Vegetation mapping
of the former Sydney Water site
62 Quarter Sessions Road, Westleigh

Natural Resources October 2016

Introduction

The former Sydney Water site is bounded to the north by Dog Pound Creek bushland, to the east by Waitara Creek bushland and to the west by Berowra Valley National Park. Vegetation on the site has been mapped as part of the Smith & Smith (2008a) study which identified the presence of Sydney Turpentine Ironbark Forest within the Council owned land and Blue Gum High Forest in the adjacent Sydney Water land to the south. This vegetation is part of a contiguous corridor linking the Sydney Water land, Council reserves and the National Park. The site comprises large areas of remnant vegetation with smaller patches of weeds on the margin of the cleared lands and along drainage lines. There is an expansive unauthorised mountain bike track network across the site through the remnant vegetation and cleared lands. The vegetation has been exposed to regular small scale burning as part of a prescribed burn program.

The site has recently been purchased by Council with a long-term vision of providing a range of recreational facilities and for the conservation of bushland. Future planning will be guided by the various values of the site including the conservation significance of local flora and fauna. The vegetation on the site has been remapped to provide an accurate description of the vegetation communities and fauna habitat present. The survey also identified the presence of threatened species and an indication of vegetation condition. The vegetation communities have been classified in accordance with previous Smith & Smith (2008a) mapping and the NSW Vegetation Classification Plant Community Types and any communities listed under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* or *NSW Threatened Species Conservation Act 1995*.

Methodology

Since 1990 vegetation mapping studies have been undertaken throughout Hornsby Shire to classify native vegetation into plant communities based on floristic composition. The most recent studies by Smith & Smith (2008a, 2008b & 2009) provided an update on previous studies with the inclusion of remnant stands of trees in the vegetation community listing. The addition of the remnant trees studies was due to the recognition of the conservation value of these patches and their inclusion in amendments to the NSW Scientific Committee listing for Blue Gum High Forest and Sydney Turpentine Ironbark Forest communities.

Survey Area

The vegetation survey was undertaken in remnant vegetation comprising a native canopy with or without native understorey. The survey included areas where weed species were present in the understorey but were still dominated by native canopy species. The vegetation surveyed is within the bounds of the site as shown in figure 1.

Previous vegetation surveys

Vegetation mapping of Hornsby Shire has been recently updated in the *Native Vegetation Communities of Hornsby Shire: 2008 Update* (Smith & Smith 2008a). This report built upon their previous studies and identified 34 native vegetation communities. Further studies of relevance include *Remnant Trees in the Southern Rural District of Hornsby Shire* (Smith & Smith 2008b) and *Remnant Trees in the Urban District of Hornsby Shire* (Smith & Smith 2009) which considered the conservation value of patches of remnant trees with minimal or no native understorey.

Vegetation on the site has been surveyed by UBM as part of a *Property Environmental Management Plan: Thornleigh Reservoir* (UBM 2010). The northern part of the site has been mapped in the assessment of the Dog Pound Creek BioBanking site (Parsons Brinckerhoff 2014).

Vegetation Community Classification

When classifying the vegetation communities consideration was given to the following studies and databases:

- *Defining local community descriptions*
  The floristic compositions of vegetation communities as described by Smith & Smith (2008a). The report provides descriptions of each community noting common species throughout each stratum. A total of 494 sites were sampled during 1989-1993 and a further 53 sites as part of the 2008 report. This provides information on local variations and conditions in which these communities occur. Table 4 of their report summarises canopy species found within each community which enables a basic definition of community boundaries.
- *Defining broad community descriptions*
  Tozer *et al* (2010) provides a comprehensive review of vegetation in south-east NSW based on previous work from Tozer (2003) *The Native Vegetation of the Cumberland Plain*. Tozer *et al* (2010) defines 191 map units throughout NSW providing a general description of the floristics, structure and geology and soils of each map unit. A key outcome of this report is the identification of a relationship between floristics and map units. The identification of positive diagnostic species for each community enables a comparison between field data and the map units to be undertaken.
- *Defining conservation significance*
  The site has previously been identified as containing Sydney Turpentine Ironbark Forest (STIF) with Blue Gum High Forest (BGHF) occurring in adjoining lands (Smith & Smith 2008a; UBM 2010). These communities are both listed under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC) and *NSW Threatened Species Conservation Act 1995* (TSC). The NSW Scientific Committee have described the communities as listed under the TSC Act while the Commonwealth Department of the Environment have provided descriptions of these communities as listed under the EPBC Act. Of particular note is the inclusion of stands of remnant trees in the TSC Act listing of BGHF and STIF while only the good quality patches are listed under the EPBC Act.
- *Defining Duffy's Forest*
  Smith & Smith (2000) prepared a report on the Duffy's Forest vegetation community primarily though the Warringah local government area. They have identified significant variations of the community both in its floristics and structure which ranges from tall open forest to woodland. Further, to distinguish between Duffy's Forest, Sandstone Ridgetop Woodland and Sandstone Gully Forest they have developed a list of most frequently occurring species in these vegetation types. Hence a Duffy's Forest index can be calculated using these positive diagnostic species to determine the likelihood of each community occurring at the site. Duffy's Forest has previously been recorded in Hornsby Shire at Cowan, Dural and North Epping (Smith & Smith 2008a).
- *Defining site value*
  The NSW Vegetation Information System (VIS) is a database that has been established to standardise vegetation mapping and classification throughout NSW. The VIS provides descriptions of the Plant Community Types (PCT) based on floristic composition. The VIS also provides benchmark information on each PCT which enables a comparison of condition for various elements

of the community including species richness and canopy cover. The BioBanking Assessment Methodology utilises the PCT's and benchmark data when undertaking BioBanking assessments.

- *Defining geology and soils*
  Geology and soil landscapes of the site as described by Chapman & Murphy (1989)

Vegetation Mapping

Mapping vegetation on the site utilised a combination of fieldwork and analysis of data gathered from previous studies, reports and databases. The survey methodology was similar to that described in Smith & Smith (2008a) and is consistent with the recommendations of Tozer *et al* (2010). Additional survey elements were consistent with the BioBanking Assessment Methodology 2014 and Appendix 2 of the BioBanking Operations Manual. Surveys were undertaken between 14th June 2016 and 5th September 2016 with further threatened species searches and mapping occurring through September 2016. Table 1 provides a summary of the survey and data analysis methodologies used.

A total of 14 quadrats were placed throughout the site (figure 2). The location of the quadrats was determined with consideration of canopy species present. Table 4 of Smith & Smith (2008a) notes the frequency of canopy species within each vegetation community. Using this information we were able to broadly identify where changes in canopy composition occurred indicating transition areas between vegetation communities. A quadrat was located on either side of the transition area to ensure it was representative of the canopy species found in the vicinity of the quadrat. The location of the quadrat within the vegetation was then randomly placed which resulted in the inclusion of weed patches and mountain bike tracks through the quadrats and transects.

The layout of the quadrat and transect is shown in Appendix 2 of the BioBanking Assessment Methodology and Credit Calculator Operations Manual (figure 3). The quadrat consisted of a 20m x 20m square and a 50m transect placed through the middle of the quadrat. Floristic data in the quadrat was gathered by starting in one corner of the quadrat, walking along the base and then returning in a zig-zag pattern across the quadrat until reaching the top boundary. Appendix 2 of the BioBanking Assessment Methodology and Credit Calculator Operations Manual outlines the methodology for developing a site value assessment score. This is used in the BioBanking methodology to enable a comparison of site values and condition of a site (nominally the ecological value) before and after any restoration works have occurred. This methodology provides an opportunity to gather condition data for each of the quadrats/transects and enables a comparison between like communities. During the surveys opportunistic sightings of fauna and habitat features were recorded.

Figure 1: The boundaries of the vegetation mapping

Figure 2: Location of quadrats and transects throughout the site

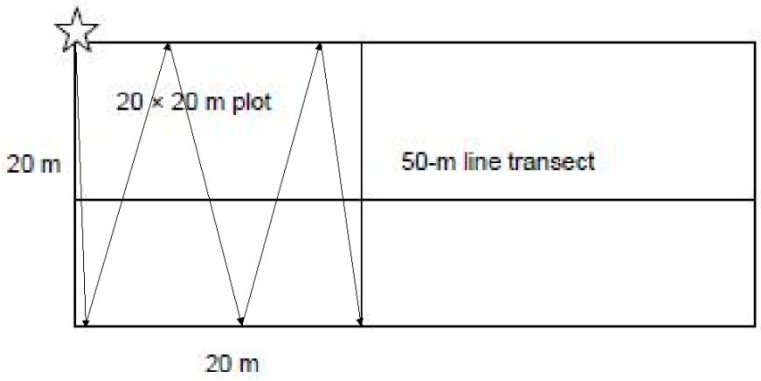

Figure 3: Layout of survey methodology for quadrat and transect

Data Analysis

Quadrat data was compiled and analysed using positive diagnostic species as per Tozer *et al* (2010) to determine the relevant vegetation map unit. The map units were then compared with Smith & Smith (2008a) community descriptions to determine the likely local vegetation communities. When analysing data characteristic of Duffy's Forest the Duffy's Forest Index (Smith & Smith 2000) was used to determine the most likely vegetation classification (Duffy's Forest, ridgetop woodland or gully forest).

The vegetation map units were also compared with the NSW VIS PCT's. Benchmark reports were generated from the NSW VIS for each PCT represented at the site. This benchmark data was compared with transect data gathered in the field and used as an indication of condition compared to the benchmark. Provisions in the BioBanking methodology permit the use of local benchmarks which may provide a more accurate assessment of local conditions. It was considered that for the two EEC's at the site, STIF and Duffy's Forest, that local benchmarks could be used to provide a more relevant site value assessment. It is recommended that at least three sites be used to develop a local benchmark but in this case it was decided that one quadrat for each community would be chosen as the local benchmark. The selection of a quadrat to be used as a local benchmark was based on the lack of human induced impacts within the quadrat (i.e.: absence of mountain bike tracks, rubbish or clearing) and being generally representative of the community. Quadrat 1 was chosen as the local benchmark for STIF and quadrat 6 was chosen as a local benchmark for Duffy's Forest.

Table 1: Summary of survey and data analysis methodologies

Fieldwork	Reference
Floristic data (quadrats)	Smith & Smith (2008a), Tozer et al (2010), Tozer (2003)
Site value data (transects)	OEH (2014)
Fauna	Opportunistic sightings

Data analysis	Reference
Broad vegetation classifications (NSW map units and PCT's)	Tozer et al (2010), NSW VIS
Local vegetation classifications	Smith & Smith (2008a)
Site value assessment	OEH (2014)
Duffy's Forest Index	Smith & Smith (2000)
Conservation significance	TSC Act and EPBC Act listings

Mapping results

Vegetation Communities

The surveys have identified 244 individual flora species in the 14 quadrats. Appendix 1 lists the species observed in each quadrat while Appendix 2 provides a visual representation of the vegetation in each quadrat and transect. The quadrat surveys identified two threatened flora species:

- *Tetratheca glandulosa*
- *Darwinia biflora*

and several flora species not previously recorded or rare in Hornsby Shire including:

- The largest population of *Prostanthera howelliae* (figure 4)
- *Coronidium scorpiodes*
- *Brachycome angustifolia (*now known as *Brachycome sieberi)*

There have also been 11 species of Orchids observed on the site including the Leopard Orchid (*Diuris maculata*) (figure 5), 11 species of *Lomandra*, nine species of *Acacia*, five species of *Banksia* and four species of *Pultenaea*, *Persoonia*, *Grevillea* and *Hibbertia*.

Figure 4: *Prostanthera howelliae*

Figure 5: Leopard Orchid (*Diuris maculata*)

The vegetation surveys on the site have identified approximately 23 hectares of native vegetation comprising 5 vegetation communities as per Smith & Smith (2008a) (Appendix 3):

- Sydney Turpentine Ironbark Forest (5.5 ha.)
- Duffy's Forest (3.3 ha.)
- Scribbly Gum Open Woodland (0.7 ha.)

- Bloodwood Scribbly Gum Woodland (9.6 ha.)
- Peppermint-Angophora Forest (4.6 ha.)

Table 2 provides a summary of the vegetation communities mapped within each quadrat.

Table 2: Summary of vegetation communities in each quadrat

Quadrat	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Vegetation community	STIF	STIF	STIF	STIF	DUFFY	DUFFY	SCRIBBLY
Quadrat	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Vegetation community	DUFFY	BLOOD	BLOOD	PEP-ANG	PEP-ANG	SCRIBBLY	STIF

STIF: Sydney Turpentine Ironbark Forest, Duffy: Duffy's Forest, Scribbly: Scribbly Gum Open Woodland, Blood: Bloodwood Scribbly Gum Woodland, Pep-Ang: Peppermint-Angophora Forest

Sydney Turpentine Ironbark Forest is listed as Critically Endangered under the EPBC Act and an Endangered Ecological Community under the TSC Act. Duffy's Forest is listed as an Endangered Ecological Community under the TSC Act.

Site Value Assessment

The site value assessment attribute score for 13 of the 14 transects were similar ranging from 202.5 to 262.5. Transect 11 only achieving a score of 182.5. Table 2 shows the scores when compared to PCT and local benchmarks. For those communities identified as STIF PCT benchmark values were taken from PCT ID: 1281, HN604; Duffys Forest from PCT ID: 1085, HN567; Bloodwood Scribbly Gum Woodland PCT ID: 1083, HN566; Peppermint-Angophora Forest PCT ID: 1183, HN587; Scribbly Gum Open Woodland PCT ID: 882, HN541. Transect 1 was used as the local benchmark for STIF and Transect 6 was used as the local benchmark for Duffy's Forest.

Table 2: Comparison of site value assessment score

Transect	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
PCT benchmark score	237.5	245	225	240	240	240	262.5	237.5	205	227.5	182.5	240	202.5	225
Local benchmark score	*a*	227.5	187.5	230	260	*b*	*c*	202.5	*c*	*c*	*c*	*c*	*c*	167.5

a: Used as local benchmark for STIF, b: used as local benchmark for Duffy's Forest, c: no local benchmark used

The site value assessment score provides an indication of similarity for the vegetation along transects to their chosen benchmark. The assessment measures 10 attributes in the quadrats and transects including (score weighting in brackets): Native plant species richness (25%), Native over-storey cover (10%), Native mid-storey cover (10%), Native grass cover (2.5%), Native shrub cover (2.5%), Leaf litter cover (2.5%), Exotic plant cover (5%), Number of trees with hollows (20%), Over-storey regeneration (12.5%) and Total length of fallen logs (10%). If benchmark values were recorded for all attributes in the transect then a score of 300 would be achieved. All transects surveyed achieved scores below the benchmark value of 300 for either PCT or local benchmarks.

Independently the data shows that all quadrats exceeded PCT benchmark values for the key attribute 'species richness', ranging from 115 - 222% of benchmark. Five of the six quadrats that used a local benchmark exceeded those benchmark values ranging from 104 – 140%. Quadrat 14 achieved 95% of local benchmark value. For the second key attribute 'number of trees with hollows' 13 of the 14 transects exceeded PCT benchmark values. For the attribute 'native over-storey cover' 11 of the 14 transects

exceeded PCT benchmark values ranging from 102 – 230% while three transects achieved 71, 81 and 91% of benchmark values. Figure 6 shows that for the vegetation cover attributes, equating to 50% of the total score, the majority of transects exceeded PCT benchmark values. The most variable attribute was 'mid-storey cover' with transect 3 the lowest at 6% and transect 13 highest at 94% of PCT benchmark values.

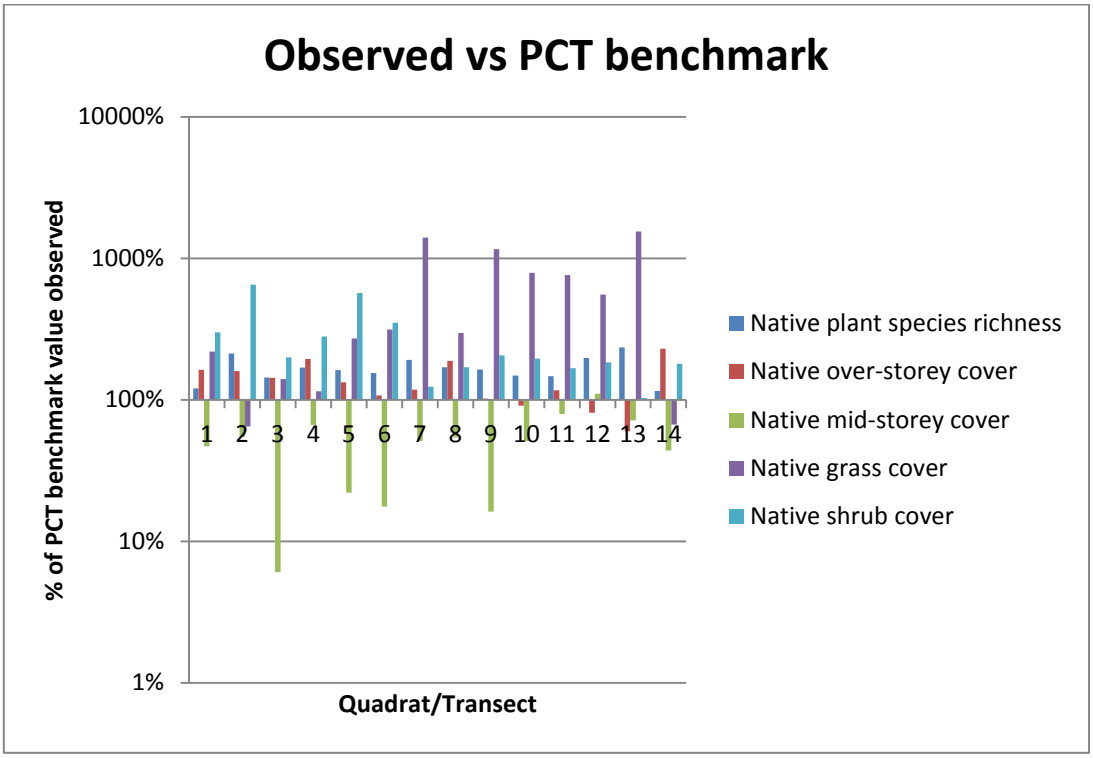

Figure 6: Observed values versus PCT benchmark values for 5 vegetation cover attributes

Fauna species

Incidental observations throughout the site identified a high diversity of bird species (50), while only 3 reptile and 2 mammal species were observed or scats and tracks indicated they occurred on the site (Appendix 3). Data collected from the 14 transects observed a total of 38 tree hollows comprising basal, trunk and branch hollows. Incidental sightings outside of the marked transects identified the presence of numerous additional hollows (including arboreal termite nests) indicating a higher density of hollows than may be suggested by the transect data.

Discussion

Vegetation communities

The mapping results shows some consistency with the Smith & Smith (2008a) mapping which identified 4 communities on the site. The current study differs from Smith & Smith (2008a) due to the presence of Duffy's Forest and variations in the extent of the previously identified communities. UBM (2010) identified 3 vegetation map units as per Tozer *et al* (2010) including STIF, Coastal Sandstone Ridgetop Woodland (equivalent to Bloodwood Scribbly Gum Woodland) and Sydney Hinterland Transition Woodland (equivalent to Grey Gum Scribbly Gum Woodland). The map units identified by UBM are at a larger scale than those prepared by both Smith & Smith (2008a) and this survey. This scale difference explains some of the variations in the mapping units described in each study.

The vegetation communities have aligned closely with the underlying soils and geology. Notably STIF and Duffy's Forest occur on the shale dominated Glenorie and Lucas Heights soil landscapes, whilst the Hawkesbury Sandstone soil landscape supports the communities of Scribbly Gum Open Woodland and Peppermint-Angophora Woodland. The patches of STIF on the western side of the site (Q14) occur on shale soils with a higher sandstone influence which indicates a transitional form of this community.

Duffy's Forest is known to occur on Hawkesbury Sandstone geology where shale and laminite lenses (thinly bedded sedimentary rock) occur on ridgetops with some sandstone influence on the fringes with typical sandstone vegetation (Smith & Smith 2000). Throughout Hornsby Shire Smith & Smith (2008a) noted that in areas of adjoining STIF and Duffy's Forest the Duffy's Forest had a higher sandstone influence. Quadrats 2, 4 & 5 contained positive diagnostic species for both STIF and Duffy's Forest communities. It is possible that a quadrat may achieve a 'pass' for positive diagnostic species representing several vegetation communities (map units as per Tozer *et al* 2010). In such cases the number of species recorded above the minimum required for a 'pass' and other factors such as soils, geology and topography may be used to assess the vegetation community most represented by the plot data. There was an observed gradational influence of sandstone and presence of sandstone species in quadrats 2, 4 & 5, indicating a transitional area between STIF and Duffy's Forest. The STIF was observed to occur on the upper slopes and ridges transitioning into Duffy's Forest downslope where there was an increased sandstone influence. As the sandstone influence became more dominant the vegetation community changed to Scribbly Gum Open Woodland and Bloodwood Scribbly Gum Woodland on the upper slopes and into Peppermint-Angophora Forest in the lower slopes and gullies.

To define the edges of the community's, key diagnostic canopy species from Table 4 (Smith & Smith 2008a), geology and topography were also considered. Q 12 &13 recorded similar positive diagnostic species and achieved a 'pass' for the two communities Peppermint-Angophora Forest and Scribbly Gum Open Woodland but have been mapped as different communities. The presence of different canopy species and topography indicates the quadrats support two different, but similar, vegetation communities. This also indicates a transitional area between the two communities. Q13 is located on upper slopes rather than a gully and supports species similar to those observed in Q7. This indicates that Q13 is more likely to support the Scribbly Gum Open Woodland community whereas Q12, located in the gully, is more likely to support Peppermint-Angophora Forest. The resultant mapping of these transitional areas is also consistent with the geology and soils of the site.

Site value assessment

The site value assessment methodology combines observations of certain ecological features to develop an ecological value for the site. The overall values provide a snapshot to compare a quadrats ecological value against the benchmark, with higher scores indicating they are more like the benchmark than sites achieving lower scores. The methodology used to generate a score generally follows the premise of the closer to the benchmark the higher the score given for that attribute. However if site observations are too high above benchmark values then the score is reduced. (This may have been incorporated into the calculations to demonstrate communities that have been frequently impacted or unmanaged and as a result altering their composition and structure.) This created some unexpectedly lower overall scores for quadrats that exhibited high species diversity and low impacts (such as the presence of weeds). Q2 recorded 83 species which was well above the PCT benchmark of 40 species and was accordingly attributed a maximum score of 3 for species richness. Native over-storey cover was observed as 48% while the PCT benchmark value is 27%, the observed value being 178% of the benchmark and attributed a score of 1. Native shrub cover was observed as 32.5% while the PCT benchmark value is 5%, the observed value being 650% of the

benchmark and attributed a score of 0. Q12 achieved or bettered PCT benchmark values in 9 of the 10 attributes measured with an overall ecological score of 245. If all attributes equalled PCT benchmark values the overall score would be 300. The results suggest while the overall score provides an indication as to a quadrats similarity with the benchmark it should not be used as a static number. Consideration needs to be given to the individual attributes when reviewing ecological value of the vegetation.

The species richness attribute is given the highest weighting (25%) of the total score. All quadrats achieved greater than PCT benchmark value and 5 of the 6 quadrats achieved local benchmark values. This attribute is considered to be one of the positive indicators of ecological value and condition. Other attributes measured that would be useful in developing an overall view of ecological value of the site would be 'exotic plant cover', 'over-storey regeneration' and the two habitat attributes 'number of trees with hollows' and 'total length of fallen logs'. Consideration should also be given to the leaf litter cover which provides an indication as to areas of disturbance but would need to consider naturally occurring areas of exposed rock and outcrops.

Conservation significance

The total flora species list observed on the site (244 species) accounts for approximately 25% of all flora species previously recorded in Hornsby Shire (see Hornsby Shire Council online herbarium http://www.photosau.com.au/HornsbyHerbarium/scripts/home.asp). Two threatened flora species were recorded on the site being *Darwinia biflora* (TSC & EPBC) and *Tetratheca glandulosa* (TSC). Vegetation communities on the site include STIF listed as Critically Endangered under the EPBC Act and an Endangered Ecological Community under the TSC Act and Duffys Forest listed as an Endangered Ecological Community under the TSC Act.

The site also exhibits high diversity in birds species with 50 species observed including the threatened Square-tailed Kite (TSC) and summer migrants the Sacred Kingfisher, Eastern Koel, Channel-billed Cuckoo and Dollarbird. There were only a few reptile species and few indications of mammals (scats and tracks, burrows and feeding scars). The vegetation is likely to support a variety of microbats and has preferred food resources of the Grey-headed Flying-fox (TSC & EPBC) which is known to occur in this locality. The site also contains habitat that is likely to support other threatened species including Eastern Pygmy Possum, Red-crowned Toadlet, Powerful Owl, Glossy Black-cockatoo, *Epacris purpurascens*, Magenta Lilly Pilly, Tangled bedstraw and *Lasiopetalum joyceae*. An existing Eastern Pygmy Possum study in Council reserves has been extended to this site due to the presence of Bloodwood Scribbly Gum Woodland and Scribbly Gum Open Woodland that contain flora species preferred by this species.

There is approximately 22 ha. of vegetation on the site including native vegetation and weeds. The patch size of vegetation supports a diversity of flora and fauna species with weeds limited to creek lines and edges and a largely undisturbed core. The width of the corridor is a key factor for the long-term survival of these ecosystems with native species diversity known to decrease with reduced corridor width. An increase in edge to area ratio excludes its use by numerous fauna species with particular emphasis on forest and migratory bird species. Narrower corridors enable weed species to penetrate further into good bushland outcompeting and dispersing native species. Smith & Smith (2008a) have previously mapped stands of Duffy's Forest throughout Hornsby Shire comprising 15.5 ha of vegetation located in Cowan, Dural and North Epping. The stand of Duffy's Forest at Westleigh has a different floristic composition compared to other observed stands and dramatically increases the size and distribution of this community in Hornsby Shire, accounting for an additional 3.3 ha. Due to the high diversity of flora species the site provides an exceptional source of seed for Council's Nursery and bush regeneration programme.

It is considered that the remnant vegetation on the site is of high conservation value due to the presence of threatened species, EEC's and its overall good condition. The vegetation provides a significant diversity of habitat for local fauna including threatened species. The vegetation provides a connective link with adjacent BioBanking sites and with Berowra Valley National Park and is an important contribution to Council's reserve system.

Fire

The UBM (2010) report provides an outline of an historical and intended burn program for vegetation in the southern section incorporating the patches of STIF and Duffy's Forest and populations of *Tetratheca glandulosa* and *Darwinia biflora*. The presence of trees with fire scars, regenerating trees and shrubs, epicormic growth and charcoal, indicates that there has been a high frequency of fire throughout this southern section. The frequency of fire in some areas (west of Q3 & Q4 in particular) adjacent to the open grassed areas is considered to have been significantly more frequent than recommended fire regimes for these communities. The intensity of fire and high frequency has contributed to the area being devoid of understorey and groundcovers (figure 7).

The risk of wildfire would be of concern to some residences on the eastern side of the site. Typical bushfire risk mitigation strategies include the removal and modification of vegetation. However these actions are limited in their effectiveness if no mitigation measures are implemented within the private properties (i.e. use of steel mesh flyscreens, mesh over openings and vents, maintenance of leaf litter around the house). The eastern boundary of the site contains an electricity easement which is currently managed as mown grass. The width of this cleared area is approximately 20m and provides significant defendable space and access for firefighting services. Houses are setback from the rear boundary which provides an additional buffer from the vegetation. The existing buffer would be considered to be adequate to prevent the direct transferral of fire from the site to adjoining residences. Consideration of future hazard reduction burning within the site would need to consider historical fire regime and the ecological fire regimes for the vegetation communities and threatened species present on the site.

Clearing/encroachment

The easement on the eastern side of the site has been used by adjoining residents to extend their private open space into the public land. Residents have cleared the edges of the bushland being and placed garden furniture and exotic plants in the bushland. Further, garden waste is being dumped in the bushland which has led to the spread of environmental and noxious weeds on the fringes of the remnant vegetation (figure 8).

The major impact on the remnant vegetation has been due to the creation of an expansive network of mountain bike trails throughout the forest. The trail network is approximately 9km long within an 18 hectare area of remnant bushland. The trails extend through all areas of the site and vegetation communities. Sections of the trails pass through patches of threatened species and EEC's and are within the Dog Pound Creek BioBanking site and proposed Waitara Creek BioBanking site. Sections of the mountain bike tracks have been built immediately adjacent to threatened species and likely to have required the clearing of these species (figures 9 & 10). Ongoing use of the track generates a significant amount of dust which covers the adjacent plants potentially reducing their long-term viability (figure 13). The removal of vegetation and creation of tracks has led to areas exhibiting severe gully erosion (figure 11) often exposing trees roots which are then directly impacted by bikes (figure 12).

Figure 7: Frequent fires in STIF have reduced species diversity and structure of the forest (near Q3)

Figure 8: Encroachment and dumping of green waste within the remnant bushland (near Q7)

Figure 9: Bike tracks adjacent to *Tetratheca glandulosa* (near Q9)

Figure 10: Bike tracks adjacent to *Darwinia biflora* (near Q9)

Figure 11: Gully erosion caused by bike tracks (near Q8)

Figure 12: Erosion along bike tracks exposing tree roots (near Q12)

Weeds

The vegetation on the site is considered to be in generally good condition with minimal weeds present. The presence of weeds (Lantana, Crofton Weed, Privet) is generally associated with drainage lines or disturbed soils. Q11 exhibited the highest cover of weeds on the site which is likely exacerbated by the presence of a drainage line and impeded drainage of soils. A large patch of lantana is located along the drainage line adjacent to Q3. The western side of the site (adjacent to Warrigal Drive) is impacted by disturbed soils and drainage lines and contains patches of intact vegetation, patches of remnant trees with a weedy understorey and patches of weeds. Open and exposed edges of trails are often the preferred habitat for *Darwinia biflora* and *Tetratheca glandulosa* which are impacted by weed spread from trail users. Dumping of garden waste on the edges of the electricity easement has also led to the spread of weeds through the remnant bushland.

Figure 13: *Tetratheca glandulosa* adjacent to the track impacted by dust deposition (near Q9)

Future management options/recommendations

Vegetation on the site supports threatened flora and fauna species and endangered ecological communities protected under Commonwealth and State legislation. Long-term management for these species and communities is required to be consistent with the objectives of the TSC Act and in particular the management actions in the Saving our Species Conservation projects for *Tetratheca glandulosa*, *Darwinia bilfora* and Duffy's Forest, *The Best Practice Guidelines for Sydney Turpentine Ironbark Forest* (DECC 2008) and the *Darwinia biflora Recovery Plan* (DEC 2004). The long-term management of these species and communities is best guided by the ongoing monitoring of the site considering aspects of flora and fauna, the condition of the vegetation, bike tracks and erosion.

To ensure the conservation of remnant vegetation including threatened species and EEC's consideration for future management options should include:

- The proximity of mountain bike tracks to threatened species: vegetation clearing and edge effects of riding impacting on individual plants and isolating populations
- Location and density of tracks passing through vegetation impacting on remnant EEC's, threatened species and local flora and fauna
- Track use causing erosion and the intensity of use of tracks that leads to an increase in track width and alternate paths
- The presence of weeds and pathways of dispersal – watercourses, people and bikes
- The presence and spread of soil and water borne pathogens
- Impacts of the density of and high use of tracks on the presence of fauna
- The location of tracks within BioBanking sites
- Illegal track construction
- Bushfire risk mitigation and the need for ecological burning to ensure appropriate ecological fire regime is maintained

Recommendations include:

- **Flora and fauna**
    - Ongoing monitoring of vegetation using existing quadrat locations and data. Identify an appropriate control site for comparative assessment (i.e.: BGHF in adjacent Sydney Water site)
    - Additional flora surveys in the northern section of the site adjoining BioBanking sites. This area is likely to contain additional Duffy's Forest.
    - Develop and implement fauna survey strategies targeting indicator species for ecosystem health (use of song meters for frogs and birds; IR cameras and boxes for Eastern Pygmy Possum; Anabat for microbats)
    - Use of community, volunteers and academic research in fauna surveys
    - Weed mapping
        - Develop weed management plan
        - Incorporate Water Sensitive Urban Design elements for managing weeds along creek lines
        - Implement strategic weed management actions: Bush regeneration contractor and Council
    - Supplementary planting and vegetated buffers for
        - Edges of encroachment and clearing to reduce the impact of weeds and clearing
        - Edges of future playing fields and incorporation with Water Sensitive Urban Design elements for future stormwater management of the site (raingardens, vegetated swales, wetlands)
        - Creek lines as part of future weed management
        - Tracks and other impacted areas to be closed
    - Develop a restoration plan for any tracks and impacted areas to be closed
    - Soil testing for soil and water borne pathogens including Phytopthora and Armillaria

- **Education**: promoting conservation and appropriate land use
    - Use of interpretive and regulatory signage promoting conservation and appropriate land use
    - Adjoining residents
    - Council departments
    - Sydney Water
    - Track users
    - Use of the site for guided bushwalks

- **Mountain bike tracks**
    - Develop and implement regular monitoring and compliance protocols for illegal track construction
    - Reduction, removal or redesign of tracks within EEC's, areas adjacent to threatened species and areas with a high density of tracks
    - Removal of tracks from BioBanking sites
    - Redesign and reconstruction of tracks over drainage impeded soils, drainage lines and areas of erosion

- **Fire**
    - Maintain working relationship with Westleigh RFS at the site.

- Develop an ecological burns programme in accordance with appropriate fire regime for species and communities. This may be implemented in association with the RFS and their need for training burns

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Appendix 1: Floristic data

Species	Quadrat													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Acacia brownei			y											
Acacia fimbriata		y												
Acacia implexa														y
Acacia linifolia	y	y	y	y	y	y	y	y		y	y	y	y	y
Acacia longifolia	y		y	y	y						y			
Acacia myrtifolia	y	y		y	y	y	y	y						
Acacia parramattensis				y	y	y								
Acacia suaveolens						y	y	y	y					
Acacia ulicifolia				y		y		y	y	y			y	
Actinotus minor						y	y	y	y	y		y	y	
Adiantum aethiopicum											y			
Allocasuarina littoralis	y	y	y		y	y	y	y			y	y	y	y
Angophora costata	y	y	y		y	y		y				y		y
Angophora hispida							y			y		y	y	
Anisopogon avenaceus	y	y		y		y	y		y	y		y	y	
Aristida vagans	y	y	y	y	y	y		y				y		
Astrotriche longifolium													y	
Austrostipa pubescens		y			y		y	y	y	y		y	y	
Austrostipa sp.				y										
Baeckea diosmifolia									y	y		y		
Baeckea imbricata							y							
Banksia ericifolia									y	y		y	y	
Banksia marginata						y			y			y		
Banksia oblongifolia						y	y			y		y	y	
Banksia serrata							y		y	y			y	
Banksia spinulosa	y	y		y	y	y		y	y		y	y	y	y
Billardiera scandens	y	y	y	y	y	y	y	y	y	y		y	y	y
Blechnum ambiguum											y			
Boronia ledifolia										y				
Boronia pinnata							y		y	y				
Bossiaea heterophylla													y	
Bossiaea obcordata	y	y	y	y	y	y		y					y	y
Bossiaea scolopendria									y	y			y	
Brachycome angustifolia		y												
Breynia oblongifolia					y									
Brunoniella pumilio		y	y	y				y						
Burchardia umbellata									y					
Caladenia carnea													y	
Callistemon citrinus											y			
Callistemon linearis											y	y		
Calochlaena dubia														y
Cassinia denticulata								y						
Cassytha glabella	y	y		y			y	y	y	y			y	
Cassytha pubescens						y					y	y		
Centella asiatica				y			y	y			y			
Cheilanthes sieberi			y		y									y

Comesperma ericinum						y			y					
Conospermum longifolium									y					
Coronidium scorpiodes		y												
Corymbia gummifera	y	y	y	y	y	y	y	y	y				y	y
Cryptostylis erecta			y			y		y		y		y	y	y
Cryptostylis subulata		y				y	y		y					
Cyathochaeta diandra					y	y	y		y	y		y	y	
Cyperaceae sp.											y			
Cyperus sp.				y							y			
Cyrtostylis reniformis		y	y											
Dampiera stricta							y		y	y		y	y	
Darwinia biflora#*									y	y				
Desmodium varians			y	y										
Dianella caerulea									y		y			
Dianella caerulea var. producta	y	y	y	y	y	y	y	y				y	y	y
Dianella prunina					y		y			y		y	y	
Dianella revoluta		y		y										
Dichelachne rara		y												
Dichelachne sp.	y						y							
Dichondra repens				y				y			y			
Dillwynia elegans									y					
Dillwynia retorta						y	y	y	y	y			y	
Dodonaea triquetra														y
Drosera peltata									y					
Drosera sp.		y		y								y		
Echinopogon caespitosus	y		y	y	y	y		y			y			y
Echinopogon ovatus											y			
Elaeocarpus reticulatus		y		y							y		y	y
Entolasia marginata				y				y			y			y
Entolasia stricta	y	y	y	y	y		y	y	y	y	y	y	y	y
Epacris microphylla												y	y	
Epacris pulchella		y			y	y	y		y	y	y	y	y	
Eragrostis brownii					y									y
Eucalyptus globoidea	y	y	y	y	y	y								
Eucalyptus haemastoma						y			y	y		y	y	
Eucalyptus pilularis	y	y	y											
Eucalyptus racemosa				y	y	y	y	y			y			
Eucalyptus resinifera	y	y			y			y			y	y	y	y
Eustrephus latifolius				y				y						y
Gahnia erythrocarpa											y			
Gahnia sieberana											y			
Geranium homeanum		y									y			
Glochidion ferdinandi											y			
Glycine clandestina	y	y	y	y	y		y	y						
Glycine tabacina	y	y		y				y						y
Gompholobium glabratum										y			y	
Gonocarpus tetragynus		y		y		y		y						
Goodenia bellidifolia									y	y		y	y	
Goodenia heterophylla		y												
Grevillea buxifolia					y			y	y	y		y	y	
Grevillea linearifolia		y											y	y
Grevillea sericea														

Grevillea speciosa						y	y	y	y	y			y	
Hakea gibbosa											y			
Hakea laevipes						y	y		y	y		y	y	
Hakea sericea	y	y	y	y	y	y	y	y	y	y	y	y	y	
Hardenbergia violacea		y	y	y										y
Hibbertia aspera		y	y	y	y	y		y		y	y			
Hibbertia bracteata		y						y	y	y				
Hibbertia empetrifolia							y	y	y	y		y	y	
Hibbertia monogyna													y	
Hovea linearis			y				y		y	y		y	y	
Hydrocotyle peduncularis		y						y						
Hydrocotyle tripartita											y			
Hypericum gramineum												y		
Hypericum japonicum		y												
Imperata cylindrica	y	y	y	y	y	y		y			y			y
Juncus continuus											y			y
Juncus usitatus											y			y
Kennedia rubicunda	y													
Kunzea ambigua					y			y			y	y	y	
Lagenophera stipitata				y				y						
Lambertia formosa					y	y	y		y	y		y	y	
Lasiopetalum ferrugineum													y	
Lasiopetalum parviflorum				y	y									
Lepidosperma gunnii		y	y		y		y			y		y	y	
Lepidosperma laterale	y	y			y	y						y	y	
Leptospermum arachnoides							y		y	y		y	y	
Leptospermum polygalifolium											y	y		y
Leptospermum squarrosum												y		
Leptospermum trinervium					y	y	y		y	y		y	y	
Lepyrodia muelleri											y	y	y	
Lepyrodia scariosa							y		y	y		y	y	
Leucopogon juniperinus	y	y	y	y	y	y		y		y	y			y
Leucopogon microphyllus									y					
Lindsaea linearis				y	y	y	y	y	y	y		y	y	
Lindsaea microphylla		y		y	y		y					y		
Lomandra brevis				y	y		y			y		y		
Lomandra confertifolia							y					y		
Lomandra cylindrica	y	y	y		y			y			y	y	y	
Lomandra filiformis spp. *coriacea*			y		y	y	y	y	y	y		y	y	
Lomandra filiformis ssp. *Filiformis*														y
Lomandra glauca						y						y		y
Lomandra gracillis	y		y	y	y		y	y	y			y	y	y
Lomandra longifolia	y	y									y	y	y	y
Lomandra micrantha		y		y			y							
Lomandra multiflora		y	y	y	y								y	y
Lomandra obliqua		y	y	y	y	y	y	y	y	y		y	y	
Lomatia silaifolia	y	y	y	y	y	y	y	y	y		y	y	y	y

Melaleuca nodosa		y												
Micrantheum ericoides	y	y	y		y	y	y	y			y	y	y	
Microlaena stipoides	y		y	y	y	y	y	y			y		y	y
Microtis sp.									y					
Mitrasacme polymorpha									y	y		y		
Monotoca scoparia							y		y	y		y		
Olax stricta									y					
Olearia microphylla		y			y									
Opercularia diphylla	y	y	y	y	y	y	y	y						
Opercularia varia		y												
Oplismenus aemulus			y	y				y			y			
Oplismenus imbecillis			y											
Oxalis perrenans		y		y	y			y						
Ozothamnus diosmifolium			y	y	y	y	y	y			y			y
Pandorea pandorana			y											
Panicum simile	y	y	y	y		y		y						
Patersonia glabrata		y							y					
Patersonia sericea							y					y	y	
Patersonia sp.										y				
Persoonia laurina	y	y		y	y									
Persoonia levis	y	y		y	y	y	y		y					y
Persoonia linearis			y			y					y		y	
Persoonia pinifolia	y		y							y	y		y	
Petrophile pulchella					y		y		y	y		y	y	
Phyllanthus hirtellus				y	y	y				y		y	y	
Phyllota grandiflora									y	y			y	
Phyllota sp.												y		
Pimelea linifolia						y	y		y					
Pittosporum revolutum											y			
Pittosporum undulatum	y	y	y	y	y	y	y	y		y	y	y	y	y
Platylobium formosum	y	y	y	y										
Platysace ericoides						y								
Platysace lanceoloata														y
Platysace linearifolia									y	y		y	y	
Poa affinis														y
Polyscias sambucifolia	y	y	y	y	y	y	y	y			y		y	y
Pomaderris discolor		y												
Pomax umbellata			y		y									
Poranthera ericifolia								y						
Pratia purpurascens	y	y	y	y	y	y	y	y			y			y
Prostanthera howelliae		y	y	y										
Pseuderanthemum variabile		y						y						
Psilotum nudum										y				
Pteridium esculentum	y	y			y			y			y			y
Pterostylis longifolia				y	y									
Pterostylis pedunculata			y											
Pultenaea polifolia		y												
Pultenaea retusa		y		y										
Pultenaea scabra		y												
Pultenaea tuberculata						y	y	y	y	y		y	y	
Pultenaea villosa		y						y						

Rhytidosperma racemosum		y												
Rhytidosporum procumbens									y					
Schizaea bifida									y				y	
Schoenus imberbis													y	
Senecio diaschides		y												
Senecio linearifolius				y										
Smilax glyciphylla		y			y			y			y	y	y	
Stackhousia spathulata							y		y	y		y	y	
Stephania japonica											y			
Stylidium graminifolium									y					
Styphelia tubiflora												y		
Syncarpia glomulifera	y	y	y	y				y						y
Tetrarrhena juncea							y						y	
Tetratheca ericifolia														
*Tetratheca glandulosa**									y					
Thelymitra ixioides													y	
Thelymitra sp.					y									
Themeda australis	y	y	y	y	y	y								
Veronica plebeia		y						y						y
Xanthorrhoea arborea			y	y		y			y	y				
Xanthorrhoea media	y				y	y		y	y	y		y	y	
Xanthorrhoea minor		y												
Xanthosia tridentata		y	y			y	y	y				y	y	
Additional species observed adjacent to quadrats														
Actinotus helianthii														
Amperea xiphoclada														
Bauera rubioides														
Blandfordia grandiflora														
Bossiaea ensata														
Callicoma serratifolia														
Caustis flexuosa														
Cymbidium suave														
Cymbopogon refractus														
Dillwynia rudis														
Dillwynia acicularis														
Dipodium sp.														
Diuris maculata														
Eucalyptus pilularis x racemosa														
Eucalyptus piperita														
Gompholobium latifolium														
Hybanthus monopetalus														
Lyperanthus suaveolens														
Mirbelia rubiifolia														
Muelleriana eucalyptiodes														
Stylidium productum														
Tetratheca thymifolia														
Tricoryne simplex														
Xanthosia pilosa														

(* Threatened species listed under TSC Act, # Threatened species listed under EPBC Act)

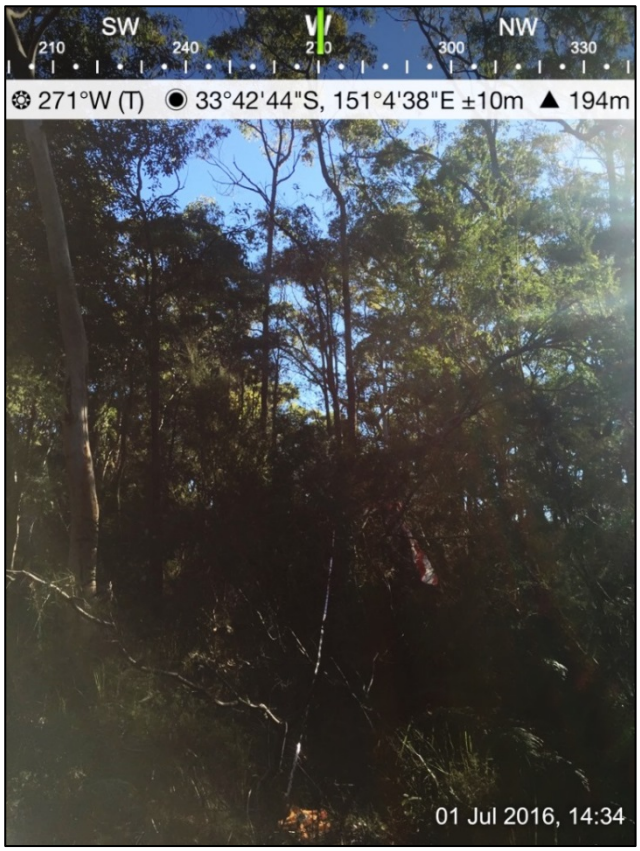
Appendix 2: Quadrat vegetation images

Quadrat 1: STIF vegetation

Quadrat 2: STIF vegetation

Quadrat 3: STIF vegetation

Quadrat 4: STIF vegetation



Quadrat 5: Duffy's Forest vegetation

Quadrat 6: Duffy's Forest vegetation

Quadrat 7: Scribbly Gum Open Woodland vegetation

Quadrat 8: Duffy's Forest vegetation

Quadrat 9: Bloodwood-Scribbly Gum Woodland vegetation

Quadrat 10: Bloodwood-Scribbly Gum Woodland vegetation

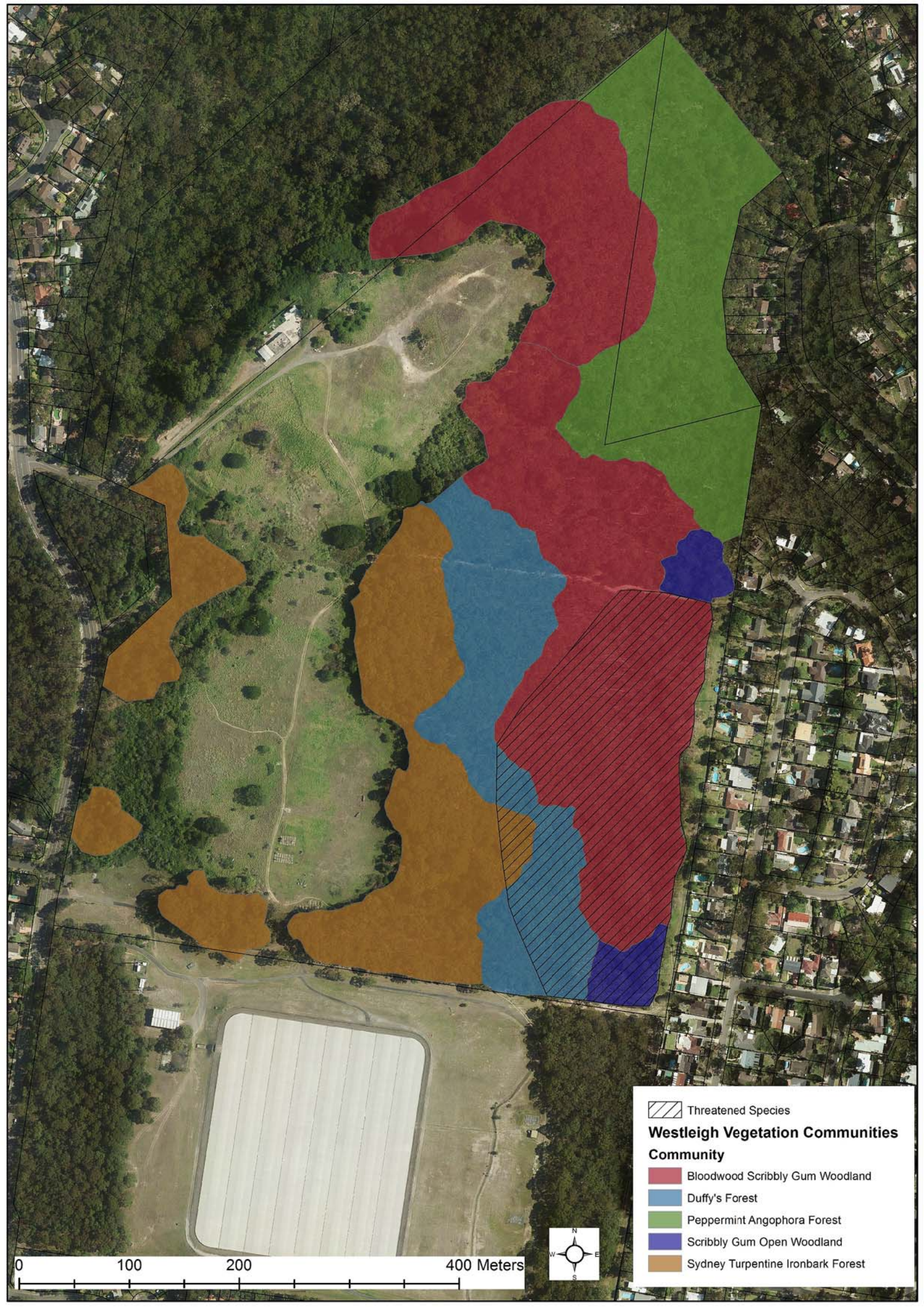
Quadrat 11: Peppermint-Angophora Forest vegetation

Quadrat 12: Peppermint-Angophora Forest vegetation

Quadrat 13: Scribbly Gum Open Woodland vegetation

Quadrat 14: STIF vegetation

Appendix 3: Vegetation map


Threatened Species
Westleigh Vegetation Communities
Community
Bloodwood Scribbly Gum Woodland
Duffy's Forest
Peppermint Angophora Forest
Scribbly Gum Open Woodland
Sydney Turpentine Ironbark Forest
0
100
200
400 Meters
N
W
E
S

Appendix 4: Fauna species

Bird Species	26/08/2016	5/09/2016	4/10/2016	6/10/2016	Notes
Collared Sparrowhawk				x	
Brown Goshawk	x	x		x	
Square Tailed Kite *	x				
Wonga Pigeon		x			
Brown Cuckoo Dove				x	
Sulphur Crested Cockatoo	x	x	x	x	
Little Corella		x			
Galah			x		
Australian King Parrot		x			
Rainbow Lorikeet	x	x	x	x	Nesting in hollow of E. globoidea
Musk Lorikeet		x			
Crimson Rosella		x	x	x	
Channel Billed Cuckoo					Summer Migrant
Eastern Koel			x	x	Summer Migrant
Dollarbird				x	Summer Migrant
Laughing Kookaburra	x	x	x	x	
Sacred Kingfisher			x	x	Summer Migrant
Spotted Pardalote	x		x	x	
White throated Treecreeper		x	x		
Superb Fairywren		x		x	
Variegated Fairywren			x	x	
Brown Thornbill	x		x	x	
Striated Thornbill	x	x	x	x	
Brown Gerygone	x	x	x	x	
White Browed Scrubwren		x		x	
Eastern Whipbird	x	x			
Noisy Friarbird		x			
Red Wattlebird		x	x	x	
Little Wattlebird	x	x	x	x	
Noisy Miner		x		x	Only on suburban edges
Lewins Honeyeater		x		x	
Yellow Faced Honeyeater	x	x	x	x	
White Naped Honeyeater	x				Flowering E. globoidea
White Cheeked Honeyeater	x	x	x	x	
Eastern Spinebill	x	x	x	x	
Scarlet Honeyeater	x		x		
Mistletoebird			x		
Grey Fantail	x	x	x	x	
Silvereye	x	x	x	x	
Golden Whistler	x	x	x		
Eastern Yellow Robin	x	x	x	x	
Rose Robin		x			In adjacent bushland around reservoir

Olive Backed Oriole				x	
Australasian Figbird			x		In fig on suburban edge
Black Faced Cuckoo Shrike	x		x	x	
Welcome Swallow		x			
Austalian Magpie		x	x	x	x
Pied Currawong		x	x	x	x
Grey Butcherbird		x	x	x	x
Australian Raven			x		
* NSW Threatened Species Conservation Act 1995					

Other fauna species	**26/08/2016**	**5/09/2016**	**4/10/2016**	**Notes**
Swamp Wallaby	x	x	x	Scats Only
Sugar Glider			x	Bark damage on Red Bloodwoods- feeding marks
Red Bellied Black Snake		x		Grassed cleared area
Water Skinks		x	x	
Garden Skinks		x	x	