Herpetofaunal community of the constructed
Lime Kiln Bay Wetland, south Sydney, New South Wales

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Abstract
The Lime Kiln Bay Wetland in south Sydney was constructed between 1999 and 2001. This paper provides the first comprehensive description of the herpetofaunal assemblage at the site from observations made between 2006 and 2014. Twenty-three species were detected: six frogs (Hylidae, Limnodynastidae, Myobatrachidae), one freshwater turtle (Cheluidae), 12 lizards (Agamidae, Carphodactylidae, Scincidae, Varanidae) and four snakes (Colubridae, Elapidae, Pythonidae). (The Victorian Naturalist 132 (3) 2015, 64–72)

Keywords: constructed wetland, frog, reptile, species assemblage, urban ecology

Introduction
The Oatley Bushland Corridor is an important stretch of remnant habitat in the St George area of southern Sydney (Waterhouse 1997), along with the Wolli Creek Valley and Rockdale Wetland Corridor. It supports a broad range of habitats, including two endangered ecological communities (Swamp Sclerophyll Forest on coastal floodplain, and Swamp Oak Floodplain Forest). A key feature of the area is the constructed Lime Kiln Bay Wetland, restored as part of Hurstville City Council’s rehabilitation of recreational spaces (Bavor et al. 1995). A comprehensive fauna survey of the Oatley bushland corridor is lacking, although there have been efforts to document bird assemblages (Fairley et al. 2013; B Groves and J Cockayne unpubl. data). Further information is limited to consultant reports (e.g. White 2010a) and website postings (Oatley Flora and Fauna Conservation Society (OFF) 2014).

Studies that provide an inventory of fauna for a given land tenure contribute much toward recognising local ecological values. Knowledge of species present and their habitat requirements is a key resource for informing management decisions (Murphy and Murphy 2011), especially for bushland remnants. Inventories are also useful for detecting biodiversity changes over time, as well as evaluating the metapopulation status of threatened species (Val et al. 2012).

This paper provides the first comprehensive description of the herpetofaunal assemblage in the Lime Kiln Bay Wetland. Information for this inventory was generated by casual observations between 2006 and 2014, and compares the frog and reptile assemblages of the study area with those of the Wolli Creek Valley and Rockdale Wetland Corridor.

Methods
Study area
The Lime Kiln Bay Wetland is built on one of the last natural floodplains in the Georges River catchment (Bavor et al. 1995), nestled between the suburbs of Oatley, Mortdale and Peakhurst (Fig. 1). Remnant native vegetation is present; however, there has been an extensive history of clearing. The soil types are mostly from the Hawkesbury Sandstone series.

The wetland area includes three main ponds, which cover approximately 4 ha, flanked by a further 24 ha of remnant vegetation. The banks are dominated by Swamp Oak Casuarina glauca, Narrow-leaved Paperbark Melaleuca linariifolia and Prickly Paperbark M. styphelioides. Spiny-headed Matrush Lomandra longifolia and other ground cover species have been planted extensively to provide bank stability. The Primary Sediment Pond is the collection point of sediment run-off. The pond is fed by Dairy Creek (back cover), which drains water from the Mortdale area. The creek bed is mostly exposed sandstone and varies in width from 3 to 5 m. There is a gross pollutant trap (Allison et al. 1997; Bennett 2002) along its 900 m length. Waterfall Creek drains into the transition zone between the Primary Sediment Pond and the Eastern Ridge Pond. Two small islands
more specifically, the understorey was dominated by Broad Leaf Privet *Ligustrum lucidum*, Narrow Leaf Privet *L. sinense* and Pussy Willow *Salix cinerea*. The cover of these invasive weeds has been substantially reduced and they are subjected to frequent removal. Dense thickets of Giant Reed *Arundo donax*, a native species, occurred between Waterfall Creek and half of the area that is now the Primary Sediment Pond. Other prevalent weeds included Japanese Honeysuckle *Lonicera japonica*, Morning Glory *Ipomoea indica*, Madeira Vine *Anredera cordifolia*, Blackberry *Rubus fruticosus*, Cape Ivy *Delairea odorata*, Balloon Vine *Cardiospermum grandiflorum* and Tradescantia *Tradescantia fluminensis*. The native Common Reed always has been present and widespread, especially over the Eastern Ridge Water Course where it formed a continuous patch.

Construction of the Primary Sediment and Macrophyte Ponds occurred between 1999 and 2001 (Fig. 5). Hurstville City Council’s volunteer bushcare program commenced in 1999, primarily carrying out bush regeneration along the boundaries during construction. Additional work to establish the current Eastern Ridge Pond from a shallow reedbed was undertaken between May and September 2005.

Previous state and construction of the Lime Kiln Bay Wetland
The wetland differs markedly from its pre-restoration state (Fig. 4), which has been described as ‘a weed-infested place, essentially a forest of privet and willow’ (J Cockayne pers. comm). More specifically, the understorey was dominated by Broad Leaf Privet *Ligustrum lucidum*, Narrow Leaf Privet *L. sinense* and Pussy Willow *Salix cinerea*. The cover of these invasive weeds has been substantially reduced and they are subjected to frequent removal. Dense thickets of Giant Reed *Arundo donax*, a native species, occurred between Waterfall Creek and half of the area that is now the Primary Sediment Pond. Other prevalent weeds included Japanese Honeysuckle *Lonicera japonica*, Morning Glory *Ipomoea indica*, Madeira Vine *Anredera cordifolia*, Blackberry *Rubus fruticosus*, Cape Ivy *Delairea odorata*, Balloon Vine *Cardiospermum grandiflorum* and Tradescantia *Tradescantia fluminensis*. The native Common Reed always has been present and widespread, especially over the Eastern Ridge Water Course where it formed a continuous patch.

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Species detection

The taxonomy in this paper follows Cogger (2014). Most data are derived from casual observations made by the author between 2006 and 2014 (one to seven visits per month). Observations of some species (mainly nocturnal, shade-loving or fossorial species) were aided by microhabitat disturbance from bush regeneration methods, e.g. clearing vegetation or moving rocks and fallen logs. Spotlighting was carried out on 20 nights between February and August 2010. Frogs were heard during the day and while spotlighting, and their calls were identified to species level by reference to Griffiths (2012). In addition, audio recordings were received from residents of adjoining properties. An effort was made to visit the study area after heavy rains to maximise the detection of frogs. Whenever possible, bushcare workers and park users on site were consulted for their personal fauna sightings. Additional records were obtained from the Atlas of Living Australia (ALA 2014) and Atlas of NSW Wildlife (Office of Environment and Heritage (OEH) 2014). Trapping methods were not used due to frequent visitation to the study area, which was a major limitation on species detection. Inaccessible parts of the study area (e.g. the Phragmites Reedbed and mangroves) were not studied.

Species assemblages for two other bushland remnants in the St George area were drawn on to place the results of this study into a regional context. Data for the Wolli Creek Valley (Manidis Roberts Consultants 1996; White and Burgin 2004; Department of Environment and Climate Change (DECC) 2007; Little et al.)
2010) and Rockdale Wetland Corridor (White and Burgin 2004; White 1999, 2002, 2010b) were based on secondary sources and the author’s personal observations.

Results
A total of 23 species was detected over the study period (Table 1). Taking this as the complete inventory, it is notable that it passed the 50% mark in the first year of study (2006) and the 95% mark in the sixth year (2011) (Fig. 6). The three species detected in the last five years of the study were observed only once over the entire study period; these were the Eastern Brown Snake *Pseudonaja textilis* (2010), Smooth Toadlet *Uperoleia laevigata* (2011) and Copper-tailed Skink *Ctenotus taeniolatus* (2013).

The ALA (2014) and OEH (2014) databases yielded nine records of six species (Table 2), two of which were not detected in the present study: Black-bellied Swamp Snake *Hemiaspis signata*, one specimen collected in 1996; and Blackish Blind Snake *Ramphotyphlops nigrescens*, one specimen collected in 1997. As noted by Shea (2010), the former record is the last for the species in the St George area. The latter is a fossorial species (Webb and Shine 1992), which may explain the rarity of its detection.

Table 3 contextualises the results of this study with the herpetofauna assemblages of the Wolli Creek Valley (Manidis Roberts Consultants 1996; White and Burgin 2004; DECC 2007; Little *et al.* 2010) and Rockdale Wetland Corridor (White and Burgin 2004; White 1999, 2002, 2010b).

Frogs
Six species of frog were identified by call in this study; four of them also by sightings (Table 2). All were recorded only in the warmer months, except for the Striped Marsh Frog *Limnodynastes peronii*. It was heard during the day and night in thick vegetation (>50 cm tall) in water year round, and was observed only by spotlighting. It was most common in Waterfall Creek, Dairy Creek at the gross pollutant trap and temporary pools below the Southern Rock Outcrop. An adult was seen falling prey to a Red-bellied Black Snake *Pseudechis porphyriacus* (M Barbic pers. comm). The frog was concealed in leaf litter at the top of Waterfall Creek and was not seen until it was seized by the snake.

Leaf Green Tree Frog *Litoria phyllochroa* adults were seen by day huddled on the leaves of Elephant Ear *Colocasia esculenta* in Waterfall Creek. They were also seen by day when displaced from refuges in Tradescentia by bush regeneration operations along the narrow canal between the Macrophyte Pond and Oatley Heights Park and were also found here and in Dairy Creek during spotlighting. At night, individuals were sighted on rocks, soil banks and the fronds of low tree ferns (*Cyathea* sp.).

The distribution of sightings reflects this species’ preference for flowing water (Gillespie and Hines 1999; Hazell *et al.* 2004).

The Eastern Dwarf Tree Frog *L. fallax* was also observed during the day when disturbed by clearing of Tradescentia. It was more often
located by spotlighting perched on the blades of Spiny-headed Matrush. This species was apparently restricted to the Macrophyte Pond and nearby canal. Its call was heard by day and night, particularly after rainfall.

The Peron's Tree Frog *L. peronii* was sighted only once, clinging to the wall of a building near Waterfall Creek. On some nights, its calls were heard from around an artificial pond on an adjoining property and the Macrophyte Pond. Although calling frogs could not be seen, it was clear that they were located in elevated positions in Narrow-leaved Paperbarks.

The two smallest frog species, the Common Eastern Froglet and Smooth Toadlet, were heard but not sighted. The latter was restricted to a section of temporary pools below the Southern Rock Outcrop. The loud call of the Common Eastern Froglet was difficult to locate, but this species seemed to be widespread.

Turtles

The Eastern Snake-necked Turtle *Chelodina longicollis* is the only turtle known to occur in the study area (Table 1). It was shy and difficult to observe, mostly seen in spring and early summer when basking on the islands. In 2012 and 2013, turtles were seen basking on floating booms set up to catch suspended rubbish. They were also intermittently recorded asleep in Dairy Creek during spotlighting in March 2010. Except for one turtle travelling to the Macrophyte Pond from the nearby canal, no overland movements were recorded (Roe and Georges 2008). Carapace lengths of individuals observed were at least 15 cm, which may indicate low breeding.
success in the St George area (Little et al. 2010), but is more probably due to the greater likelihood of sighting larger animals.

Bushcare workers and park users mentioned they had seen people release turtles into the wetland, presumably pets or rescued animals from suburbia (J Cockayne, B Groves and R Staples pers. comm). It is not known whether these releases were of other species of turtle.

### Skinks

Seven of the nine skink species were readily observed by day. The remaining two species, the saxicolous Three-toed Skink *Saiphos equalis* and shade-loving Weasel Skink *Saproscincus mustelina* were recorded by *microhabitat disturbance* by bush regeneration operations. The former were particularly numerous under logs at the Frog’s Hollow clearing (Fig. 1).
All but three skink species were found in the wetland area. The Elegant Snake-eyed Skink Cryptoblepharus pulcher pulcher was restricted to the built environs along the boundary of the study area, and the Greater Bar-sided Skink Eulamprus tenuis and Copper-tailed Skink were restricted to the Southern Rock Outcrop. Five species (Eastern Water Skink E. quoyii, Pale-flecked Sunskink Lampropholis guichenoti, Dark-flecked Sunskink L. delicata, Three-toed Skink and Eastern Blue-tongued Skink Tiliqua scincoides scincoides) were widespread in the valley and on the sandstone slopes. The Eastern Water Skink was conspicuous during the day, and was also found in sandstone crevice retreats in Oatley Heights Park at night. The two sunskinks and the Elegant Snake-eyed Skink were the only species commonly observed over the cooler months.

**Agamids**

The only agamid species was the Eastern Water Dragon Intellagama lesueurii lesueurii, found in all waterside areas. Its population appears to have increased in density since wetland construction (R Casey pers. comm). The rocky embankments of Dairy Creek were a focal area of its distribution, particularly around the gross pollutant trap. It also occurred in adjoining backyards, and some mature males may have established territories (Thompson 1993) there. Faithfulness to home sites was evident in some animals with distinctive markings. For at least four years one individual with a broken tail was seen frequently in the warmer months on a property off Bay Road (B Groves pers. comm). The rocky embankments of Dairy Creek were a focal area of its distribution, particularly around the gross pollutant trap. It also occurred in adjoining backyards, and some mature males may have established territories (Thompson 1993) there. Faithfulness to home sites was evident in some animals with distinctive markings. For at least four years one individual with a broken tail was seen frequently in the warmer months on a property off Bay Road (B Groves pers. comm). Rock crevices were the main retreat sites, although individuals were also found sleeping overnight on tree trunks and underwater. Some poaching of this species has been reported (J Cockayne pers. comm), but it was still numerous.

A second agamid species, the Eastern Bearded Dragon Pogona barbata disappeared from the St George area in the early 1990s. It was formerly common in the Southern Rock Outcrop, and individuals often basked on Bay Road, where many were run over (R Staples pers. comm). The closest known population is now located in Georges River National Park (NPWS 1994).

**Other lizards**

One species of gecko, the Broad-tailed Gecko Phyllurus platurus occurred in the study area. It was found in all rock outcrops and was particularly abundant in Oatley Heights Park, where a population study detected densities of up to three animals per 100 m² of rock wall surface (Mo 2014). On five occasions, geckoes were found co-habiting in crevices with Eastern Water Skinks. In one large sandstone crevice, up to 12 geckoes could be seen during the day at any time of year. This species also occurred on brick walls of some adjoining properties (B Groves pers. comm), and has been noted in other locations (Green 1973; White and Burgin 2004).

A single Lace Monitor Varanus varius was sighted in December 2005 between the Macrophyte Pond and Bay Road (J Cockayne pers. comm). In the early 2000s, this species was seen intermittently in Oatley Park, adjoining the study area (R Staples pers. comm). More recently, it has been observed in other bushland remnants along the Georges River in the Hurstville area (V Willes pers. comm; pers. obs). Monitors possibly access the habitat remnants from larger tracts of bushland, e.g. Georges River National Park (NPWS 1994) and the Menai district (L Hedges and A Turnbull pers. comm).

**Snakes**

Four species of snake have been recorded (Table 2); however, only the Red-bellied Black Snake was commonly seen. Between 1999 and 2003, it was encountered by bushcare workers on most days in the warmer months, particularly during wetland construction when the Eastern Ridge Pond was being converted from a reedbed. Numbers appear to have declined from 2004 onwards. Prior to this study, it could be found in locations as elevated as Oatley Heights Park (J Cockayne pers. comm), which is up to 8 m higher than the wetland. However, during this study, it was confined to the immediate wetland area and Dairy and Waterfall Creeks, with one isolated observation in Hurstville Golf Course (Fig. 1) in December 2008—this snake retreated to the mangroves. This species may also have been present in the Phragmites Reedbed, which was not accessible to this study.
A large Red-bellied Black Snake (>2 m in length; ~10 cm in girth) was seen by various people at least 15 times between 2002 and 2012, including three times on an adjoining property on Bay Road, where it was observed at close range (B Groves pers. comm). In 2003, between clumps of Spiny-headed Matrush on the banks of the Macrophyte Pond, male combat was witnessed, in which several smaller snakes were coiled around the large individual (J Cockayne pers. comm).

An adult Eastern Brown Snake was observed in November 2010 in the western portion of Oatley Heights Park. There were three sightings of the Diamond Python Morelia spilota spilota, all adults; two in trees on the edge of the mangroves, and one active on the ground (P Hayler pers. comm). The Green Tree Snake Dendrelaphis punctulata was recorded twice: once on the walking track in the Western Rock Outcrop in December 2009 and on a tree near Frog’s Hollow in February 2012.

Discussion

The status of herpetofauna in urban landscapes has received increasing attention in recent times (Anderson and Burgin 2002; Koenig et al. 2002; Jellinek et al. 2004; Butler et al. 2005a, b; Cogger 2010; Hamer and McDonnell 2010; Wotherspoon and Burgin 2011; Mo 2014). Considerable interest has focused on Sydney (e.g. Murphy 1996; Murphy 2010; Shea 2010) as the largest and oldest city in Australia. Although this study focused on an area smaller than both the Wolli Creek Valley and Rockdale Wetland Corridor, more species were recorded for the Lime Kiln Bay Wetland than at these sites. The species assemblage of the Lime Kiln Bay Wetland probably provides a fair representation of the herpetofaunal diversity of the wider St George area.

Biodiversity in remnant bushland is clearly related to habitat complexity (Wilks 2010). For example, the presence of flowing water is important for the persistence of the Leaf Green Tree Frog (Gillespie and Hines 1999), an amphibian species that was not detected in the other sites. The Broad-tailed Gecko and Greater Bar-sided Skink were associated with remnant sandstone formations, a habitat that is lacking in the Rockdale Wetland Corridor. The Oatley bushland corridor is considered a significant area for the Greater Bar-sided Skink in the Sydney region (Griffiths 2012).

This study adds significantly to the sparse records in atlas databases (ALA 2014; OEH 2014), which appear to be limited to unusual findings, with more common species apparently overlooked. A comprehensive fauna inventory is generally achieved only when the data have been collected over a substantial period and by multiple surveying techniques (Murphy and Murphy 2011). This allows for variation in seasonal conditions (Sass et al. 2011) and increases the likelihood of cryptic and rare species being detected. From a management perspective, records of declining species are perhaps the most valuable information provided by a site inventory. The prime example in this study is the Copper-tailed Skink, a declining species in the Sydney Metropolitan Area (Murphy 2010; Shea 2010), which was detected only towards the conclusion of the study.

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