra Point Nature Reserve attracts students of all academic levels for education and research.	1
	Aesthetic amenity	The wetlands of Towra Point are relatively pristine and the nature reserve protects some of the typical wetland types that are now rare in the area due to development. Towra Point is also one of the most important migratory bird-feeding and roosting sites in the Sydney region, and provides a pleasing view of a natural landscape in a heavily industrialised area.	1
Supporting	Hydrological processes	Towra Point wetlands maintain natural hydrological processes including evapotranspiration, runoff, infiltration and groundwater flow. Hydrology is critical in the Towra Point ecosystem, as it has a major influence on the morphology of the site and on habitat types, and determines distribution of flora and fauna species.	1
	Food webs	Mangroves and saltmarsh in Towra Point NR and seagrass meadows adjacent to the reserve are critical links in the food chain due to the large amounts of organic matter, or detritus, they produce, which is a reliable food source for invertebrates. The tidal regime in Botany Bay supports the food web at Towra Point by exporting crab and crustacean larvae from saltmarsh to intertidal and subtidal areas (outwelling) and by transporting detritus from seagrass meadows to intertidal and supratidal areas (inwelling).	1, 3
	Physical habitat	Suitable habitat for threatened species, endangered ecological communities, diverse range of shorebirds, and seagrass, mangrove and saltmarsh species growing next to each other, which enhances the area's biodiversity.	1, 2, 3, 4, 8
Supporting	Sediment trapping and stabilisation	Seagrass, saltmarsh and mangrove communities at Towra Point trap sediments; reducing both sediment loads in Botany Bay and erosion. These communities also trap contaminants which can be filtered out through the soil. Semi-diurnal tides in Botany Bay maintain good mixing of the water and suspended sediments. The high quality of the water surrounding Towra Point is evident in the health of the oysters produced in Quibray Bay. The presence of the vegetation at Towra Point supports water clarification by nutrient uptake and sediment accumulation.	1, 3

Ecosystem service		Service relating to the Ramsar site	Ramsar criteria
	Nutrient cycling	Movement of nutrients that promote the biological growth, development and maintenance of the wetland ecosystem	3
	Biodiversity	Connectivity between saltmarsh, mangrove and seagrass habitats at Towra Point is critical for maintaining species of fish and crustaceans. Towra Point is used for foraging by the threatened grey-headed flying fox, and there is a large maternal camp adjacent to Towra Point that supports the genetic diversity of the species.	1, 2, 3, 4, 8
	Special ecological, physical or geomorphic features	High levels of productivity from the combination of saltmarsh, mangrove and adjacent seagrass meadows support a high density and abundance of fish and crustaceans. Seagrass, saltmarsh and mangrove communities are important nursery habitats for fish and crustaceans, including those of commercial importance.	3, 4, 8
	Threatened wetland species, habitats and ecosystems	Towra Point supports three threatened species listed under the EPBC Act, and 23 threatened species and five endangered ecological communities under the TSC Act. Towra Point supports the largest stand of coastal saltmarsh in the Sydney Basin bioregion	1, 2, 4
	Priority wetland species	Towra Point NR and adjacent areas support 34 species of migratory birds listed under JAMBA, CAMBA and ROKAMBA. These birds use the mudflats, saltmarsh, mangrove and sand spit areas for feeding and roosting due to their high productivity and protection from predators and disturbance.	4
	Ecological connectivity	Towra Point provides important roosting, feeding and nesting sites for migratory birds, and supports significant habitat that is connected with surrounding natural areas such as Kamay Botany Bay NP, Royal NP and Georges River NP, and with Taren Point Shorebird Community. Shorebirds such as the eastern curlew and pied oystercatcher forage along the Georges River and in Port Hacking but, due to lack of suitable habitat elsewhere, return to Towra Point to roost.	2, 3, 4, 8

4 Ecosystem services

Towra Point was listed as a Ramsar site for its value in supporting threatened and endangered species and ecological communities, plants and animals at critical life stages, and fish populations. The critical benefits and services of Towra Point are, firstly, those relevant to its biodiversity value, including hydrological, nutrient cycling, food web and habitat services. Provisioning services are also of critical importance at Towra Point, as it serves as critical habitat for fish species and contributes to the local fishing industry.

The critical ecosystem services of Towra Point are described according to the categories identified in the Millennium Ecosystem Assessment (2003), with particular emphasis on provisioning services and services supporting the site's biodiversity values. The services are listed in Table 4.

4.1 Provisioning services

Towra Point is a critical habitat for fish species and contributes significantly to the finfish industry which provides food for human consumption. The oysters cultivated in Botany Bay and the Georges River are the only ones now produced in the Sydney area between the Hawkesbury and Shoalhaven rivers (DPI 2006).

4.1.1 Fisheries production

Finfish industry

The fish, crustaceans and molluscs of Botany Bay were a critical food source for the indigenous people and early settlers (ALS 1977). Due to its proximity to a growing colony and the relatively shallow and extensive waters, Botany Bay was used for fishing by the early settlers from the mid-19th century, and by 1880 a Royal Commission on Fisheries expressed concern about the declining number of fish in Botany Bay (SPCC 1979c). Commercial fishing continued in Botany Bay and for the 1977–78 financial year approximately 266 000 kg of catch was sold for approximately $280,000 (SPCC 1979c).

Changes since 1984

Towra Point Aquatic Reserve was declared in 1987 and is protected under the FM Act. Two zones have been defined: a sanctuary zone, which prohibits any form of fishing or collection of marine vegetation, and a refuge zone, which allows recreational fishing only (DECC 2008b). Commercial fishing, with the exception of lobster and abalone collection, was banned in Botany Bay and its tributaries in May 2002 as other coastal areas were exploited. This was to establish a recreational fishing haven for the exclusive use of anglers (Williams et al. 2004). The habitats at and surrounding Towra Point Nature Reserve are an important link for the commercial fishing industry to raise and protect juvenile fish, crustaceans and molluscs as they may migrate to areas that are commercially fished (Bell et al. 1984; Mazumder et al. 2005; Saintilan et al. 2007).

Oyster cultivation

The Georges River and Botany Bay system was one of the two most important areas for oyster production in NSW and was at a peak in 1971–72 with a yield of 41,068 bags (SPCC 1979c). Over half of the oysters produced in the Georges River/Botany Bay system were from Woolooware Bay, with the remainder from Quibray Bay and Georges River (SPCC 1979c), outside the Ramsar site.

Changes since 1984

The oyster industry grew due to the health and productivity of the oysters produced in the Georges River, Woolooware Bay and around Towra Point, aided by proximity to Sydney's markets (SPCC 1979c). An outbreak of Qx disease in 1994 stopped oyster farming in all areas of Botany Bay and the Georges River except for the leases in Quibray Bay and Woolooware Bay (DPI 2006). Some of the oyster leases around Towra Point have been abandoned and discarded oyster farming materials litter some parts of the nature reserve (Figure 20). During high tides, the remaining leases in Quibray and Woolooware Bay provide roosting sites for migratory birds such as the eastern curlew and bar-tailed godwit (*Limosa lapponica*) (P. Straw 2007, pers. comm.) (Figure 21). Today there are only a small number of active leases around Towra Point which are approved for cultivating Sydney rock oysters (*Saccostrea commercialis*).

4.1.2 Trophic relay

The complex food web at Towra Point provides numerous biological interactions and allows transfer of energy and nutrients to different parts of the estuary; this transfer is called trophic relay. Trophic relay can occur through tidal movement of organic material in the water column or through predator–prey interactions (Connolly et al. 2005b; Connolly 2009).

Stable isotopic analysis of carbon and nitrogen in organisms can help to determine how energy and nutrients are transferred through an ecosystem (Connolly et al. 2005b; Szymczak and Mazumder 2007). Organic material transferred from seagrass meadows into intertidal areas is used by many organisms that live in the saltmarsh and mangrove habitats (Connolly et al. 2005a, 2005b). Export of zooplankton from saltmarsh during spring tides enables transfer of energy and nutrients into otherareas (Mazumder et al. 2006a; Connolly 2009). These are two examples of trophic relay at Towra Point and a loss of these critical processes would cause loss of biodiversity (Connolly et al. 2005b).

Photo: K. Brennan 2007

Figure 20: Discarded oyster farming materials

Photo: Phil Straw

Figure 21: Eastern curlew on an oyster lease in Weeney Bay

4.2 Regulating services

The regulating services of Towra Point Nature Reserve Ramsar site include maintenance of hydrological regimes, shoreline stabilisation, biological control and pollution control.

4.2.1 Maintenance of hydrological regimes

Natural hydrological processes include rainfall, tides, evapotranspiration, runoff, infiltration and groundwater flow. Sydney is a growing city with more areas being cleared for development, and this changes some of these processes or prevents them from occurring. Water-sensitive urban design can help to minimise the impacts of development on the natural hydrological cycle.

Maintenance of natural hydrological regimes is critical for many of the components and processes of Towra Point. Crabs use the tidal cycle to release larvae which is critical to the productivity of the wetland as the larvae are a reliable food source for many fish and birds (Mazumder et al. 2006a). The vegetation communities have adapted to the tides and a change in the tidal cycle could lead to a change in ecological character of the site (Clarke and Hannon 1970).

Towra Point Nature Reserve supports recharge and discharge of groundwater. The wetland also has the ability to retain excess water and release it slowly into Botany Bay, which prevents flooding and filters some contaminants from the water. The conservation of this wetland will prevent further depletion of aquifer reserves and maintain the natural hydrological cycle.

4.2.2 Shoreline stabilisation and storm protection

The soils of Towra Point Nature Reserve include marine and fluvial sands, which are highly susceptible to erosion (Roy and Crawford 1979). The presence of vegetation prevents soil erosion, especially in areas affected by tides, storms and high rainfall. (ALS 1977).

Vegetated areas help to stabilise the seabed which reduces the effect of waves on the shoreline, and also prevent inundation of urban and industrial areas. Mangroves and seagrass trap sediment, protecting the seabed and shoreline.

Erosion at Towra Point has been intensified by dredging for the extension of the Sydney Airport runway and the container terminal at Port Botany which changed the wave patterns of the bay (SPCC 1979d; McGuinness 1988; NPWS 2001a). Erosion of Towra Beach is significant and is due to changes in the hydrological cycle in Botany Bay (SPCC 1979d).

4.2.3 Biological control of pests and disease

Towra Point supports habitat for native predators, such as the masked owl (*Tyto novaehollandiae*), white-bellied sea eagle (*Haliaeetus leucogaster*) and whistling kite (*Haliastur sphenurus*) which are often seen foraging at Towra Point and may prey on introduced rodents. Other birds such as the Australian white ibis (*Threskiornis molucca*) feed on grasshoppers.

4.2.4 Pollution control

The ability of mangroves and other vegetation types to trap sediments prevents the flow of contaminants directly into the water system. The contaminants are trapped and filtered through the soil where a combination of biological activity and physical adsorption onto soil particles removes contaminants and improves effluent water quality (Birch et al. 2004). The presence of a wetland acting as a buffer between land and water is extremely valuable for the health of the waterway. Kurnell Peninsula's land use is mostly industrial and runoff can be toxic; however, the wetland has a limit to which it can buffer the effects of such pollution. During high flow the probability of contaminated runoff is greatly increased and this places pressure on the wetland.

4.3 Cultural services

Towra Point has significant cultural services and benefits for Aboriginal and non-Aboriginal people. It provides cultural services through recreation and tourism, science and education, and aesthetics.

4.3.1 Recreation and tourism

Botany Bay and its tributaries are important and popular places for swimming, fishing and boating (SPCC 1978b). The Towra Point Nature Reserve is categorised under the plan of management for education and research only for which permits issued by DECCW are required.

No recreational activities are permitted, apart from at the day-use area on the western side of Towra Point where people can moor boats and use part of the beach. More than 500 people and 120 boats have been observed using this area over the summer months (NSW Maritime 2005). Commercial fishing is banned in the waters surrounding Towra Point, but in some parts recreational angling is allowed and these are popular fishing spots.

There are several viewing points for bird watching and nature observation outside the boundary of the nature reserve, and a horse riding facility is located adjacent to the nature reserve along the south-eastern shore of Quibray Bay.

Due to its proximity to Sydney, Kurnell Peninsula attracts a large number of regular visitors, especially to Kamay Botany Bay National Park (approximately 400,000 visitors in 2002) where Captain Cook first landed in Australia in 1770 (NPWS 2002). Towra Point is relatively concealed with limited signage which has probably helped to protect it from further degradation.

4.3.2 Science and education

DECCW encourages and supports ongoing scientific research by providing permits and access. Being the largest wetland of its type in Sydney, Towra Point Nature Reserve attracts students of all academic levels. Schools and universities use the wetland for projects, reports and theses.

In Kamay Botany Bay National Park there is an education centre from where NPWS runs educational tours and activities through its Discovery program, including a Towra Point tour every three months. The low frequency of this tour is intended to reduce disturbance and impact on the wetland. The guided tour visits areas that will have minimal impacts on the wetland and includes information about the unique and important ecosystem and the different vegetation communities and fauna species, especially the migratory shorebirds (A. Bianchi 2007, pers. comm.).

4.3.3 Aesthetic amenity

The areas surrounding Towra Point Nature Reserve are highly modified but Towra Point itself remains relatively pristine. The reserve represents some of the typical wetland types that used to be found in the area that are now rare due to development. Towra Point is also one of the most important migratory bird-feeding and roosting sites in the Sydney region, and provides a pleasing view of a natural landscape in a heavily industrialised area.

4.3.4 Aboriginal heritage

The country of the Gweagal clan of the Dharawal nation is located on the southern shore of Botany Bay and is of great significance to the Aboriginal people (Colman and Hopkins 2001). Middens, rock shelters, engravings and burial sites provide evidence that it is an important area for Aboriginal heritage and Towra Point Nature Reserve contains three known sites (NPWS 1998). Parts of Towra Point were used for food (mainly seafood) and freshwater from the ponds. Captain Cook learnt from the Aboriginals about food and land use in Botany Bay. There is still a strong association of the Aboriginal community with Towra Point and Botany Bay and, through the Discovery Program at Kamay Botany Bay National Park, others in the community are being educated about Aboriginal heritage.

The Towra Team, which consists of members of the La Perouse Aboriginal community, undertakes projects in the Kurnell area such as bush regeneration, leading Discovery Program tours and patrolling Towra Spit Island by boat during little tern nesting season. The Aboriginal community in the Botany Bay region has lost connectivity to Country since settlement, so the Towra Team helps to restore this connection and also provides training in transferable skills.

4.3.5 Non-Aboriginal heritage

Captain James Cook and his crew on the *Endeavour* were searching for fresh water when they sailed into Botany Bay in 1770. Cook explored Towra Point and mapped Towra Lagoon; Joseph Banks, Daniel Solander and other scientists took the first recorded botanical and zoological samples of Australia from Towra, Botany Bay and Kurnell (Benson and Eldershaw 2007).

Non-Aboriginal use of Towra Point began in the 1860s and caused significant changes to the area. Thomas Holt was a major landholder in the Kurnell area and used Towra Point to farm sheep and cultivate oysters (McGuinness 1988). His oyster leases in Woolooware and Quibray bays in the 1890s were the site of the first successful commercial oyster cultivation in Australia (SPCC 1979c; McGuinness 1988). The only known relic of grazing at Towra Point is a split rail fence extending

from Towra Bay to Weeney Bay. However, the exotic species buffalo grass (*Stenotaphrum secundatum*) is a consequence of this past use (NPWS 2001a). Clearing of the vegetation for lumber on the Kurnell sand dunes commenced in the early 1800s, and began major sand displacement which lasted for many years (McGuinness 1988). Foundations of a civil aviation navigation facility and causeway constructed in the 1950s still remain at Towra Point.

The oyster industry is part of the cultural heritage of Towra Point, as it supported the leases of about 50 growers who employed over 300 people in 1979. In Botany Bay and the Georges River the leases were family owned, and spanned two or three generations (SPCC 1979c). The oysters produced around Towra Point were of high quality ('plate grade'), and the peak of the industry was in 1971–72 (DPI 2006). Today there are only a small number of active leases in Quibray and Woolooware bays. The vegetation at Towra Point, including adjacent seagrass, filters contaminants and suspended sediments from the water, which supports healthy oyster production (SPCC 1978a).

4.4 Supporting services

Supporting services include water cycling, nutrient cycling, food webs and habitat.

4.4.1 Hydrological processes

Towra Point is a critical wetland in the Sydney area because it maintains natural hydrological processes including evapotranspiration, runoff, infiltration and groundwater flow. Hydrology is critical in the Towra Point ecosystem and has a major influence on the morphology of the site and the habitat types, and determines both flora and fauna species distribution. Hydrological processes relevant to Towra Point Nature Reserve are discussed in section 5.4.

4.4.2 Food webs

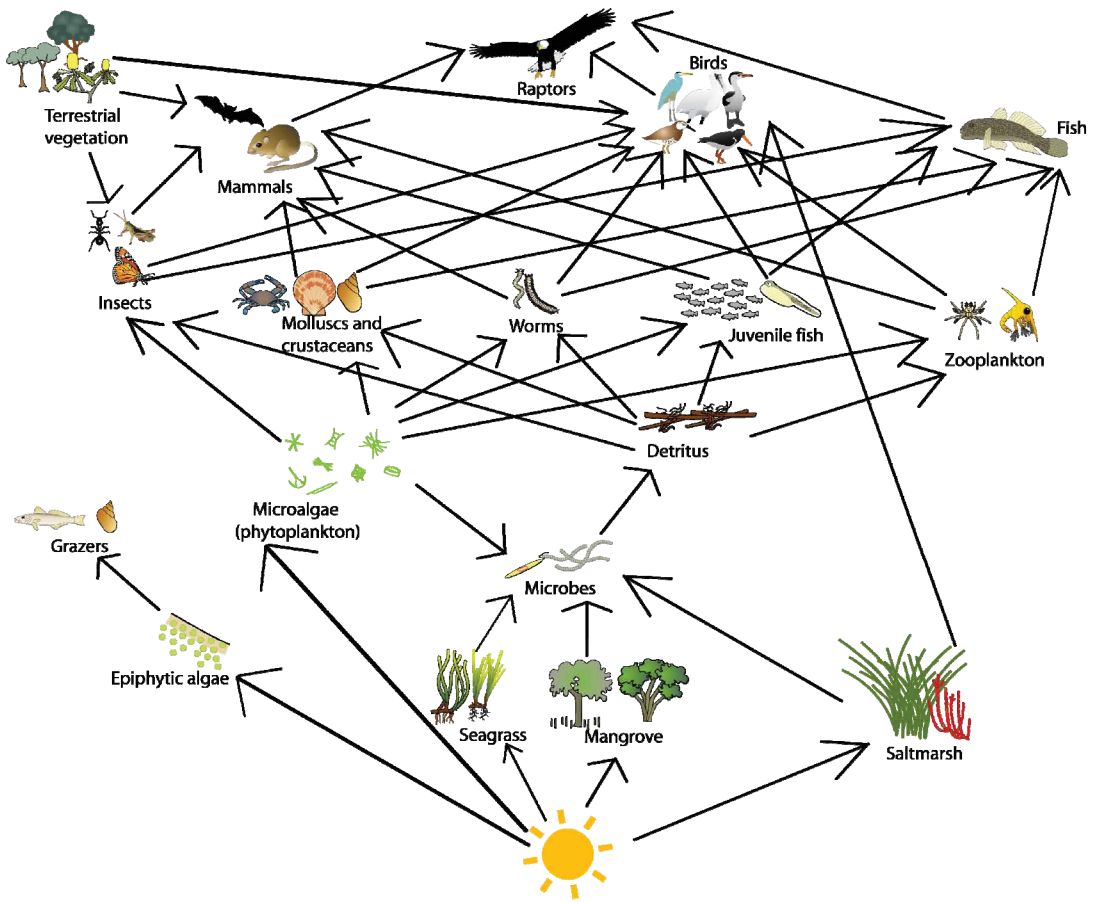
Towra Point supports a large number of interactions between organisms and the transfer of nutrients and energy, and the biodiversity of the reserve is a consequence of this. Seagrass meadows adjacent to Towra Point Nature Reserve and mangrove and saltmarsh communities are critical links in the food chain due to the large amounts of organic matter, or detritus, they produce (Connolly et al. 2005a, 2005b), which is a reliable food source for invertebrates. The food web in Figure 22 illustrates the importance of detritus on higher trophic levels.

Critical biological interactions include those involving birds and mammals, such as the grey-headed flying fox, which play an important role in seed dispersal and pollination of many native tree species (Pallin 2000), and the export of crab larvae in the spring tide which transfers energy from saltmarsh areas to Botany Bay (Mazumder et al. 2006a).

The tidal regime in Botany Bay supports the food web at Towra Point by exporting crab and crustacean larvae from saltmarsh to intertidal and subtidal areas, a process known as outwelling (Mazumder et al. 2009; Connolly 2009), and by transporting detritus from seagrass meadows to intertidal and supratidal areas, a process known as inwelling (Connolly et al. 2005a, 2005b).

4.4.3 Physical habitat

Towra Point supports remnant habitats, threatened species and endangered ecological communities which were once found throughout Sydney. Shorebirds, including little terns, have specific habitat requirements (Lawler 1996) and will only



Source: K. Brennan 2007

Figure 22: Generic food web for Towra Point Nature Reserve

use Towra Point if their requirements are met (NPWS 2003). A diverse range of shorebird species use Towra Point, which indicates that the wetland supports critical physical habitat for these birds. The physical conditions of Towra Point allow seagrass, mangrove and saltmarsh species to grow next to each other, which also enhances the biodiversity of the area (Jelbart et al. 2007; Saintilan et al. 2007).

The size of the Towra Point wetland in comparison to any other wetlands of its type in the Sydney Basin is a critical factor in maintaining suitable habitat for a large number of species (Clynick and Chapman 2002; Connolly et al. 2005a). Towra Point supports the largest stand of saltmarsh, an endangered ecological community under the TSC Act, and almost half of the mangrove community in the Sydney region (NPWS 2001a).

4.4.4 Nutrient cycling

A fine balance of nutrients maintains the healthy status of an ecosystem. The largest variation in nutrients occurs in the upper catchment of the Georges River where there are industrial and urban land uses and where there is the least amount of tidal flushing (SMCMA 2007c). Within the Botany Bay catchment, nutrients enter the water directly from surface runoff, sewage overflows and stormwater, and indirectly from groundwater discharge. Catchment land use has a major influence on the types and loads of nutrients entering the waterway. The sources of water that enter the sub-catchment containing Towra Point are mostly from residential and industrial areas with a small amount of recreational land, and the runoff has been found to be generally high in nutrients (SSC 2004).

The flora and fauna at Towra Point are critical components in nutrient cycling, especially the primary producers (phytoplankton, seagrass, mangrove and saltmarsh) which have a high nutrient requirement and convert nutrients to a more usable form for other species (SPCC 1978a).

Semi-diurnal tides in Botany Bay maintain good mixing of the water and suspended sediments. The high quality of the water surrounding Towra Point is evident in the health of the oysters produced in Quibray Bay. The presence of the vegetation at Towra Point supports water clarification by nutrient uptake and sediment accumulation. Land use has changed in the upper Georges River catchment from agriculture to residential development. This may decrease the nutrients entering the waterway, but may mean higher sediment loads due to an increase in impermeable surfaces (SMCMA 2007c). From 1997, Sydney Water Corporation began improvements to the sewer and stormwater systems of the Georges River catchment to improve water quality (SWC 2007a).

4.4.5 Primary production

Primary producers are green plants and some bacteria that rely on light for energy production through photosynthesis. Phytoplankton is one of the main primary producers in the Botany Bay and Georges River system. It is a major food source for invertebrate grazers and therefore critical in the food chain (Kunz and Richardson 2006). Towra Point Nature Reserve provides a suitable habitat for phytoplankton and other primary producers such as mangroves, saltmarsh and terrestrial vegetation. Seagrass meadows are especially known for their high productivity and also support higher levels of the food chain (West 1983; Connolly et al. 2005b).

4.4.6 Sediment trapping and stabilisation

Seagrass, saltmarsh and mangrove communities at Towra Point trap sediments; therefore they reduce both sediment loads in Botany Bay and erosion. These communities also trap contaminants which can be filtered out through the soil.

4.4.7 Biodiversity

Towra Point supports a large variety of plant and animal species (see Appendices B–E). The relatively large size of the wetland allows a greater number of species to co-exist and the different habitat types provide habitat and food for a diverse range of species (see section 5.5).

The food web illustrates the importance of the different vegetation types in providing ample food for a large number of higher order species. Intertidal areas surrounding Towra Point, including at Taren Point, consist of a different substrate which favours a more diverse range of invertebrates and, consequently, shorebird species. The proximity of seagrass to mangrove and saltmarsh areas allows trophic relay at different levels, therefore supporting biodiversity (Saintilan et al. 2007).

4.4.8 Special ecological, physical or geomorphic features

The saltmarsh community at Towra Point is listed as an endangered ecological community under the TSC Act and supports habitat for a number of birds such as the white-fronted chat. Towra Point and adjacent areas support migratory shorebirds during part of their annual migratory cycle. These birds return to this site annually to accumulate fat reserves for their northward migration and breeding. The high levels of productivity from the combination of saltmarsh, mangrove and adjacent seagrass meadows support a high density and abundance of fish and crustaceans (Jelbart et al. 2007; Saintilan et al. 2007). The importance of seagrass, saltmarsh and mangrove

communities as a nursery habitat has been established for fish and crustaceans, including those of commercial importance (Bell et al. 1984; Mazumder et al. 2005).

Prior to anthropogenic changes to the northern side of Botany Bay, there were extensive mud flats and saltmarsh areas in that area for shorebirds to feed, nest and roost (Hindwood and Hoskin 1954). Land reclamation and development have destroyed those sites and shorebirds have been forced to find and compete for suitable habitat on the southern side of Botany Bay (Pegler 1997). Structures within Quibray, Weeney and Woolooware bays and along the Taren Point shoreline provide additional roost sites. Oyster leases in the bays around Towra Point are high-tide roosts for birds such as eastern curlew, whimbrel (*Numenius phaeopus*), bar-tailed godwit and cormorants. An abandoned jetty at Taren Point is an important roosting site for pied oystercatchers and an old barge in Woolooware Bay is used by ruddy turnstone (*Arenaria interpres*), common greenshank (*Tringa nebularia*) and other birds (Figures 23 and 24).

4.4.9 Threatened wetland species, habitats and ecosystems

Towra Point supports four threatened species listed under the EPBC Act, and 23 threatened species and five endangered ecological communities under the TSC Act (Tables 5, 6, 7 and 8). There are five endangered ecological communities in, and one adjacent to, Towra Point Nature Reserve (Table 8, Figure 25). Taren Point Shorebird Community is supported by habitat at Towra Point (see section 5.5.2).

Due to knowledge gaps in species occurrence, the tables give an indication only of species present. Some species, such as the bush stone-curlew (*Burhinus grallarius*), have not been recorded for over 20 years, and others, such as the curlew sandpiper (*Calidris ferruginea*), have significantly reduced in number (AWSG 2008).

4.4.10 Priority wetland species

Towra Point Nature Reserve and adjacent areas regularly support approximately 34 of the 80 species of migratory birds listed under various agreements, including JAMBA, CAMBA and ROKAMBA (NPWS 2001a) (Table 9). These birds use the mudflats, saltmarsh, mangrove and sand spit areas for feeding and roosting, and these areas provide a favourable habitat due to the high productivity of the reserve and the protection from predators and disturbance (Laegdsgaard 2006; Spencer et al. 2009). Some species have not been recorded since the 1980s, but there is insufficient information to conclude whether they have disappeared from the area or have not been detected during surveys (Appendix D).

4.4.11 Ecological connectivity

Sydney is a highly developed city in terms of urban and industrial development, and this has caused a loss and fragmentation of natural habitats. Ecological corridors are critical to assist the connectivity of natural areas to allow movement of species from one area to another and to reduce the risk of extinction of species. Corridors maintain the genetic biodiversity of an area and improve species viability (Mech and Hallett 2001). Towra Point supports significant habitat that connects it with surrounding natural areas such as Kamay Botany Bay National Park, Royal National Park, Georges River National Park, Taren Point Shorebird Community and Heathcote National Park.

Shorebirds such as the eastern curlew and pied oystercatcher forage along the Georges and Port Hacking rivers but, due to lack of suitable habitat elsewhere, return to Towra Point to roost (P. Straw 2007, pers. comm.). In the absence of connectivity to these areas species viability would diminish.

The grey-headed flying fox can forage 25 kilometres from their roost camp, and the same camps are used each year (Eby 2006). There is a large maternal camp adjacent to Towra Point that supports the genetic diversity of the species and Towra Point is used for foraging (Eby 2006; Schulz 2006). Connectivity to other native landscapes is critical for this vulnerable species.

Large birds such as the white-bellied sea eagle also rely on corridors for their home range. The connectivity between saltmarsh, mangrove and seagrass habitats at Towra Point is critical in maintaining species of fish and crustaceans (Bell and Pollard 1984; Mazumder et al. 2005; Saintilan et al. 2007).

Photo: John Dahlenburg 2007

Figure 23: Abandoned jetty at Taren Point, a roosting site for pied oystercatchers

Photo: Phil Straw 2002

Figure 24: Shorebirds roosting on an old barge

Table 5: Nationally threatened fauna and flora species under EPBC Act

Scientific name	Common name	Status*	Location recorded
Syzygium paniculatum	Magenta lilly pilly	V	In littoral rainforest along Captain Cook Drive
Litoria aurea	Green and golden bell frog	V	End of Towra causeway and Towra Lagoon
Pteropus poliocephalus	Grey-headed flying fox	V	Various locations throughout Towra Point

* E = endangered, V = vulnerable (EPBC Act)

Source: ALS (1977); DECC (2009)

Table 6: Threatened fauna under the TSC Act

Scientific name	Common name	Status*	Location recorded
Litoria aurea	Green and golden bell frog	E	End of Towra causeway and Towra swamp
Burhinus grallarius	Bush stone-curlew	E	Towra Point, Botany Bay #
Sterna albifrons	Little tern	E	Towra Point, Towra Spit Island and the Elephants Trunk
Dugong dugon	Dugong	E	Towra Point, Botany Bay
Calidris alba	Sanderling	V	Botany Bay
Calidris tenuirostris	Great knot	V	Towra Point
Charadrius leschenaultii	Greater sand-plover	V	Towra Point
Charadrius mongolus	Lesser sand-plover	V	Botany Bay
Haematopus fuliginosus	Sooty oystercatcher	V	The Elephants Trunk, Towra Point Nature Reserve, Botany Bay
Haematopus longirostris	Pied oystercatcher	V	Towra Point, various locations
Limicola falcinellus	Broad-billed sandpiper	V	Botany Bay
Oxyura australis	Blue-billed duck	V	Kurnell Lagoon
Tyto novaehollandiae	Masked owl	V	Towra Point, south-east of Mirrormere
Xenus cinereus	Terek sandpiper	V	Botany Bay
Pteropus poliocephalus	Grey-headed flying fox	V	Various locations throughout Towra Point
Scoteanax rueppellii	Greater broad-nosed bat	V	Towra Point, south-east of Mirrormere

* E = endangered, V = vulnerable (TSC Act)

Thought to be extinct in the area (Schulz 2006).

Source: ALS (1977); DECC (2009)

Table 7: Threatened flora under the TSC Act

Scientific name	Common name	Status*
Chamaesyce psammogeton	Sand spurge	E
Senecio spathulatus	Coast groundsel	E
Caladenia tessellata	Tessellated spider orchid	E
Pterostylis sp. *Botany Bay*	Botany Bay bearded orchid	E
Acacia terminalis subsp. *terminalis*	Sunshine wattle	E
Callistemon linearifolius	Netted bottle brush	V
Wilsonia backhousei	Narrow-leafed wilsonia	V
Syzygium paniculatum	Magenta lilly pilly	V

* E = endangered, V = vulnerable (TSC Act)

Source: DECC (2005)

Table 8: Endangered ecological communities under the TSC Act

Endangered ecological community	Location	Condition in 2007
Coastal saltmarsh in the NSW North Coast, Sydney Basin and South East Corner bioregions	Found on the landward side of the mangroves throughout Towra Point and along the shores of Woolooware and Quibray bays. Extensive saltmarsh on Towra causeway.	Very good condition with no weed infestation. Mangrove encroachment has been documented.
Kurnell Dune Forest in the Sutherland Shire and City of Rockdale	Fragments of this community are found on the inner part of Towra Point, at The Knoll and at Pelican Point.	Variable condition with widespread weed infestation.
Littoral Rainforest in the NSW North Coast, Sydney Basin and South East Corner bioregions	The one location within the Towra Point Nature Reserve Ramsar site boundary is in the middle of the site. There is a smaller area on the opposite side of Captain Cook Drive.	Weed infested, especially by lantana (*Lantana camara*).
Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner bioregions	In areas of lower elevations within Towra Point, usually on the landward side of saltmarsh.	Moderate to good. Weed infestation by buffalo grass.
Sydney Freshwater Wetlands in the Sydney Basin bioregion	Named freshwater lagoons at Towra Point are Towra Lagoon, Mirrormere and Weedy Pond, all situated between Weeney Bay and Towra Beach. There are at least three other unnamed lagoons with no ecological information.	Moderate to good with some weed infestation and rubbish pollution. Saline intrusion has occurred in some ponds.
Taren Point Shorebird Community on the relict tidal delta sands	On a small strip of intertidal shoreline found adjacent to Towra Point, on the north-western side of Woolooware Bay at the mouth of the Georges River.	Suitable supporting habitat at present, but is at risk of disturbance due to residential and industrial development.

Source: DECC (2005); SSC (2006a); WODEC (2007)

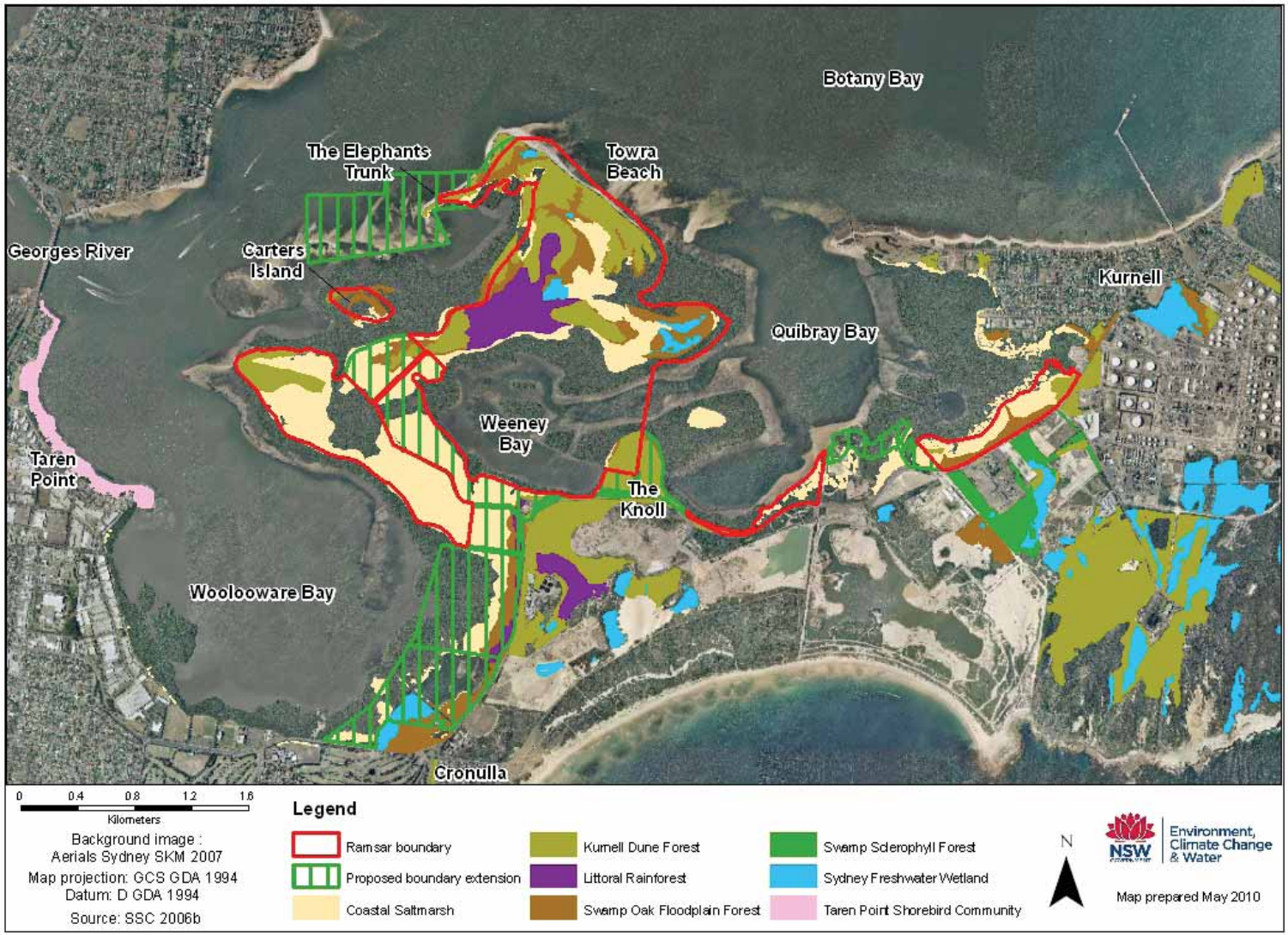


Figure 25: Endangered ecological communities

Table 9: Migratory bird species protected under international agreements

Scientific name	Common name	Protection agreement*
Egretta alba	Great egret	C
Bubulcus ibis (*Ardeola ibis*)	Cattle egret	J C
Plegadis falcinellus	Glossy ibis	C
Haliaeetus leucogaster	White-bellied sea eagle	C
Charadrius leschenaultii	Greater sand plover	C R
Charadrius mongolus	Lesser sand plover	C R
Pluvialis squatarola	Grey plover	J C
Pluvialis dominica	Lesser golden plover	J C
Numenius phaeopus	Whimbrel	J C R
Numenius madagascariensis	Eastern curlew	J C R
Numenius borealis (*Numenius minutus*)	Little curlew	C R
Limosa lapponica	Bar-tailed godwit	J C R
Limicola falcinellus	Broad-billed sandpiper	J C R
Xenus cinereus (*Tringa terek*)	Terek sandpiper	J C R
Calidris acuminata	Sharp-tailed sandpiper	J C R
Calidris ferruginea	Curlew sandpiper	J C R
Tringa hypoleucos	Common sandpiper	J C R
Tringa stagnatilis	Marsh sandpiper	C R
Tringa glareola	Wood sandpiper	J C R
Tringa incana (*Tringa brevipes*)	Grey-tailed tattler	J C R
Tringa incana	Wandering tattler	J
Arenaria interpres	Ruddy turnstone	J C R
Capella hardwickii (*Gallinago hardwickii*)	Latham's snipe	J C R
Calidris canutus	Red knot	J C R
Calidris tenuirostris	Great knot	J C R
Calidris ruficollis	Red-necked stint	J C R
Crocethia alba (*Calidris alba*)	Sanderling	J C R
Chlidonias leucoptera	White-winged black tern	J C
Hydropogne tschegrava (*Hydroprogne caspia*)	Caspian tern	C
Sterna hirundo	Common tern	J C R
Sterna albifrons	Little tern	J C R
Sterna bergii	Crested tern	J
Apus pacificus	Fork-tailed swift	J C R
Tringa nebularia	Common greenshank	J C R

Source: ALS (1977); WSG (2007); AWSG (2008); DECC (2009)

* J = JAMBA; C = CAMBA; R = ROKAMBA