Lake Macquarie *Tetratheca juncea* Planning and Management Guidelines

Lake Macquarie City Council

Lake Macquarie City Council March 2014

Acknowledgements

This report was prepared by Martin Fallding in collaboration with a wide range of contributors, including the participants at a scientific workshop. Particular thanks are due to Colin Driscoll and Robbie Economos. Workshop and other contributors included Carmen Castor, Anne Jones, Robert Payne, Stephen Bell, and Sarah Warner. Support from the NSW Office of Environment and Heritage is acknowledged.

Partially funded by the Commonwealth Department of the Environment through the Sustainable Regional Development Program.

Photo credits

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SUS 14049

Contents

Executive summary

The listed threatened plant species *Tetratheca juncea (T. juncea),* commonly known as Black-eyed Susan, has a very limited geographic distribution and most of its known population occurs within the Lake Macquarie Local Government Area (LGA). Many development projects and activities occurring within the LGA impact on *T. juncea*. The occurrence of *T. juncea* also significantly affects many development projects.

T. juncea is a low shrub occurring in native woodland vegetation, growing as a single stem or a clump. It is difficult to identify except when flowering.

These guidelines compile information about *T. juncea* to inform conservation and strategic land use planning and land management. One objective of this document is to compile current knowledge about the species into one reference document to inform planning and management and to influence future scientific research programs.

A strategic assessment of long term land use within the Lake Macquarie LGA indicates that around 25% of modelled habitat for the species has the potential to be directly affected by development to 2050. Estimated annual loss of *T. juncea* habitat at current rates is probably approximately 10 – 25 ha per year and will significantly fragment current populations. Only 15% of modelled habitat, and a much smaller proportion of the known population is protected within conservation reserves.

These guidelines replace the Lake Macquarie *T. juncea* Conservation Management Plan prepared by R Payne in November 2000 following significant advances in knowledge about the species, especially its distribution and biology. Information in this document needs to be incorporated into land use planning and decision-making processes, and while it specifically applies to the Lake Macquarie LGA, it has relevance for the six LGAs where *T. juncea* is known to occur.

Priorities for scientific research have been identified, which are important for informing future planning and management. These primarily relate to the genetic characteristics of local populations, investigation of the predicted occurrence of the species in habitat models, and the refinement of methods to accurately determine populations in the field. Further investigation of the species management requirements is also important.

The guidelines inform future land use planning and management, and give more certainty to government and the development industry as to the future requirements that will apply when development proposals impact on *T. juncea*.

Proposals to be incorporated in future strategic planning include:

- Specific objectives for local land use strategies.
- Guidelines for assessment of the significance of impacts.
- Guidelines for acceptable losses and offset requirements for *T. juncea.*
- Areas to be investigated for conservation reserves.
- Post development vegetation management plans.
- Guidelines for management of *T. juncea* data.

These guidelines have been prepared by Lake Macquarie City Council in consultation with the NSW Office of Environment and Heritage (OEH) and Commonwealth Department of the Environment (DE).

1. Background

T. juncea (common name Black-eyed Susan) is a geographically restricted endemic plant species listed as a threatened species at the state and national level under the NSW *Threatened Species Conservation Act 1995 (TSC Act)* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).* The species is poorly represented in conservation reserves and is subject to widespread clearing arising mainly from urban development.

The population of the species is very restricted in distribution and most occurs within the Lake Macquarie LGA, although its range extends from north of Wyong to Bulahdelah.

The Lake Macquarie *T. juncea* Conservation Management Plan (Payne 2000) was prepared for Lake Macquarie City Council in association with the development industry and NSW Government. The Plan compiled information about the population distribution of the species and outlined conservation management strategies.

The Lake Macquarie *T. juncea* Conservation Management Plan (Payne 2000) was prepared at a time when information about the distribution of the species was limited and its biology and ecology not well understood. The Plan successfully provided a basis for the development of field survey methodology for the species and for assessing the impact of individual developments upon it. Since its preparation, many more records have been reported, further research has been undertaken on the biology and ecology, and the extent of the species population within Lake Macquarie City and over its whole range is now clearer.

A scientific workshop was held in 2009 to review the referral and assessment requirements for the species, in co-operation with the NSW and Commonwealth governments. This was informed by a review of the ecology and biology of *T. juncea* prepared by Colin Driscoll for Lake Macquarie City Council (Driscoll 2009). The workshop contributed to the production of *Environment Protection and Biodiversity Conservation Act* 1999 referral guidelines for *T. juncea* by the Commonwealth Government (Department of Sustainability, Environment, Water, Population and Communities 2011).

Further research has also been conducted on the clonality and genetic variability of *T. juncea*. As a result of the increased knowledge of the species and its distribution, updated planning and management guidelines are required.

This document provides a summary of the current knowledge of *T. juncea* and reviews the implications of this understanding for land use planning and management within the Lake Macquarie LGA. The purpose of this document is to provide information to inform land use decision-making and biodiversity conservation planning. It provides planning and management guidelines, which may be included in local government planning documents and replaces the earlier conservation management plan.

The information in this document (especially sections 6 and 7) should be used as a reference for strategic planning and project development assessment where potential impacts on *T. juncea* may occur. It will also be relevant to decision-making over the full range of the species.

This report:

1 Compiles and summarises current scientific knowledge and presents this in an accessible way for land use decision-making.

2 Identifies strategic land use planning considerations which need to be integrated with conservation planning, including current land use programs, and an assessment of potential impacts on the species in the medium to long term.

3 Makes land use planning proposals for measures to protect *T. juncea* in relevant strategic planning documents, such as the Lower Hunter Regional Strategy (LHRS), Lower Hunter Regional Conservation Plan (LHRCP), Lake Macquarie Lifestyle 2030 Strategy, Lake Macquarie Local Environmental Plan (LEP), Lake Macquarie Community Strategic Plan 2013-2023.

4 Provides land management guidelines for landowners with *T. juncea* on their property, both public and private.

Typical *T. junea* growth form

2. Legislative and planning context

There is a legislative requirement for impacts on listed threatened species to be considered as part of planning and development approval processes. Since *T. juncea* is listed as threatened under both NSW and Commonwealth legislation, two approval frameworks exist where developments or activities are likely to impact upon the species.

Lake Macquarie City Council is the local planning and consent authority for its area and has responsibilities under the *Threatened Species Conservation Act 1995 (TSC Act) and Environmental Planning and Assessment Act 1979 (EP&A Act)* to consider the significance of potential impacts on threatened species. The preparation of planning and development guidelines is an effective way to assist the Council in carrying out its responsibilities. As a land manager, the Council also has responsibilities for actions, which may affect the species.

The guidelines will inform local, state and Commonwealth based decision-making processes affecting *T. juncea* and its habitat within the Lake Macquarie LGA. The guidelines provide locally specific information for decision-making. In particular, the plan will be relevant for recovery planning, including implementation of the NSW Threatened Species Priorities Action Statement (DECC 2007) and the Lower Hunter Regional Conservation Plan (DECC 2009).

Apart from the survey techniques, these guidelines are consistent with the *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)* referral guidelines for the vulnerable Black-eyed Susan *Tetratheca juncea* 2011 (SEWPaC 2011)

3. Biology and ecology

An understanding of biological and ecological characteristics is essential for informing future planning and management actions.

T. juncea is a low shrub occurring in native woodland vegetation communities. Stems can grow up to 1.5 metres high and are generally leafless. Plants grow as a single stem or clumps of stems arising from a single rootstock, and are often difficult to distinguish from nearby vegetation except when flowering.

The ecology and biology of *T. juncea* has been reviewed by Driscoll (2009) and is also summarised in Commonwealth and State species threatened species profiles. Biological and ecological characteristics of the species which are important for planning and management purposes within Lake Macquarie LGA are summarised in Table 1. More detail on key biological and ecological characteristics influencing planning and management is outlined later in this section.

Table 1:
Summary of important characteristics of *T. juncea*

Characteristic	Review and comment
Growth habit	Low shrub with generally leafless stems with a distinctly angular, winged structure. Can grow as discrete clumps of stems like a grass tussock or in more spreading patches of stems. The term 'clump' is often incorrectly used interchangeably with 'plant' to describe the species. Slow growing, with some clumps or sub populations possibly a hundred or more years old. Regarded as cryptic because it is often difficult to locate when not in flower.
Habitat	Mostly occurs in Eucalypt woodland on low nutrient soils in association with mycorrhizal fungi, with some growing in coastal heath and tall forests. A generalist in its habitat requirements, notwithstanding its restricted occurrence. About 40% of the vegetated area of Lake Macquarie LGA provides suitable potential habitat (based on modelling).
Flowering & fruiting cycles (reproductive phenology)	Annual plant flowering over a relatively long period from mid to late winter through to late summer, indicating probable photoperiodicity. There are two phases of budding in June and late September, with peak flowering in late September. Therefore, field surveys should be undertaken between mid September and mid October. Conversion of flower into fruit is estimated at about 35% but is highly variable over time and space.
Propagation & reproduction	Propagates through both rhizomal spread and seed dispersal and germination. Clonality gives the plant longevity and durability in response to disturbances. Pollination by at least 6 species of native bees has been observed, with pollen transfer generally 30 metres or less. However, pollen transfer has potential to occur as far as pollinators disperse (300 to 500 metres). Seed is dispersed by ants and possibly other species which may include macropods, cockatoos or possums. Unknown lifespan of the soil seed bank.
Genetics	Study of one sub-population showed it to be genetically diverse with sexual reproduction the dominant reproductive mode. On a small spatial scale 83% of individuals were genetically different from each other. The 17% that were clonal had a maximum clonal range of 1.15 metres. More work is required across the distribution (Jones 2011).
Environmental conditions	Occurs on soils from Carboniferous sediments (Mid North Coast) Permian sediments with Narrabeen Sandstone (Lake Macquarie and Central Coast), comprising mainly erosional soil landscapes and some depositional and aeolian sands. At the north of its range it occurs in crevices in rocky cliff faces. Pollinating bees require good continuous vegetation with some bare ground for nesting sites.
Vegetation community associations	Within Lake Macquarie LGA, the majority of records are from the Coastal Plains Smooth-barked Apple Woodland (MU 30), Coastal Plains Scribbly Gum Woodland (MU31) vegetation communities described by NPWS (2000). It also occurs in the Coastal Foothills Spotted Gum – Ironbark Forest (MU15) ecotone.
Distribution	The species has a very restricted area of distribution at the national scale, in two metapopulations. The Central Coast metapopulation is between Wyong and Beresfield and concentrated within Lake Macquarie LGA, and the North Coast metapopulation occurs between Karuah and Bulahdelah. Distribution knowledge is based on surveys and modelling, and the reliability of knowledge is variable across its range. Distribution is probably associated with soil types.
Population size	While metapopulations of the species have been identified, further subdivision of populations is a function of factors such as fragmentation, dispersal distances, pollinator characteristics and local population lifespan. Average of 40 clumps/ha over full range. Populations are generally structured as a dense population with outlier plants scattered around.

Characteristic	Review and comment
Significant populations	In the absence of genetic information across its distribution, a significant population has not been determined. However, for impact assessment purposes at the national level an important population has been generally determined to be a population with greater than 1,000 plant clumps, an area of habitat with an average estimated plant clump density of 20 clumps/hectare or greater, or occurring in rare habitat or at or near the distributional limits of the species (SEWPaC 2011).
Population viability	The requirements for a self-sustaining population are difficult to determine due to the longevity of plants and relatively long and unknown period for a generation.
Conservation status	Listed as a threatened species under *TSC Act* and *EPBC Act.* ROTAP status is 3VCa (Briggs & Leigh 1995). About 36% of modelled potential habitat has been lost since 1750. Vulnerability is dependent on the length of a generation and is therefore difficult to assess.
Fragmentation & connectivity	Fragments of >1,000 ha contain 29% of the population. Connectivity of populations is associated with movement of pollinators.
Bush fire response	Appears to require periodic fire. Plants have been observed to resprout following fire, and are capable of growing from seed. It appears that plants grow from seed only after fire events, and that fire intensity affects germination, with no seedlings after intense fire. Increased pollinator activity is evident after fire events. Increasing time following fire appears to reduce the *T. juncea* population, and may be due to competition from grasses. Cool fires appear to promote growth.
Disturbance response	Plants have been shown to withstand disturbance by slashing or nearby clearing. Can persist in areas of weed invasion, but weed infestation over the long term appears to gradually diminish the *T. juncea* population size.
Translocation response	Translocation is at an experimental stage, with mixed results. Some success where whole clumps are removed to a nearby location and heavily watered. In principle, translocation is not supported and can cause extensive disturbance which is unwarranted.

Notes:

1. Information in the table is from Driscoll (2009) or Driscoll (2012, pers comm.), unless otherwise attributed and was reviewed by participants at the scientific workshop held on 3 April 2012.
2. This table has been compiled for the Lake Macquarie LGA. Some identified characteristics may differ across the full geographic range of the species (eg associated vegetation characteristics).

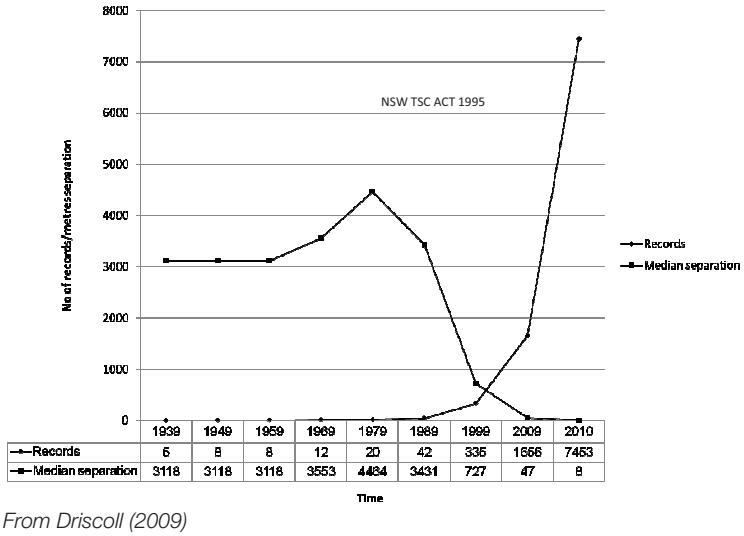
Although many aspects of the biology and ecology are well understood, key questions remain which are important for future planning and management. These are discussed below and include population issues, genetic characteristics, connectivity issues and management issues. The discussion includes an outline of important research questions which affect future planning and management.

3.1 Population issues

Understanding the *T. juncea* population is essential for effective land use planning and the long term conservation of the species. Important issues relating to the understanding of *T. juncea* include the distribution of the species, abundance and population density, fragmentation of populations, population viability, and minimum size requirements. Terms used to describe population characteristics are defined in the glossary.

Over the last decade there has been a significant increase in the number of *T. juncea* records as shown in Figure 1. This is primarily a result of increased field survey and development proposals on a small number of sites with high population densities. There may also be other factors such as climatic conditions which have facilitated detection of more plant clumps. This means that records in recent years have substantially increased the known population.

Figure 1: Change in *T. juncea* records over time, and separation distance



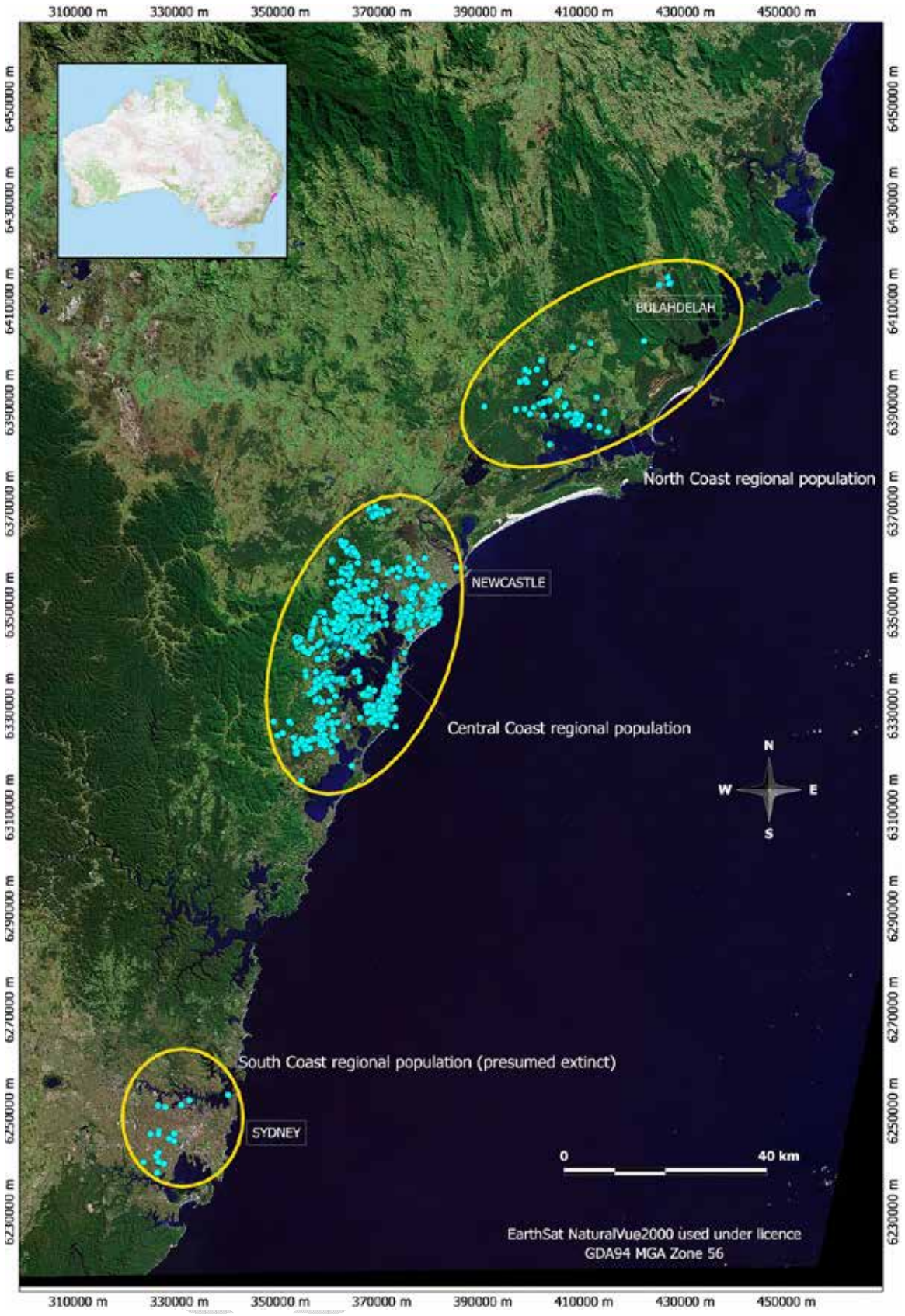
	1939	1949	1959	1969	1979	1989	1999	2009	2010
Records	6	8	8	12	20	42	335	1666	7453
Median separation	3118	3118	3118	3553	4434	3431	727	47	8

From Driscoll (2009)

Habitat suitability modelling can assist with the interpretation of records of the species for planning purposes. Driscoll (2009) reviewed the population of *T. juncea* across its full range and undertook habitat suitability modelling. He identified 3 metapopulations as shown in Map 1 based on the geographic distribution of known records, comprising the presumably extinct southern metapopulation in the Sydney area (17? records), Central Coast metapopulation from Wyong to Beresfield (approx 25,000 records), and northern population from Karuah to Buladelah (about 60 records). Driscoll considers the distance between metapopulations is sufficient that there would be no transfer of genetic material between them in normal circumstances. He speculates that *T. juncea* may be a palaeoendemic species, meaning it was more widespread in the past, but its range has reduced as a result of recent environmental change. As a result its current distribution is very restricted and may be contracting further even in the absence of human induced disturbance.

Map 1:

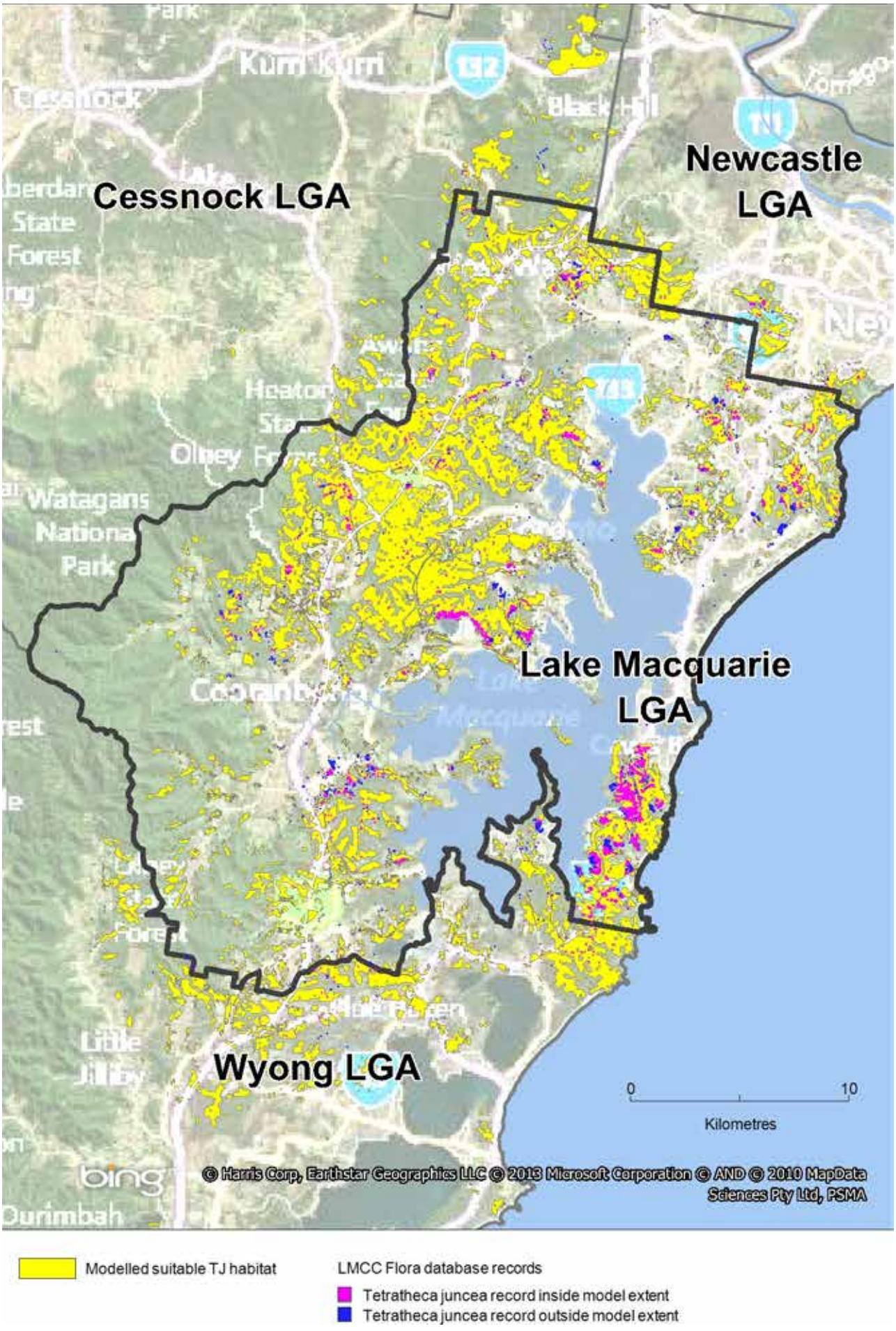
Historic geographic range of *T. juncea* and metapopulations



Habitat suitability modelling using compiled species records shows a broader potential distribution of *T. juncea*, and a much greater population than was known at the time of preparation of the Lake Macquarie *T. juncea* Conservation Management Plan (Payne 2000). The area of modelled suitable habitat in Lake Macquarie LGA is outlined on Map 2, and shows a greater, and more concentrated population relative to other LGAs. There are extensive populations on the western side of Lake Macquarie in the Wyee, Morisset and Awaba areas.

Map 2:

Modelled *T. juncea* habitat and distribution of records within Lake Macquarie LGA



Habitat suitability modelling is used to estimate the distribution and habitat preferences of plant species where records for the species are limited. In principle, habitat suitability modelling compares environmental conditions at known target species presence (some methods also include known absence data) sites against all other locations within the model area. All locations within the model area are then scored according to their degree of similarity to the conditions at known/unknown locations. Environmental variables can include, for example, soil landscape type, aspect, elevation, rainfall, solar radiation, and distance to streams. Driscoll (2009) used Maxent species habitat modelling software and presence only data for a 100 metre square grid (1 ha) over the full known range of *T. juncea* adjusted for sampling bias to estimate probability of habitat suitability. The modelling indicated that the main predictors of occurrence are rainfall and soil, and that the species occurs predominantly in erosional soil landscapes where rainfall is at or above 1,000 mm per annum. This was used to estimate the pre-1750 distribution, and the loss of suitable habitat to 2007 using extant vegetation mapping from aerial photography and shows that over 30% of modelled *T. juncea* habitat has been lost since European settlement (Driscoll 2009).

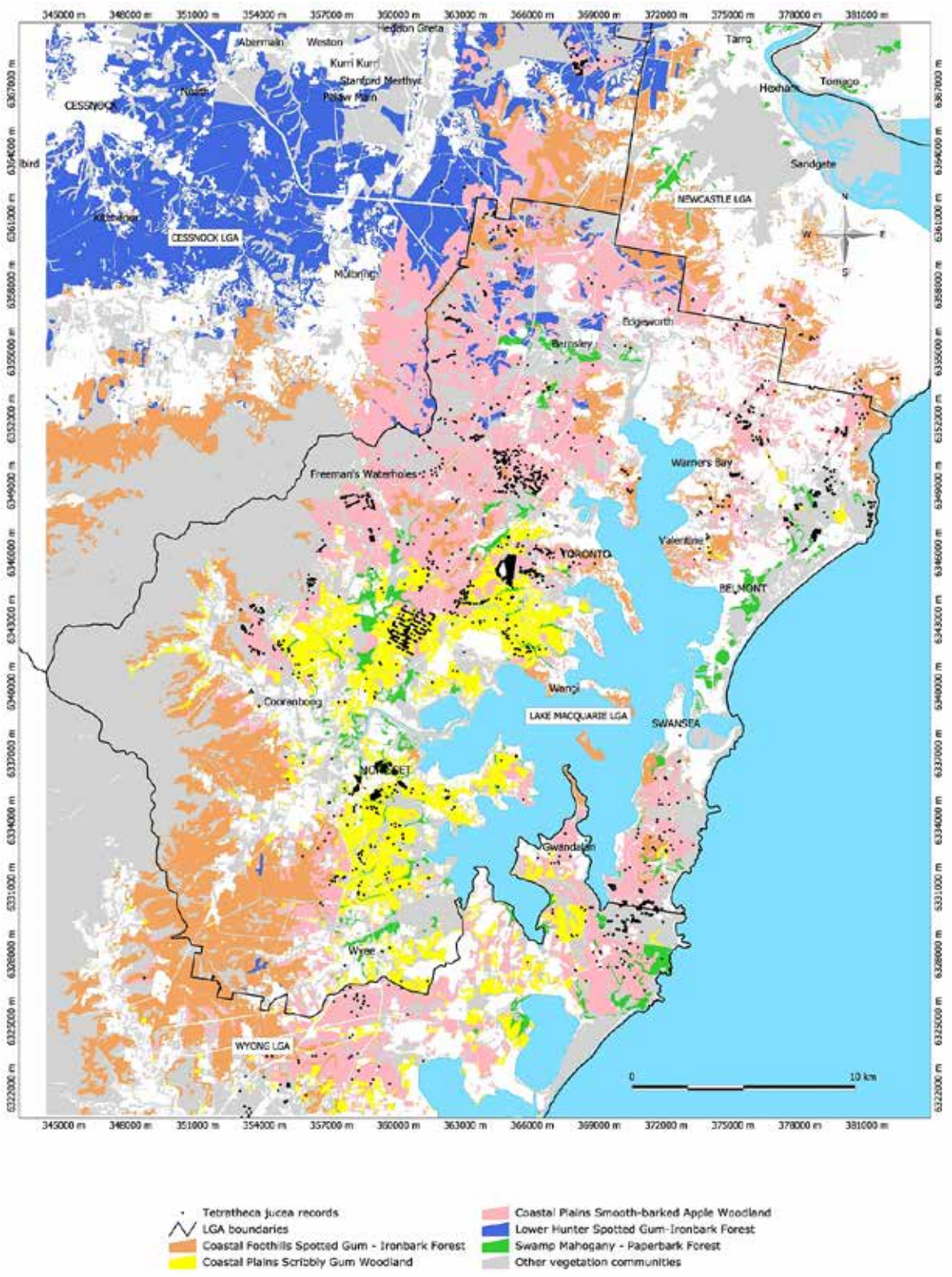
Analysis of modelled *T. juncea* habitat and vegetation communities shows a clear association between vegetation communities and the occurrence of *T. juncea*. Table 2 shows that the Coastal Plains Scribbly Gum Woodland and Coastal Plains Smooth-barked Apple Woodland vegetation communities account for about 67% of the area of modelled *T. juncea* habitat. The spatial distribution of the main vegetation communities where *T. juncea* occurs and modelled habitat is shown on Map 3.

Table 2: Vegetation communities, modelled habitat and *T. juncea* records in Lake Macquarie LGA

Vegetation community (LHCCREMS 2003)	Map Unit	Area of modelled habitat (ha)	Proportion of total modelled habitat
Coastal Plains Smooth-barked Apple Woodland	30	6,217	46%
Coastal Plains Scribbly Gum Woodland	31	2,878	21%
Coastal Foothills Spotted Gum – Ironbark Forest	15	1,733	13%
Coastal Ranges Open Forest	9	664	5%
Hunter Valley Moist Forest	12	473	3%
Lower Hunter Spotted Gum – Ironbark Forest	17	328	2%
Alluvial Tall Moist Forest	5	292	2%
Coastal Sheltered Apple – Peppermint Forest	11	235	2%
Other (19 communities)		788	6%
Total		**13,608**	**100%**

From Driscoll 2012

Map 3: Simplified map of vegetation communities associated with *T. juncea* within Lake Macquarie (from Driscoll 2009)



Suitable habitat for *T. juncea* represents 40% of the vegetated area of Lake Macquarie LGA outside of reserves. Much of its preferred habitat is land likely to be subject to development pressure. The implications of the understanding of *T. juncea* populations and planning issues are reviewed later in the section relating to planning guidelines.

Driscoll compiled modelled spatial data for the Central Coast metapopulation to estimate area of suitable habitat and abundance of clumps. Clump density was estimated from 12 sites where all clumps were counted comprising a total of 24,563 clumps. This gave a range of 1.19 – 282.92 clumps per hectare with a median density of 47.83 ± 14.16 clumps per hectare. Results are summarised in Table 3.

Table 3: Modelled habitat and clump estimate for *T. juncea* Central Coast metapopulation

	Modelled habitat (ha)	Clumps estimate
Pre-1750	40,241	1,924,727
Extant	25,716	1,229,996
Loss (36%)	14,525	694,731
Reserved	2,664	127,419

From Driscoll 2012

3.2 Genetic issues

The genetic characteristics of *T. juncea* are not well understood, especially the genetic variability across the full range of the species or at the population level. In particular, genetic analysis has the ability to clarify the numbers of individual plants within a population as opposed to the number of clumps identified using current field survey methods. This has implications for the characterisation of the two extant metapopulations and for determining important *T. juncea* populations for conservation purposes and future land use planning. Presently, all stems within 30 cm are regarded as one plant.

Jones (2011) undertook an assessment of clonality, genetic diversity and structure of a geographically discrete *T. juncea* sub-population (100 plants in Lake Macquarie State Conservation Area at Bolton Point). This study indicated that determination of sub-populations by counting clumps may not be accurate as more than one genet can occupy the area currently assigned as one plant (Jones 2011). Effective population size determined by genotyping is greater than that estimated by visual surveying. If these species characteristics apply across the full species range they will directly affect how *T. juncea* is surveyed and managed. The study provides information on short range dispersal of plants with the majority of plants studied being individuals derived from seed rather than vegetatively.

If the study by Jones (2011) is extended to the whole population, its finding that most individuals in the patch studied were derived from seed rather than vegetatively and were dispersed over small distances suggests that the species can effectively reproduce. However, further population studies are needed to confirm this result and to demonstrate whether this is representative of the species across its whole range.

Recent data show that *T. juncea* can reproduce both vegetatively and by seed, and that local populations are probably more genetically diverse than previously assumed. However, it is unknown whether the North Coast and Central Coast metapopulations are genetically distinct, or whether plants at the edge of its range or within metapopulations have different characteristics. This will inform the size of populations required if the full species diversity is to be conserved and understanding of the links between the distribution of the species and environmental characteristics.

The genetic characteristics influence field survey requirements, and affect what is considered to be an important population for conservation. In addition, genetic knowledge informs decision-making about the connectivity requirements for the species. Recent advances in gene technology mean that it will be possible to obtain genetic information for *T. juncea* at a relatively low cost which may be able to answer important questions to inform decision-making.

Future studies should investigate within- and between-population genetic diversity. Maintenance and/or genetic diversity in *T. juncea* populations is dependent on the effective management of pollinator activity (Jones 2011) and genetic studies can indicate whether there are barriers to gene flow (eg infrastructure or easements). Genetics may in the longer term provide a basis for prioritising management actions for conservation.

Important scientific questions to inform planning and management include the following:

- What is the extent of genetic variability within the population?
- What is the structure of ramets and genets across populations?
- Is clonality affected by soil type, especially on sandy soils?
- How accurately does the current clump based counting method reflect the genetic variability of populations?
- Is the clump based counting method appropriate across the full range of the species?
- What represents an important population from a genetic perspective?
- Over what distances can *T. juncea* genetic material be dispersed, and can habitat fragmentation guidelines be determined?

3.3 Conservation status

T. juncea is listed as a threatened species under both the *NSW Threatened Species Conservation Act 1995* and the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*. It is also listed as a rare or threatened Australian plant (ROTAP) with status 3VCa (Briggs & Leigh 1995).

Conservation requirements are largely based on requirements for a self-sustaining population. Vulnerability of a species to extinction is dependent on its capacity to reproduce and on the length of a generation. No data is available on generation length although it is speculated that this is quite long, and may be in the order of tens to hundreds of years. Therefore, vulnerability of the species is difficult to assess for evaluating conservation requirements. However, it appears that historically the range of the species has probably declined significantly, and the distribution is continuing to contract due to development pressures.

As a general principle, larger populations are more important for conservation purposes, as well as populations with a high clump density, plants growing in rare or uncommon habitat, and at the edges of the geographic range of the species. For impact assessment purposes under the *Environment Protection and Biodiversity Conservation Act 1999* an important population has been generally determined to be a population with greater than 1,000 plant clumps, an area of habitat with an average estimated plant clump density of 20 clumps/hectare or greater, or occurring in rare habitat and at or near the distribution limits of the species (SEWPaC 2011).

About 36% of modelled potential habitat within Lake Macquarie LGA has been lost since 1750. Increasing records in recent years show that in Lake Macquarie LGA the species is often locally common, while rare at the regional, state and national scales. Local populations are threatened by clearing from development while on some sites it occurs in high densities and with large populations.

Of the records identified in the NSW Wildlife Atlas in Lake Macquarie LGA it is estimated that approximately 20 - 30% of these no longer occur as they have been cleared following development. This is because the majority of surveys for the species are associated with development projects.

Table 4 shows area of modelled suitable habitat within conservation reserves Driscoll (2012) and shows that *T. juncea* populations in reserves are small and scattered, and that there are no reserves of substantially connected habitat. The most significant reserve is Sugarloaf State Conservation Area (SCA) followed by Munmorah SCA. Importantly however, conservation reserves have not been extensively surveyed for *T. juncea* so the actual populations and density of clumps within these areas is not known.

Table 4: Areas of modelled habitat reserved in Lake Macquarie LGA

Conservation Reserve	Area (ha)
Awabakal NR	118
Glenrock SCA	164
Jilliby SCA	1
Lake Macquarie SCA	81
Pulbah Island NR	14
Sugarloaf SCA	1,195
Tingira Heights NR	7
Wallarah NP	122
Watagans NP	43
Total	**1,745**

Updated from Driscoll 2009 Table 10

The strategic assessment (Appendix B) shows that approximately 16% of modelled habitat within the LGA is within a conservation reserve, and that around 24% of modelled habitat is expected to be affected by development. This means that around 60% of modelled habitat within Lake Macquarie LGA is not secure for conservation but is not subject to development that can currently be identified.

Opportunities for the establishment of additional conservation areas should be subject to further investigation.

Important scientific questions to inform planning and management that relate to conservation reserves are:

How many plants/clumps occur within conservation reserves?

What is an adequate area of conservation reservation to secure the long term persistence of the species?

What are significant areas for conservation that should be within conservation reserves?

Where is conservation required and in what spatial configuration?

3.4 Fragmentation and connectivity issues

Fragmentation and connectivity refers to the number and distribution of discrete habitat fragments containing *T. juncea* and the extent to which these are connected. Within these fragments the separation of individual plants is also a consideration. The size and connection of habitat affects the ability of individual plants to disperse seed and genetic material, and also determines what constitutes a population and future viability.

Fragmentation and connectivity are primarily long term issues relating to population viability and the likelihood of species extinction and must take into account the landscape scale distribution of habitat as well as site specific characteristics relating to the biology of the species. In the long term, effective pollination is important to maintain population viability. This

suggests that attention needs to be given to the habitat requirements of pollinators as well as the habitat needs of the plant itself.

The connectivity of *T. juncea* habitat is determined primarily by the ability of pollinators to transfer genetic material to habitat fragments that are geographically separated and by dispersal of seed. Jones (2011) suggests that short-range dispersal of *T. juncea* seeds was likely and is in the order of tens of metres.

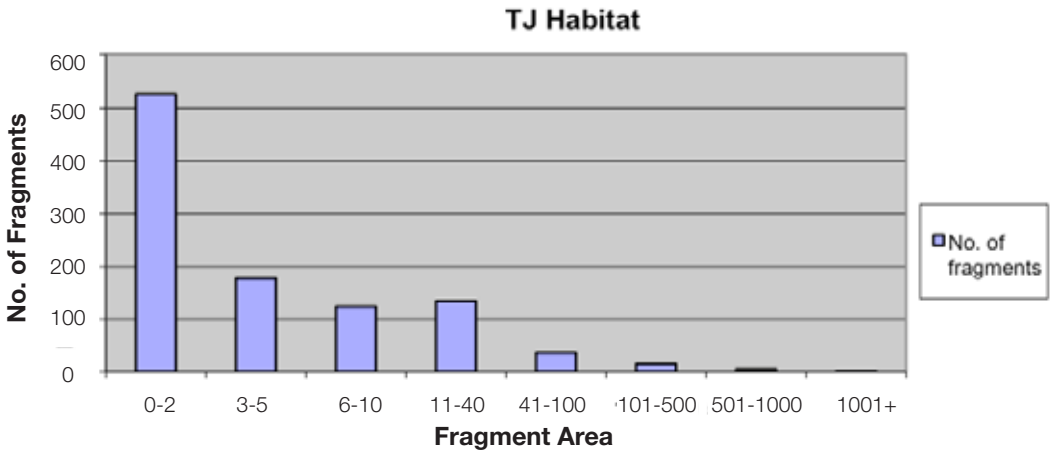
Areas of unsuitable habitat for insect pollinators are likely to form an effective barrier for the transfer of pollen between habitat fragments. A barrier could include a busy road (eg the freeway) or unsuitable (non vegetated) habitat. A distance of around 300 – 500 metres between areas of suitable habitat is expected to be the maximum distance for pollination between populations based on likely flying distances of known *T. juncea* pollinators. Using habitat suitability modelling, Driscoll (2009) estimated the size and number of fragments of *T. juncea* habitat within the Lake Macquarie LGA as shown in Figure 2. This shows that 29% of extant habitat is in fragments of greater than 1,000 ha and 24% is in fragments 100 to 1,000 ha in size.

This figure demonstrates that there are a large number of very small fragments and a small number of very large fragments. Given that fragment size is very important in future management and potential disturbance, this is an important factor in identifying habitat suitable for conservation priority and the future vulnerability of the species to disturbance as a result of development and land management actions. This can be used to inform future conservation and development planning.

Based on the distribution of *T. juncea* habitat and populations across the Lake Macquarie LGA, habitat fragmentation and major barriers to pollination, important sectors for planning and management purposes have been identified (Map 4).

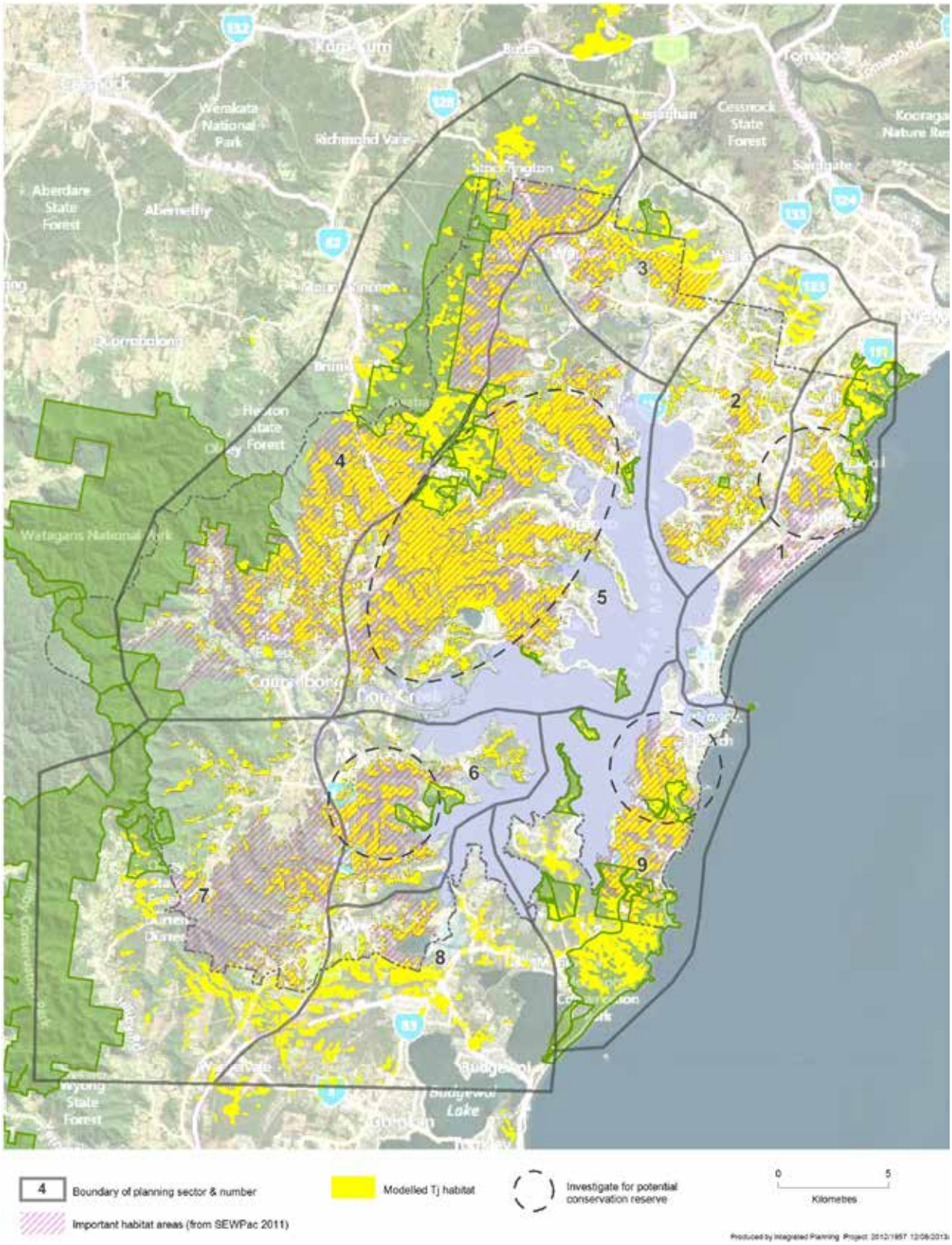
Because a substantial portion of extant habitat is outside reserves, further fragmentation of *T. juncea* habitat can be expected over time.

Figure 2: Graph showing distribution of modelled habitat fragments and size from Driscoll 2009)



Map 4:

Planning sectors for *T. juncea* within Lake Macquarie LGA



Map note: Nine planning sectors are based on derived sub-population boundaries which represent barriers for pollinators and movement of genetic material. Plant genetic material is not expected to be shared across boundaries and populations may evolve separately. Important *T. juncea* habitat area mapped by SEWPaC (2011) excluding modelled extant habitat is shown as Important Habitat Area and is important for maintaining habitat connectivity for enable transfer of genetic material.

While recent research has provided important data to inform planning and management, scientific questions to remaining to be investigated are:

- How far plants can disperse?
- What are the implications of pollen dispersal vs seed dispersal?
- Is there need for better understanding of pollinators and their populations?
- To what extent does linear infrastructure (eg F3 Freeway, Main Northern Railway, or a future East Coast High Speed Rail Corridor) provide a barrier to dispersal?

3.5 Management information

To date, scientific research into *T. juncea* has not focused on management requirements for the species. Driscoll (2009) has reviewed the bush fire response of the species based on a small number of observations, but little information is available to guide land managers in actively managing for its conservation.

Scientific questions to inform management overlap with other scientific research but some of the most important are:

Does *T. juncea* require periodic fire to be able to persist (and at what frequency and intensity)?

What is the disease susceptibility of the plants?

What is known about seed dormancy and seed viability?

What is the microhabitat requirement?

Are there critical soil characteristics affecting growth or reproduction?

Where is *T. juncea* growing with a different suite of plants?

How does the density of populations vary, and is this affected by management?

How responsive are plants to varying seasonal and climatic conditions?

Examples of vegetation communities in which *Tetratheca junea* occurs (see Table 2)

Coastal Plains Smooth-barked Apple Woodland (Map Unit 30)

Coastal Plains Scribbly Gum Woodland (Map Unit 31)

4. Strategic land use planning issues

This section considers important issues for strategic conservation and development planning, and how *T. juncea* conservation requirements can be integrated in planning and development processes. It draws on the scientific knowledge of the species and seeks to integrate conservation planning issues with development planning requirements.

Important issues for long term planning are:

1. Identifying important *T. juncea* populations within Lake Macquarie LGA.
2. Identifying long term areas for potential conservation reserves.
3. Determining guidelines for what constitutes a significant impact.
4. Determining what loss of *T. juncea* population and habitat within Lake Macquarie LGA is acceptable.
5. Determining offset requirements for *T. juncea* and preferred offsetting arrangements and locations.

Approximately 2,500 ha and 24% of modeled suitable habitat within Lake Macquarie LGA is likely to be subject to identified development pressure to around 2050, and long term land use impacts are likely to arise for the species. Estimated annual loss of *T. juncea* habitat is probably approximately 10 – 25 ha per year in the LGA, meaning that over 50 years total loss is likely to be about 1,000 ha or around 40,000 plants. This is based on the strategic assessment of the extent of development foreshadowed in the relevant planning documents for the Lake Macquarie LGA and the Lower Hunter Region, including the Lake Macquarie Lifestyle 2030 Strategy and the Lower Hunter Regional Strategy (Appendix A). The strategic assessment shows that only around 16% of modelled habitat is within conservation reserves comprising an unknown population of plants. The assessment also notes that land use planning measures have the potential to substantially avoid future development impacts by avoiding urban development of important *T. juncea* populations and habitat.

Matters of importance for strategic planning are discussed below including species specific conservation issues, data and information issues, determining significant impacts arising from development, biodiversity offset issues, strategic planning objectives, and implementation mechanisms. These issues are discussed in more detail later in this section and provide a basis for strategic planning and development guidelines, including the determination of planning objectives.

4.1 Conservation issues

Future planning needs to make judgements about the preferred location and form of development, the adequacy of conservation of habitat and populations of species, and the security of land for conservation. Decisions are also needed to determine appropriate limits to the fragmentation of populations.

Section 3 has identified the scientific information available for decision-making. The data indicate that while *T. juncea* occurs in significant populations and will persist within the Lake Macquarie LGA over the medium to long-term, the known distribution of the species is very restricted and is subject to a consistent decline in population primarily as a result of clearing for development and associated fragmentation of habitat. Although rare and threatened at the state and national scales, there is currently an absence of specific conservation commitments or land use planning

objectives to ensure the retention of sustainable populations of *T. juncea* within the LGA.

Specific planning requirements for the conservation of the species are to identify:

- Conservation reserves and requirements.
- Important (or significant) populations.
- Connectivity requirements.
- Buffers around populations to mitigate impacts.

The Department of Environment and Climate Change (2009) applies the agreed national and state JANIS (Commonwealth of Australia 1997) targets for forested environments to the Lower Hunter as follows:

- A general principle of 15% reservation of the pre-1750 distribution of each forest ecosystem.
- Where forest ecosystems are recognised as vulnerable, then at least 60% of their remaining extent should be reserved (eg endangered ecological communities listed under the *TSC Act*).
- All remaining occurrences of rare (geographic range of <10,000 ha, total area of <1,000 ha in region or path sizes of generally <100 ha), endangered and vulnerable (approaching 70% reduction in area) forest ecosystems should be reserved or protected by other means as far as is practicable.

JANIS criteria also provide conservation guidelines for species as follows:

1 The reserve system should seek to maximise the area of high quality habitat for all known elements of biodiversity wherever practicable, but with particular reference to:

   - The special needs of rare, vulnerable or endangered species,
   - Special groups of organisms, for example species with complex habitat requirements, or migratory or mobile species,
   - Areas of high diversity, natural refugia for flora and fauna and centres of endemism and,
   - Those forest species whose distribution and habitat requirements are poorly correlated with forest ecosystems.

2 Reserves should be large enough to sustain the viability, quality, and integrity of populations.

The long term viability of *T. juncea* is dependent on the size and connectivity of populations. Therefore, minimum sizes of viable populations and minimum area requirements and conservation status cannot be reliably estimated. It is possible to produce map of planning sectors and conservation reserve priorities within the City (Map 4) based on major barriers to connectivity. Identifying these sectors and populations can be used to influence the extent of disturbance to land on which the populations occur. Suggested criteria for determining important populations are those with a patch size of over 50 ha, and/or containing a large number of plant clumps. Identifying these areas should be the subject of further investigation with preference given to identifying important areas for long term conservation land use (eg Environment Protection zones and proposed conservation reserves), populations connected by native vegetation to other

populations, and land already in secure land tenure (eg conservation reserve or Biobank site). Within these important populations, losses of clumps would be judged more significant than in other areas. The above criteria would not apply to the North Coast metapopulation where only a small number of records exist.

Currently, there is no reasonable knowledge of the total number of plants within the Lake Macquarie LGA, or whether these represent multiple populations, and how they are genetically related to the (assumed) North Coast metapopulation. While the modelled habitat area provides an estimate of the suitability of habitat, it is not certain that the species occurs over the full area of habitat identified as suitable, nor that it occurs at a consistent density.

Within Lake Macquarie LGA some areas of *T. juncea* habitat are highly fragmented and could be expected to lead to localised extinction in the long term, although much of the habitat is currently in large connected areas. Taking into account seed and pollen dispersal mechanisms the scientific workshop proposed that a 500 metre gap between populations may represent a distinct population. If this is the case, and that each population should be considered unique in the absence of genetic data that shows the contrary, then guidelines for planning and conservation can be proposed.

It is possible to provide interim precautionary guidelines for maintaining habitat connectivity or isolation criteria. A key issue here is the requirement to support populations of pollinators. *T.juncea* has been observed to be pollinated by sonnicating bees (Driscoll pers. comm. 2012). Little information exists about native bee flight distances, but it is likely that maximum flight distance would be around 300 – 500 metres (Payne pers. comm. 2012).

It has been suggested that native bees:

- travel these distances only through suitable habitat,
- could not travel more than 100 metres through hostile habitat, and
- on a regular basis tend to travel much shorter distances.

(Driscoll pers. comm. 2012).

Priority areas for conservation should be areas containing large populations and/or high clump density. Critical habitat sizes relate most importantly to connectivity and management requirements, and it is probable that areas of less than 5 – 10 ha of native vegetation enclosed by urban areas cannot be ecologically viable and maintain ecosystem functioning in their pre-development state into the long term. At a micro level, threatened plant species may be able to be retained in situ for lengthy periods in an urban context on sites as small as 1,000 square metres, but long-term persistence is likely to require active management and a change in ecosystem function is reasonable to expect. A minimum buffer area of 20 metres around populations is reasonable to reduce adverse impacts from adjoining development or land use. It is noted that the *EPBC Act* Guidelines (SEWPaC 2011) require a 30 metre buffer and given that these guidelines are dealing with significant populations the larger buffer further reduces the risk of adverse impacts from development proposals. Buffers with a width of 20 metres have been applied (as outlined by Payne 2000) and found to be reasonably effective in protecting the plant and its habitat. Buffers less than 20 metres have not proved successful.

It is also important to note the need to review the knowledge of the species over time, particularly in view of the potential for climate change to influence the distribution or persistence of the species in the future.

4.2 Survey requirements and data issues

Appropriate information for decision-making is important and requires consistent survey methods, especially plant counting. The number of *T. juncea* records and information about the species has increased substantially since the preparation of the Lake Macquarie *T. juncea* Conservation Management Plan (Payne 2000). This has been assisted by the introduction of a consistent field survey methodology giving more comparable data and reliable survey results.

The Lake Macquarie Flora and Fauna Survey Guidelines (LMCC 2013) refer to requirements for *T. juncea* field surveys as outlined in Appendix C and provide that surveys are to be undertaken during the peak flowering period from mid September to mid October.

If detected, surveys are to:

- Quantify the extent of population and proportion impacted by a proposal.
- Assess and map plant clumps within 500 m of the population to address connectivity (eg conservation requirements for stepping stone vegetation).
- Identify whether the population is a large population and its conservation importance.
- Determine if the population sets viable seed.

Currently, the method of estimating the populations of *T. juncea* in most field ecological surveys is based on Payne (2000 & 2002) and has provided a consistent and robust field survey method. The current rule counts every stem within 30 cm as one clump. Ecological surveys have used this method for over a decade, and it forms the current basis for population estimates. However, it does not take into account the genetic characteristics and variability of the plant and recent improvement in knowledge which suggests that the present methods are probably undercounting the number of individual plants present.

Genetic research by Jones (2011) suggests that the field survey method may not be adequate for determining individual genetically distinct plants and there remains uncertainty about what a clump is, particularly where there is a high density of records. In some cases it may be one clonal plant, or alternatively it might be a group of genetically distinct plants in one place, or both. This means that the conservation importance of clumps may vary from place to place. Further genetic research may clarify genetic variability and as a result the survey methodology may need review in the future.

There are also other survey methods that have been used in the past, including clump count, clumps per polygon and area searched, GPS tracks, belt transect method, habitat modelling, and extrapolation for large sites. The 2011 scientific workshop agreed that the Payne (2000 & 2002) method is reliable and provides consistent results, and there is no reason to change the standard method unless further genetic work demonstrates that it provides unreliable population estimates. The Commonwealth referral guidelines (SEWPaC 2011) recognise the Payne (2002) method with minor modification for sites with an area of 30 hectares or more. This approach is consistent with the Lake Macquarie Flora and Fauna Survey Guidelines (LMCC 2013).

Scientific workshops reviewing *T. juncea* agreed that a common method should apply to surveys used in decision-making by all levels of government. This will include identification of *T. juncea* habitat, transects, clumps, area of occupation and density estimates. It is generally agreed that while there may be a case for refining the counting method for ecological surveys in the future, the data provided by current methods is adequate for informing planning and management and there appear to be no benefits of changing survey methods at this time.

Habitat suitability modelling (Driscoll 2009, 2013) provides an estimate of the extent of suitable habitat and provides a basis for strategic impact assessment and long term planning. While the modelling is of reasonable accuracy at the regional scale, it has significant limits and is not intended to be applied at the site scale. Over time, updating the model would be appropriate as records increase. It may be desirable for consistent survey of potential *T. juncea* in Lake Macquarie LGA to determine species presence, absence, including more detailed survey in potential development areas to determine population size.

Lake Macquarie City Council maintains a GIS database of *T. juncea* records used for a variety of purposes including assessing the impacts of development proposals. Records are generated as a result of flora and fauna surveys, including those required to accompany development proposals. A standardised digital format for submitting *T. juncea* records could be included in Council's database in the future to facilitate more effective data management.

4.3 Determining significant impacts

Determining significance of impacts in development assessment is important for meeting requirements under NSW and Commonwealth legislation. In making land use decisions and approving activities affecting *T. juncea*, there are specific legislative requirements to assess the significance of impacts. The criteria for assessing significance differ between the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and the NSW *Threatened Species Conservation Act 1995.*

Driscoll (2009) reviewed issues for the assessment of significance of impacts on *T. juncea* that apply in relation to the NSW *Environmental Planning and Assessment Act 1979* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*

For the purposes of Section 5A of the *Environmental Planning and Assessment Act 1979* important matters to determine are the extent of a local population, what constitutes a viable population, and the extent of habitat fragmentation. Guidelines for threatened species assessments under NSW threatened species legislation (DECC 2007) focus on local impacts. Driscoll (2009) suggests that a local *T. juncea* population could include many sub-populations extending over distances extending to kilometres and extending beyond a site. However, in the absence of data defining a local population any sub-population could be considered to be a local population. A key issue in assessing habitat fragmentation is the extent of impact on pollen transfer and whether one population is divided into separate populations.

The Commonwealth legislation has different requirements for assessing significance and requires a development proponent to determine if a proposal has or is likely to have a significant impact on a listed threatened species. In making the assessment consideration must be given to impacts on habitat critical to the survival of a species and whether there will be adverse effects on an important population.

The *Environment Protection and Biodiversity Conservation Act 1999* referral guidelines for the vulnerable Black-eyed Susan *T. juncea* (SEWPaC 2011) provide guidance for assessing impacts under Commonwealth legislation and were developed following a scientific workshop. This states that an important population has been generally determined to be a population with greater than 1,000 plant clumps, an area of habitat with an average estimated plant clump density of 20 clumps/hectare or greater, or occurring in rare habitat and at or near the distribution limits of the species (SEWPaC 2011).

Locally specific guidelines could assist in the determination of significance of development proposals and are proposed in later sections of this document. This also relates to the important strategic planning issue of determining what loss of population and/or area of *T. juncea* habitat is acceptable.

4.4 Biodiversity offset requirements

Where impacts cannot be avoided, minimised or mitigated, offset measures can be considered in supporting the persistence of the species.

There is no generally accepted or required method for calculating the type, size or extent of biodiversity offsets. As a planning tool, offsets are usually negotiated on a case by case basis. The NSW Government Biobanking Assessment Methodology is used to support the Biobanking scheme and the establishment of Biobank sites, and the creation, transfer and retirement of credits. This methodology may be used to assess biodiversity impacts and offsetting requirements for development proposals in development approval processes.

The Biobanking Assessment Methodology has limitations when applied to the calculation of offsets for plants that reproduce clonally such as *T. juncea* because:

1. Counting stems or clumps cannot differentiate plants and no accurate indication of separate plants can be derived to provide a reasonable basis for calculating offsets, and
2. The number of plants is unlikely to be increased by management actions as assumed in the methodology.

Preliminary advice from the NSW Office of Environment and Heritage indicates that the Biobanking Assessment Methodology tool can be adjusted to improve its usability when applied to clonal species such as *T. juncea* and requires changing the species characteristics database used to operate the tool. Actions to review the approach of the methodology should be pursued if it is to be applied in calculating *T. juncea* offsets. An alternative system using replacement ratios for loss and assessing the benefits of identified offset actions may also be appropriate and would be simpler to apply.

For *T. juncea* it is important for offsets which improve the extent of land protected as conservation reserve in secure land tenure.

4.5 Strategic planning approach

Landscape scale and longer term strategic planning objectives and guidelines can be proposed as a result of improved knowledge about the species. Such an approach can address the key issue of cumulative loss of population and increasing fragmentation of habitat.

The approach should take into account land use and settlement characteristics across the distribution of suitable habitat. The Lake Macquarie *T. juncea* Conservation Management Plan (Payne 2000) included recommendations to conserve the species across its range within the City and identified conservation objectives for each of four quadrant areas across the City. While this approach is still broadly appropriate, with more recent species information it is possible to identify long term planning issues for separate planning sectors of the LGA as shown in Table 5. Planning and conservation objectives can be developed for each sector in the future to integrate with strategic plans.

While Section 4.1 the Lower Hunter Regional Conservation Plan (Department of Environment and Climate Change 2009) applies agreed national and state targets for ecosystems, the applicability of this approach to individual species is not clear. Sections 6 and 7 propose LGA-wide strategic planning objectives for *T. juncea* based on the approach of conserving the species across its range (including within each planning sector identified in Map 4 and Table 5). This approach to future planning will apply unless further investigations, including genetic work addressing the information gaps identified in these guidelines, demonstrates that it is not appropriate or necessary.

Table 5: *T. juncea* planning issues for planning sectors in Lake Macquarie LGA

Sector	**Characteristics** (land use and population issues)	**Conservation issues** (acceptable loss, conservation reserves, & offsetting)	**Planning comments**
1. Coastal North-east (Glenrock to Belmont)	Areas of habitat in conservation reserves and Crown land and Council reserves. Some urban development pressure.	Proposed Lake Macquarie Coastal Wetlands Park would protect some habitat in this sector.	Maintaining connectivity between this sector and Central North-east sector is important. Securing long term conservation reserve boundaries is important to facilitate management.
2. Central North-east (Green Point to Garden Suburb)	Highly fragmented habitat, with long term development impacts and expectations. Small area of habitat conserved. This sector is likely to be important for survival of populations to the north of the City in Newcastle LGA.	Relatively small known population. Protection of connecting habitat is essential. Management issues affect habitat.	Maintaining connectivity between this sector and Coastal North-east sector is desirable. Maintaining habitat connectivity to the north in Newcastle LGA is important.
3. Central North–west (Homesville to Minmi)	Extensive urban development pressure and committed development. No areas secured for conservation, although some offset areas proposed. This sector is likely to be important for survival of populations to the north of the City in Newcastle LGA.	Small offset areas possible, but few opportunities for large scale long term habitat conservation.	Population losses in this sector are inevitable. Long term conservation will be subject to intensive management of small areas dedicated to Council through development. Maintaining connectivity between patches of habitat within this sector and to habitat to the north in Newcastle LGA is important.

Sector	Characteristics (land use and population issues)	Conservation issues (acceptable loss, conservation reserves, & offsetting)	Planning comments
4. North-west	Extensive areas of habitat conserved in reserves, or within State Forests. Low development pressure. Relatively low fragmentation, and few population surveys.	Most habitat is unlikely to be developed in the medium term. Good opportunities for reserve extensions and protection in offset areas.	Habitat is relatively well conserved, with low development pressure. Would benefit from extended conservation reserves.
5. Westlakes	Small areas of conservation reserve. Largest populations and area of modelled habitat occurs in this sector. Long term development pressure possible. Contains extensive coal mining. Relatively low fragmentation.	Subject to ongoing development pressure and mining impacts. Proposed Awaba Conservation Reserve is in this sector. Habitat should not be further reduced until conservation reserve in this area is secured. Suitable location for offsets.	Most important sector for future long term persistence of *T. juncea* in Lake Macquarie LGA. High priority for planning and conservation reserve.
6. Morisset	Extensive populations known and well connected habitat. Identified as an emerging major centre for development with long term urban growth expected.	Contains areas known to support extensive and dense populations. Potential for conservation reserve. Important to maintain habitat connectivity. Offsets should be used to achieve adequate conservation after avoid and mitigate measures are applied.	Morisset Structure Plan took into account habitat requirements for *T. juncea* and a local study was undertaken (Driscoll & Bell 2008). A sector-wide offset plan is desirable. High priority for investigation of conservation options and reserve establishment.
7. South west	Fragmented modelled habitat, well connected with native vegetation. Few surveys undertaken in area. Important connectivity value. No habitat in conservation reserves.	No conservation reserves. A lower priority for reserves is identified for this sector relative to the other sectors due to dispersed habitat and reduced threat. Important to maintain habitat connectivity to vegetated areas to the south.	More investigations of *T. juncea* habitat in this area are desirable. Due to low medium term development pressure, this is of low priority.
8. South (Wyee & Wyee Point)	Small areas of fragmented habitat with few population surveys. Little development pressure anticipated as affected by power station. Important for connectivity to populations to south.	Maintain habitat connectivity to vegetated areas north and south.	Habitat adjoins Wyong LGA. Potential development needs to take into account connectivity requirements.
9. Coastal South-east (Wallarah)	Extensive areas committed for development plus offsets creating conservation reserves. Habitat mostly connected within sector.	Some extension of conservation areas is important to conserve as large a population as possible. Isolated *T. juncea* population should be linked to habitat to south. Includes part of the proposed Lake Macquarie Coastal Wetlands Park.	Key land use decisions have been made. Important issues are extended conservation areas and active management of reserves. Adjoining habitat is within Wyong LGA.

Note: Refer to planning sectors identified on Map 4.

4.6 Implementation mechanisms

Many mechanisms for planning implementation are available through the land use planning framework including incorporating objectives in plans and policies, land zoning, biodiversity offsets, acquisition of conservation reserves, recovery plans, legal conservation/planning agreements, development assessment requirements, and land management frameworks.

Section 6 proposes LGA wide objectives for strategic land use planning and management, and section 7 outlines specific guidelines for implementing the strategic planning objectives. Where a planning proposal is made, the planning sectors in Table 5 should be used to determine the context for the proposal and facilitates the development of sector specific planning objectives where appropriate.

A legislative framework for management of most public land applies, and provides a mechanism for enabling integration of the management guidelines in Section 7 into land management practice.

5. Scientific research priorities

Although the characteristics of *T. juncea* are now much better understood than a decade ago, details of its biology and ecology remain to be studied and documented. As discussed, there are particular research priorities that would assist future planning and management practice.

In particular, factors determining the very limited geographic distribution of *T. juncea* are unknown, no data is available on the genetic variability across populations, and further field survey work on the northern metapopulation is desirable to determine the extent of this population.

Driscoll (2009) identifies the major gap as genetic information which can provide insight into how far pollen is transferred, the clonal makeup of a group, and the local population structure. Further research is also needed to determine reproductive characteristics including seed dispersal vectors, seed longevity in the soil, microhabitat requirements, and flower opening sequence.

The following scientific research priorities are proposed to support planning and management for the species:

1. **Genetic characteristics and variability across populations**

Probably the most important priority is to determine the extent of genetic variability of *T. juncea* across the full range of the species, and whether further research confirms the results of the preliminary site specific genetic study by Jones (2011). Subsequently, research to provide a more comprehensive understanding of the genetic characteristics within important populations likely to be affected by future development could be undertaken.

The importance of undertaking such genetic research is that it would inform judgements needed to determine what constitutes a *T. juncea* population and to assess the significance of projected impacts on the species. It would also provide information on species conservation including evidence necessary to determine the consequences of fragmenting populations, habitat connectivity requirements and effectiveness of pollination.

Importantly, an understanding of genetic variability across the full range of the species and within populations would over time enable review of the current clump counting method to more accurately estimate the number of individual plants observed. This has particular implications for biodiversity offsetting, determining important populations for conservation and for land management practice.

Achieving the most value from any new genetic data to come from further study of *T. juncea* will require a comparison with other *Tetratheca* species, preferably one other clonal species and a non-clonal species. Such data would not only help identify the limits of populations in the LGA but could also identify populations or sub-populations that may contain a disproportionate amount of the total genetic variability of this species and thus flag them as being an important population warranting higher conservation significance. Similar work has been done on a *Tetratheca* species elsewhere (Butcher et al. 2009).

2. Environmental characteristics determining distribution

It may be that critical soil characteristics affect the distribution of *T. juncea*. Further scientific research is warranted to determine what is the key ingredient that makes *T. juncea* grow where it grows and this may include organic and inorganic micro-nutrients.

This may be related to the question of how the density of populations varies across the species range and may inform understanding of how *T. juncea* may respond to climate change, and the relative importance of development impacts.

3. North Coast metapopulation distribution and abundance

Little is known about the North Coast metapopulation, and there is also doubt about the actual characteristics of this population. Plant occurrence in the modelled potential distribution of this metapopulation is not known, given that much potential habitat has not been subject to field survey and there are only about 60 known records in this metapopulation.

More targeted field survey is required to determine whether it occurs in the modelled habitat, the associated vegetation communities, and the density at which it occurs. Important questions to resolve are whether the species is genetically distinct in this area and whether different management is required, particularly where it is growing with a different suite of plants.

In conjunction with the scientific research priorities outlined above and additional records of the species it would be appropriate to update habitat suitability modelling. The research applies to the whole species range not just the Lake Macquarie LGA even though most of the known records occur within the Lake Macquarie LGA.

6. Planning strategy

This section outlines the proposed strategy for planning and managing *T. juncea* within Lake Macquarie LGA. It provides information to be incorporated within or used in updates of current planning documents, including Lower Hunter Regional Strategy, Lake Macquarie Lifestyle 2030 Strategy, Lake Macquarie Development Control Plan No. 1, and local environmental studies to support draft local environmental plan proposals.

The species is relatively abundant and so widely dispersed in Lake Macquarie LGA that there will be inevitable loss of populations as a result of development and human impacts. The proposals below outline conservation objectives for *T. juncea*, losses of population that are (and are not) acceptable, and measures that should be applied in future planning and management. Detailed guidelines for implementing the strategy are outlined in Section 7.

The objectives in Table 6 should apply to planning and managing *T. juncea*.

T.junea in flower

Table 6: Planning and management objectives for *T. juncea*

Strategic planning
Retain a viable population of the species within the City within each planning sector in the long term (100+ years) across its full geographic range.
Identify important populations where no loss of population is acceptable, and determine the extent of acceptable loss in other areas.
Apply consistent field survey methods across the City and by all levels of government.
Improve the conservation status within the City by identifying potential areas for reserves (eg Crown land and land meeting suitable criteria) within each planning sector, and protect at least 20% of the modelled habitat and at least 20% of known plant populations in secure conservation reserves (eg national parks, nature reserves, Council reserves or Biobank sites). (Note that currently about 1,754 ha or 11% of modelled extant habitat within the Lake Macquarie LGA is within a conservation reserve, and that the LGA contains only 75% of modelled habitat for the species).
Ensure at least 30% of the area of modelled habitat in Lake Macquarie LGA is zoned for conservation under relevant planning instruments (eg E1 or E2) in the long term (currently about 2,400 ha or 16% is zoned for conservation).
Ensure that conservation reserves and land zoned for conservation occurs in a spatial configuration that supports conservation of the species across its range.
Incorporate objectives and measures to protect *T. juncea* and other threatened species in relevant Council strategic planning and management documents.
Development assessment and management
Assessment and determination of development proposals within Lake Macquarie LGA affecting *T. juncea* populations or potential habitat will have regard to the planning and management guidelines (specifically Table 7).
Any loss of plants or plant clumps of *T. juncea* from development or other actions is to be offset with suitable measures as specified in the guidelines, except for minor developments.
Any activity potentially impacting on *T. juncea* plants, subpopulations or populations will trigger an assessment under these guidelines.
Prepare management plans (or include in existing management plans) for Council owned and managed land to identify and manage *T. juncea* populations appropriately .
Scientific research
Support scientific research to inform planning and management with priorities as outlined in Section 5.
Ensure offset areas are appropriately managed and monitored.

Note: Area calculations used are based on land use in Lake Macquarie Local Environmental Plan 2004. Guidelines for applying these objectives are included in Section 7.

The objectives outlined in Table 6 should be considered for incorporation in planning provisions such as strategic planning or zone objectives, and in consequential plan provisions and associated maps and may include the planning maps prepared for the strategic assessment (Appendix B).

7. Planning and management guidelines

This section provides guidelines for considering *T. juncea* conservation requirements in future land use planning and management processes. These planning and management guidelines are intended to be included in policy documents such as the Biodiversity Planning Policy and Guidelines for LEP Rezoning Proposals, and Lake Macquarie Development Control Plan No. 1. These should also be considered in the review of the Lower Hunter Regional Strategy and proposed Commonwealth strategic assessment under the *Environment Protection and Biodiversity Conservation Act 1999.*

Guidelines for planning and management are outlined in the tables below. These differentiate between guidelines for planning land use and assessing development proposals (Table 7), and guidelines for the ongoing management of land (Table 8).

These guidelines are specific to Lake Macquarie LGA, and are intended to be included in future updates to policy documents. They will primarily be relevant where changes to land zoning are proposed.

Applying the proposed objectives and guidelines will require additional investigations to be undertaken as strategic planning progresses, with specific regard to requirements and opportunities for conservation reserves and balancing land use priorities.

The guidelines will also be relevant to consider in reviews of NSW Government policy and practice including the threatened species guidelines and actions, statutory approval requirements and methodologies, and management processes.

Table 7: Planning guidelines for *T. juncea*

Planning issue	Guideline
Landscape scale planning for *T. juncea*	For the purposes of these guidelines the landscape planning scale for *T. juncea* in the Lake Macquarie LGA is taken to be the full geographic extent of the Central Coast metapopulation. Only about 25% of modelled habitat is outside the LGA.
Site scale planning for *T. juncea*	Site scale planning should take into account the full extent of the land allotment, plus connected native vegetation within 500m of the boundaries of the land.
Survey guidelines	Field surveys should be undertaken between mid September and mid October. All clumps are to be identified and spatially documented as outlined in Appendix D. Surveys undertaken outside the preferred period are likely to contain inherent inaccuracies. There will be a need to determine the reliability of results and an adjustment factor may be required. Surveys undertaken outside the flowering period may not be accepted. Surveys should identify possible or potential barriers to pollination and transfer of genetic material between populations for local populations, and include observations of fruit set and any flower colour variation. Reporting is to include a summary of weather and rainfall records for the nearest Bureau of Meteorology weather station for the 3 months prior to the survey. Genetic studies may be required for isolated or disjunct populations or where distinctive plant characteristics are observed, and importance needs to be identified.

Planning issue	Guideline
Local population	A local population of *T. juncea* comprises the plants (plant clumps) on a site, plus the plants (plant clumps) on adjoining connected native vegetation. A 500m gap is assumed to represent a distinct local population, taking into account seed and pollen dispersal. In the absence of genetic data, the characteristics of each population are assumed to be unique. For the purposes of determining significance of impacts for Section 5A of the *EP&A Act* a local population includes a sub-population as defined in the EPBC Act referral guidelines (DSEWPaC 2011) and the glossary herein.
Viable population	*T. juncea* plants (plant clumps) occurring on a site and forming all or part of a local population are assumed to be a viable population in the absence of adequate genetic information that shows this is not the case.
Important population	Measures should be taken to conserve important populations in the long term. For planning purposes an important population is one in an area of land which includes suitable *T. juncea* habitat and: 1. comprises an area of over 50 ha of native vegetation and/or 2. contains more than 1,500 *T. juncea* stems or plants (or 1000 plant clumps) and/or 3. is connected by native vegetation to other *T. juncea* populations, or 4. is in a secure conservation land tenure (eg conservation reserve), or comprises 25% or more of known plants or plant clumps in a planning sector as shown on Map 4. Conservation requirements for each sector may be identified in the future. *Note: The EPBC Act referral guidelines (SEWPaC 2011) map important habitat, which is in addition to modelled suitable habitat and takes into account habitat connectivity. This should be considered when determining planning and development and requirements for conservation of important populations.*
Conservation reserve requirements	*T. juncea* habitat currently protected in conservation reserves is not adequate to either protect viable populations or to conserve the species over its geographic range. Additional conservation reserves in public ownership or with legal security are required. Priority locations for investigation of conservation reserves are shown on Map 4 and could be considered for listing as critical habitat under relevant threatened species legislation. Minimum conservation reserve size to adequately protect *T. juncea* in the long term should be 10 ha of suitable habitat. Protection of smaller sites may assist conservation of plants in the short term but is likely to require active and costly management. If the reserve forms an important native vegetation corridor, these requirements may not apply. Suitable land tenures for conservation reserves are all lands reserved under the *National Parks and Wildlife Act 1974* and Biobank sites established under the *Threatened Species Conservation Act 1995.*
Determining the significance of development impacts *(TSC Act)* *Note: Assessing whether a significant impact may occur affects whether a species impact statement (SIS) is required*	For the purposes of administering the *NSW Threatened Species Conservation Act 1995*, a significant impact on *T. juncea* includes an impact which: 1. removes 25% or more of the total number of plants or plant clumps on a site or total connected population (where the number of plants and/or clumps on a site or in the population is more than 500, and/or covers an area of more than 5 ha), and/or 2. affects a population which is isolated or at the edge of the species geographic distribution, or where plants exhibit unique and distinct characteristics, or 3. affects plants with other biological or ecological characteristics (eg connectivity or local variation) which require special consideration. Smaller populations may have a significant impact, but this is requires a merit assessment. Removal of less than 20 clumps will not normally be a significant impact provided a thorough search has been undertaken, no other plants are within 500 metres, and the site is not at the edge of the species geographic distribution. *Note:* *1. These estimates are more applicable to a sexually reproducing population than a clonal one. The priority for protecting the species is for the retention of genetically diverse, sexually reproducing individuals rather than clonal stems, but differentiating between these is not possible until further research is undertaken.* *2. The 25% of the total number of plants or plant clumps requires this proportion of the subpopulation to be in a core area surrounded by a 20 metre buffer. Plants or plant clumps within a 20 metre buffer are counted as being impacted by the works or development proposal.* *3. Determination of significance requires consideration of what constitutes a local population.*

Planning issue	Guideline
Determining the significance of the impacts of an action *(EPBC Act)*	For the purposes of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* guidelines for determining significant impacts on *T. juncea* are outlined in EPBC Act referral guidelines (SEWPaC 2011). http://www.environment.gov.au/epbc/publications/black-eyed-susan.html
Habitat connectivity	Plant populations are assumed to be biologically connected if they are separated by a distance of less than 500 metres. This distance is based on maximum flight distance of pollinators and it is important to maintain pollinator populations especially where habitat is connected by non-continuous (stepping stone) vegetation. Provide stepping stones of suitable native vegetation between populations 300 to 500 metre distances to facilitate pollen transfer (this is to sustain pollinators). Loss of stepping stone vegetation is not acceptable without prior field survey. Important habitat areas are mapped in the EPBC Act referral guidelines (SEWPaC 2011) and take into account habitat connectivity requirements. These areas should be considered in reviewing connectivity.
Buffer areas around *T. juncea* habitat	A minimum buffer distance of 20 metres of native vegetation is required to protect plants from the impacts of adjacent land uses, developments or activities. Exact buffer distances require determination of what values need to be protected and must consider ecosystem requirements and take into account bush fire asset protection zones. Larger buffers uphill from a population will generally be required. *Note: The EPBC Act referral guidelines (SEWPaC 2011) refer to 30m buffers from an important population.*
Applicable conservation standard	The standard for *T. juncea* conservation within Lake Macquarie LGA is to conserve important populations of the species and to retain a viable population in the long term (100+ years) within each of the planning sectors identified in Map 4.
Acceptable loss of plants and populations	For important populations - No loss of plants, populations or suitable habitat is acceptable within important populations. For other populations - Where loss of plants cannot be avoided on a site, no more than 25% of the population is to be lost (75% retained on site), unless a strategic area wide assessment has been undertaken and an area based plan prepared which includes suitable provision of biodiversity offsets to compensate for the loss. Loss of a small number of plants associated with the development of single dwellings and associated bushfire asset protection zones will normally be considered acceptable on existing lots.
Biodiversity offset requirements	Offset for site development will normally include: 1. 75% retention of clumps on site, or 2. strategic area wide assessment, with agreed outcomes in a planning agreement, supported by relevant planning documents (eg DCP & management plan) Where there is no alternative to the loss of *T. juncea* plants a suitable biodiversity offset is to be provided and may be offsite. Suitable offsets are: 1. replacement ratio of 5:1 for loss of area of known habitat or modelled habitat, or 2. replacement ratio of between 3:1and 5:1 for plant clumps lost. Where a significant impact is determined, replacement ratios applying under the NSW Biobanking Assessment Methodology will be applied, with some recent development approvals having higher replacement ratios than those indicated above, and in the range between 4 to 7:1. Offsets may include acquisition of offset land in an area identified as a priority for reservation (eg purchase and dedication with management plan, Biobanking agreement, or equivalent) or similar arrangements. It is preferred that offsets be located within the planning sector in which the loss is to occur (Map 4 and Table 5). Offset areas need to be well connected to other patches of native vegetation. *Note: Any offset needs to be retained and managed for conservation in perpetuity. Legal mechanisms need to ensure secure tenure and implementation of management measures.*
Criteria for planning from 2030+	Over time a transition from an acceptable loss standard to a no net loss of *T. juncea* population planning and conservation standard is required. Criteria for biodiversity planning should be developed to evaluate long term strategic planning and development options.

Land management practices affect *T. juncea* and Table 8 provides guidance in relation to how to manage land to maintain *T. juncea* populations. Management actions depend on the location of the land, the extent to which a site needs to be actively managed, and whether land has known *T. juncea* populations or simply contains suitable habitat.

Management should have regard to the planning objectives outlined in Section 6. Where land use plans identify that natural bushland and ecological systems are to be retained (eg conservation zonings) land management should have an objective to retain bushland in a natural condition and to actively manage the land to support the retention of important ecological values and processes, such as *T. juncea* populations. Where land use plans have not been finalised or development has not been approved, then existing ecological values must be retained and maintained.

Matters that need to be considered when managing land include:

- Relevant land use plans, or restrictions on development.
- Development consent conditions or requirements (eg protection of habitat or rehabilitation of land).
- Bush fire asset protection requirements.
- Bushfire regimes (fire frequency and intensity) required to maintain the species.
- Management plans applying to the land such as vegetation management plans, rehabilitation plans or plans of management for public land.
- Legislative provisions that may restrict vegetation clearing or use of the land or impose management obligations (eg noxious weed control).
- The nature and impact of adjoining land uses or activities.
- Legal restrictions on land such as easements or covenants.
- Pest and disease management.

Land management is an important consideration later in the process of development after plans have been determined, and is especially important at the construction stage. Management issues should be taken into account in planning and development approval. Specific guidelines for management actions which may affect *T. juncea* are outlined in Table 8. These guidelines are important to consider when determining planning and development consent requirements. Many of these actions are consistent with guidelines for managing other threatened plant species and should form part of integrated management programs.

Table 8: Management guidelines for *T. juncea*

Management action	Guideline
Preparing a management plan Public lands normally require preparation of management plans meeting legislative requirements. Private land may also require the preparation of a management plan in connection with an offset arrangement, development consent condition, or other agreement.	Where management plans applying to *T. juncea* habitat are being prepared, these plans should refer to the *T. juncea* planning and management guidelines. Refer to Lake Macquarie City Council guidelines for the preparation of vegetation management plans (Lake Macquarie City Council 2013). Survey and map the *T. juncea* population using the survey method outlined in the guidelines and include a map (in both hardcopy and digital form) showing known *T. juncea* habitat in the plan and site specific management guidelines if appropriate. Council is to maintain a spatial layer showing accurate distribution of mapped *T. juncea* clumps across the LGA. This is to be able to be linked with plans of management.
Protecting assets from bushfires *T. juncea* plants are relatively resilient to bushfires and resprout after fire. However, the frequency and intensity of fire affects its habitat and its pollinators. Bush fire may also contribute to the establishment and dispersal of weeds. Bush fire hazard reduction and asset protection activities also have the potential to adversely affect *T. juncea* through disturbance to plants, including clearing and track construction.	For impact assessment purposes, bushfire asset protection zones are regarded as a loss of vegetation and *T. juncea* habitat and do not form part of any buffer. Where *T. juncea* occurs in bushfire asset protection zones, this habitat may need periodic slashing to reduce hazards rather than removal of vegetation. Disturbance to soil and vegetation at ground level is to be avoided. Appropriate buffers are required outside bushfire asset protection zones to protect important *T. juncea* populations from adverse impacts.
Responding to bushfires Maintaining *T. juncea* habitat relates to the ecology of the vegetation communities in which it occurs and requires periodic fire.	Management of *T. juncea* should be considered together with the requirements of other threatened species occurring concurrently. Fire frequency should not be shorter than the time taken for plants (from resprouts and seed germination) to develop to reproductive maturity, and go through one or more reproductive cycles to replenish the seed bank. Maintaining *T. juncea* habitat requires periodic fire, and periodic fire with an interval of between 7 and 30 years is probably desirable (note the *EPBC Act* Guideline suggests an 8 year frequency). The absence of fire for long periods (over 30 to 50 years) is probably undesirable. Guidelines for fire frequency for *T. juncea* should be incorporated in the Lake Macquarie Bush Fire Risk Management Plan.
Controlling weeds No specific weed threats to *T. juncea* have been identified to date. However, over the long term weeds have the capacity to transform native vegetation, usually in combination with disturbance and changes to natural soil and water processes.	Weeds within *T. juncea* habitat are to be adequately controlled to prevent significant environmental changes and impacts on *T. juncea* plants. Where necessary weed control activities are undertaken, these shall avoid adverse impacts on non-weed species, including by not undertaking broad scale spraying or clearing ground vegetation. Significant weed impacts are associated with backyard disposal of rubbish and stormwater disposal, and where urban development occurs uphill of a *T. juncea* population, measures are to be taken to prevent or minimise impacts from these sources.
Maintaining access roads & tracks Roads and tracks are associated with soil disturbance and changes to surface and groundwater flows. Ongoing usage and periodic maintenance can contribute to the introduction of weeds or pathogens which may be harmful to natural ecosystems.	Limit road and track usage and carefully locate the construction of any new tracks to minimise impacts. Direct road drainage away from known areas of *T. juncea*. Road and track maintenance should be undertaken during dry weather, and preferably during the flowering time to enable plants to be identified and therefore disturbance can be avoided. Rubbish dumping and firewood collection are often associated with tracks and adversely affect *T. juncea* habitat.
Maintaining electricity & water easements *T. juncea* populations occur in water and electricity easements subject to vegetation clearing and periodic maintenance. Plants are therefore potentially subject to regular adverse impacts. *T. juncea* is known to persist in easements subject to regular slashing.	Clear guidelines for maintaining easements are required, including survey and monitoring of *T. juncea* populations. No broad scale spraying of herbicide is to be undertaken. Acceptable options for weeds or vegetation control within *T. juncea* habitat are slashing or targeted spraying of Eucalypts. Surveys of potential *T. juncea* habitat shall be undertaken prior to any works, preferably during the flowering period in Spring months. Periodic monitoring of populations to review impacts should be at maximum 5 year intervals.

Management action	Guideline
Vegetation clearing & maintaining habitat connectivity Vegetation clearing for purposes of development, fencing, grazing and bush fire asset protection is probably the most significant management issue affecting *T. juncea*.	Habitat clearing should only be undertaken following appropriate environmental assessment and in conjunction with an approved or permissible development or associated activity and in accordance with necessary approvals and guidelines. Assessment of clearing impacts must take into account the connectivity of native vegetation. Pollination and seed dispersal mechanisms are influenced by the connectivity of native vegetation which is important for long term population viability.
Grazing or slashing vegetation Slashing or thinning of above ground vegetation for land management purposes may adversely affect *T. juncea*.	*T. juncea* is able to cope with slashing. The height of slashing does not appear to be important. However, too frequent slashing may be a problem for the persistence of plants. Grazing has similar impacts to mechanical slashing. For regular maintenance works, it is preferable not to clear or slash *T. juncea* when it is flowering or seeding from September to November. Slashing also has the potential to spread weed seeds.
Excavating or disturbing soil Soil disturbance and changes to surface and groundwater flows have potential to impact on *T. juncea* as well as its habitat. Stormwater discharges can result in a change to the vegetation structure and facilitate weed invasion.	Excavation or soil disturbance in the vicinity (ie within 20 metres) of *T. juncea* clumps should be avoided. Urban development uphill of a *T. juncea* population (especially fertilisers and nutrients) should be avoided where possible, and where this occurs measures should be taken to ensure no adverse impacts to *T. juncea* or its habitat by incorporating native vegetation buffers of adequate width. Dispersal of *T. juncea* seed by ants is probably in the order of tens of metres, and soil disturbance may affect seed dispersal. Similarly, disturbance may introduce soil pathogens.
Monitoring *T. juncea* populations & habitat Ongoing population monitoring is essential for effective management.	Monitoring is an important management tool for reviewing the ongoing impact of management activities, and for adapting to changes over time. It should be specified in management plans and is important for prioritising management activities. Monitoring of *T. juncea* clumps and distribution is essential, but associated environmental conditions such as habitat for pollinators, bush fires, or pollinator populations may also need to be monitored to provide useful information. Site specific management plans should include provision for monitoring sufficient to determine changes in *T. juncea* populations or in the distribution of clumps on a site.
Propagating & translocating *T. juncea* In most circumstances, propagation and translocation are not supported.	Potential active species protection measures are translocation of mature clumps. seed germination, or propagation from cuttings (Driscoll 2009). Translocation is at an experimental stage, with an average plant survival rate of 27% after 5 years at Gwandalan within a local population. Mycorrhizal associations are also not known. Translocation is a last resort measure, and is not regarded as an impact mitigation or offset measure. However, it may be appropriate for rehabilitation of degraded land and may provide an opportunity for research. Refer to translocation guidelines in Vallee et al. (2004). Translocation needs to occur close to the source and minimise handling of the plants – shifting whole plant clumps (including soil) and putting them straight in the ground is preferred. Where these measures are attempted, guidelines for watering and handling of plants is needed, and for the prevention of potential plant pathogens. These guidelines should form part of a specific management plan for this activity, and should be subject to a monitoring program.
Managing *T. juncea* records & data Lake Macquarie City Council maintains a database of threatened species records	Records of the occurrence of *T. juncea* within the local government area are to be maintained and updated, using flora and fauna survey reports undertaken for planning and development proposals. Scientific research supporting planning and management will be incorporated in future updates of these guidelines.

8. Conclusions

These planning and management guidelines outline current knowledge of the biology and ecology of *T. juncea* and will inform decision-making in relation to the species within Lake Macquarie LGA. They identify the requirements for the conservation of the species in the long term, and provide improved certainty for development within the LGA.

Although these guidelines apply to Lake Macquarie LGA, the measures proposed in the guidelines have relevance across the full range of the species. They may also prove useful to other organisations making decisions about the management of this species.

T. juncea habitat is expected to be subject to development impacts over the next 50 years and beyond and these guidelines outline the possible scale of the impacts and conservation measures that are available based on current knowledge of the species and potential development until 2050.

Additional scientific research to improve knowledge of the species will contribute to improved planning and management certainty in the future. It is expected that the guidelines will be reviewed and updated as further information relating to the species becomes available.

Applying the planning objectives and guidelines will require further investigations, especially in relation to the determination of sector specific planning approaches, and conservation land requirements and opportunities.

Glossary

Clump means a group of stems separated from another group of stems by 30 cm or more.

Important population is a concept used for planning and management and refers to populations that have been identified to be important for conservation of the species in the long term. These are determined using criteria in the guidelines and taking into account planning sectors. *Note that this is slightly different from the meaning when applied in relation to the EPBC Act 1999 (Department of Environment and Heritage 2000) which refers to an important population as one that is necessary for a species' long term survival and recovery. This may include populations that are (1) key source populations for either breeding or dispersal, (2) populations that are necessary for maintaining genetic dispersal and/or (3) populations that are near the limit of the species range.*

LGA means local government area.

JANIS refers to the Joint National Forest Policy Statement Implementation sub-committee nationally agreed criteria (Commonwealth of Australia 1997).

Local population means a population spatially segregated from other local populations, and occupying a suitable, discrete habitat patch. Local populations form part of a metapopulation. Sometimes the terms "population" and "local population" are used interchangeably. For the purposes of these guidelines and the *TSC Act* a local population is defined as being separated from the adjacent local population by a distance of more than 500 metres of native vegetation or more than 100 metres of degraded or developed habitat (cleared or urban areas).

Metapopulation (also referred to as a regional population) means a group of populations of the same species between which genetic material can potentially be transferred as a result of recurrent extinction/ recolonisation patterns.

Metapopulations often occur in fragmented habitats. For *T. juncea* two metapopulations are recognised, namely the Central Coast and North Coast metapopulations.

Population means an occurrence of the species in a particular area (based on *EPBC Act* significance guidelines). Normally a population is considered to be a reproductive community of individuals sharing a common gene pool (Driscoll 2009). The *EPBC Act* referral guidelines (DSEWPaC 2011) define both *T. juncea* population and sub population based on pollen dispersal separation distances and habitat suitability, and the consequent effect on potential transfer of genetic material.

ROTAP means Rare or Threatened Australian Plant (Briggs & Leigh 2005).

Site population means the number of *T. juncea* clumps found at any site. This was referred to by Payne (2000) as a sub-population, being part of a population. A site population may be all or part of a sub-population as defined in the *EPBC Act* referral guidelines (DSEWPaC 2011).

Stepping stone vegetation refers to scattered or isolated patches of habitat providing non-continuous habitat connectivity between two or more larger habitat areas.

Viable local population is a term referred to in Section 5A of the *EP&A Act* and refers to the ability of a population to persist and to avoid extinction. Quantification of species habitat requirements can enable estimation of minimum viable populations over certain time periods and may allow reserve and connectivity requirements to be determined. For *T. juncea* no viable or critical population size has been able to be determined.

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Appendix A

Summary of characteristics of *T. juncea* populations in other LGAs

Although most of the known population of *T. juncea* occurs in Lake Macquarie LGA, the species is recorded in other LGAs. These populations include the outliers and limit of distribution and need to be considered when planning for the future of the overall population. The following table summarises the characteristics of the occurrence of the species within each of the other LGAs within which it occurs.

LGA	Comments
Wyong	*T. juncea* is rare in Wyong LGA, and populations are dispersed, generally in the north of the area. Occurs within the North Wyong Structure Plan area on land indicated as part of a green corridor and habitat network or as strategically located land subject to further investigation to define conservation requirements and development potential. Currently, none of the populations in the Wyong LGA are secure in conservation reserves.
Cessnock	Records are confined to a small part of the north east of the LGA generally along the Sugarloaf Range. Very limited modelled suitable habitat occurs within the LGA. Limited field surveys and few records mean that data on the distribution within the LGA is poor and not confirmed. Most modelled suitable habitat is not under development threat.
Great Lakes	Modelling suggests considerable potential habitat for *T. juncea* in the LGA but there are few records. Within the North Coast metapopulation and records are known to occur in different habitat types such as on Bulahdelah Mountain. More investigation is required to determine whether the species is present in areas modelled as suitable habitat but where no records are known, and whether this metapopulation is genetically distinct.
Newcastle	Although suitable habitat formerly occurred in the Newcastle LGA, most of this has now been cleared/ developed. Limited areas of occurrence are in the west of the LGA, although are subject to development pressure. Some pockets of suitable habitat with small populations may occur on reserves but are fragmented and poorly connected and unlikely to be viable in the long term.
Port Stephens	Modelled habitat occurs in the north of the Port Stephens LGA, forming part of the North Coast metapopulation. Limited knowledge of the distribution or density of occurrence within Port Stephens LGA is known due to lack of comprehensive field survey. Potential for some habitat to be affected by future development.
Maitland	Isolated records in the south of the Maitland LGA, occurring on bushland within coal mining areas. Because of the extent of historic clearing within the LGA, most suitable habitat has been cleared and developed or used for agriculture. No conservation of suitable habitat on public land in the LGA, but there are some requirements for coal mining developments to manage populations.

Appendix B

Strategic assessment of development impacts on *T. juncea* within Lake Macquarie LGA

1. Purpose and description of the strategic assessment

A strategic assessment has been undertaken for likely and potential land use impacts on *Tetratheca juncea (T. juncea)* to inform the preparation of the *T. juncea* planning and management guidelines. It takes a long-term view and provides the context for future conservation management planning for the species and its ongoing management within the Lake Macquarie local government area (LGA).

Strategic assessments are undertaken in the early stages of land use planning processes to review potential impacts of actions resulting from the implementation of one or more plan, program, policy or strategy. These impacts include legislative requirements (e.g. consent requirements for native vegetation clearing under the *Native Vegetation Act 2003* and Regulation), strategic land use plans (e.g. Lake Macquarie Lifestyle 2030 Strategy, Lower Hunter Regional Strategy), infrastructure programs, local environmental plans, or bush fire, vegetation or pest management plans. Strategic assessments account for cumulative impacts over time and space.

T. juncea has been recognised as of conservation significance at all levels of government, but the level of significance and the legislative and administrative requirements are different at each level. As an area specific assessment related to one species, this assessment is not limited by jurisdictional boundaries relating to governance.

Strategic assessments are increasingly being undertaken under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)* to review the impact of policies, programs and plans to determine referral and consent requirements under that Act for actions that may affect matters of national environmental significance such as listed threatened species, endangered ecological communities and migratory species. The Commonwealth and NSW Governments formally agreed in 2012 to prepare a regional sustainability plan and strategic assessment of matters of national environmental significance relating to the Lower Hunter Region, including *T. juncea*. This plan comprises an update of the Lower Hunter Regional Strategy 2006 and Lower Hunter Regional Conservation Plan 2009 and associated data.

The *T. juncea* assessment is not a strategic assessment for the purposes of the *EPBC Act*. It differs from such a strategic assessment, which is limited to reviewing impacts directly and indirectly arising from specific plans, policies or programs. This assessment may however, be used to inform decision-making under that Act and is a relevant consideration in updates of the Lower Hunter Regional Strategy and Lower Hunter Regional Conservation Plan.

The purpose of this strategic assessment is to document and review threats to *T. juncea* over medium and long term planning timescales (50 to 100+ years). It considers committed and projected development and also reviews other potential threats to the species. The assessment takes into account the principles of ecologically sustainable development and addresses economic, environmental and social considerations. The process enables consideration of alternative futures and planning objectives for the conservation of the species.

The assessment is specific to *T. juncea* and considers direct impacts on this single species within the Lake Macquarie LGA. To take into account the broader planning context for the species, the assessment also makes assumptions about indirect impacts and development pressures outside the LGA over the full range of its distribution.

2. Strategic assessment process

The assessment is not a review of whether anticipated land use or development meets the objects of the EPBC Act or *Environmental Planning and Assessment Act 1979* (EP&A Act), or whether referrals or development approval requirements under those Acts can be reduced. Rather it identifies the potential impacts, the geographic scale of the impact, the reversibility and timescale over which the impact operates (short term, medium term, and long term), and the potential for and effectiveness of ameliorative measures (e.g. to avoid, mitigate or offset impacts) for the Lake Macquarie LGA.

The process documented land use changes already committed or irreversible and the extent of species loss arising, how much loss can be reasonably anticipated based on potential plans and proposals, and considered what further development beyond that already committed could occur. Potential threats and risks other than those directly related to development were also reviewed.

The assessment process used the following methodology:

1 Define the boundary of the area for strategic assessment, namely the Lake Macquarie LGA.

2 Determine the review context being the full area of the species geographic distribution, based on the modelled area of suitable habitat (Map B1).

3 Define the temporal scales being assessed (2030, 2050 and 2100).

4 Identify current land use plans and projected developments and their spatial impact (Maps B2 & B3).

5 Determine other potential threats and their direct and indirect impacts.

6 Review the impacts on *T. juncea* of projected developments and potential threats.

7 Determine potential ameliorative measures to reduce impacts

8 Strategic assessment of likely and potential impacts on the species, realistic ameliorative measures, and the economic and social consequences (Map B4).

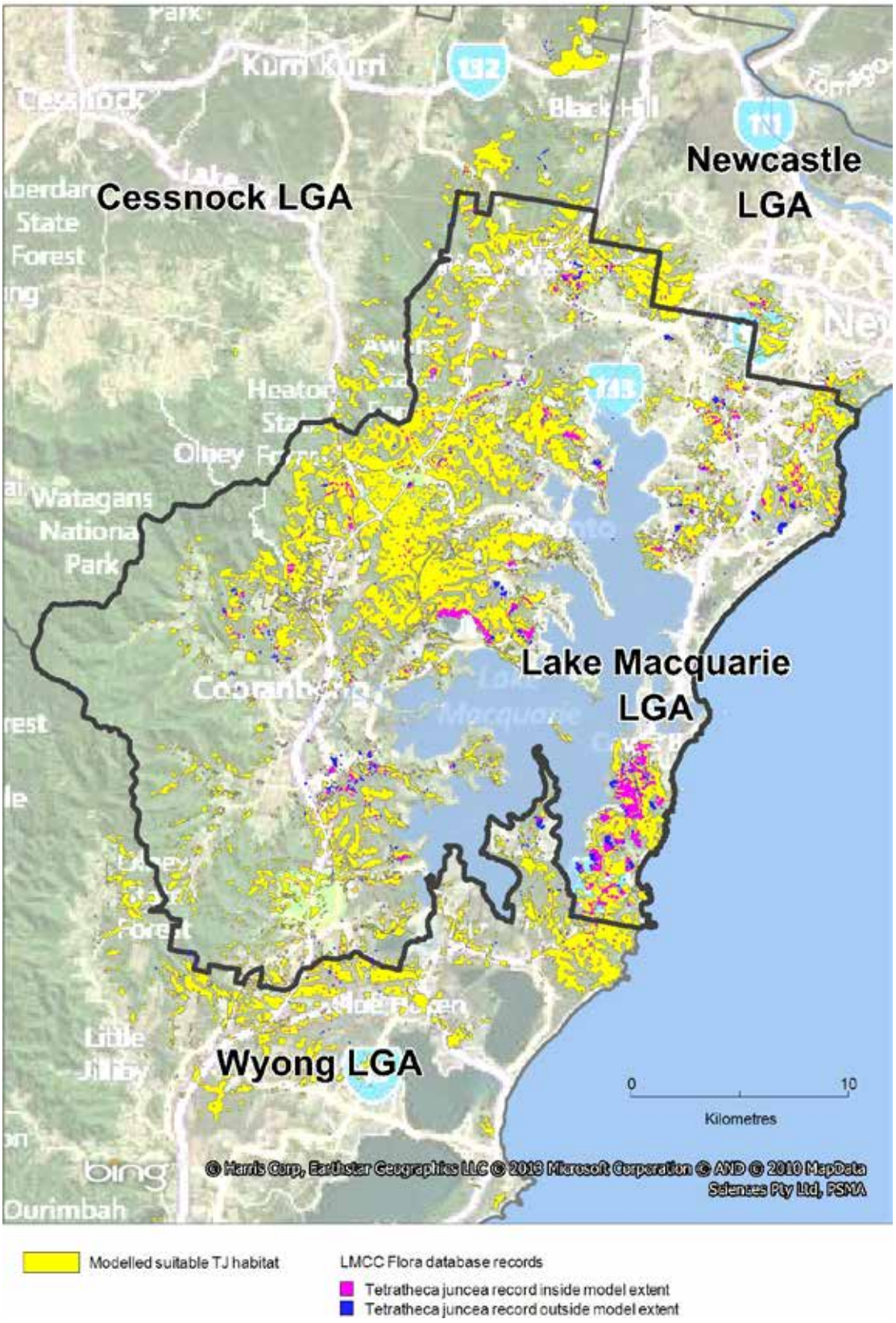
The process has been to review plans and strategies already adopted, to consult with relevant staff in agencies and private industry to identify projected developments and threats, and to review these in an expert workshop. Specific questions and key issues considered in the process are identified in Table B1.

Table B1: Strategic assessment process - Questions and key issues

Stage	Specific Questions	Key issues & factors
1. Assessment boundary	Should the assessment relate to the current geographic distribution of *T. juncea*, or to Lake Macquarie LGA?	• Relationship to recovery planning process • Involvement of adjoining LGAs
2. Temporal scales	What relevant conservation planning time scales should be assessed? Do 2030, 2050 and 2100 provide appropriate periods for reviewing impacts?	• IUCN conservation categories relate to extinction probabilities within certain time scales • Should be aligned with other planning documents • Ability to anticipate or assess location of development beyond 2030 which is the timescale of current land use strategies
3. Current & projected developments	What are the growth projections, the preferred and likely locations of growth? What conservation proposals for the species currently exist?	• Projected number of dwellings and new residential lots anticipated • Land currently zoned for urban purposes with *T. juncea* habitat
4. Potential non-development threats	What potential threats to *T. juncea* exist and how likely are these threats?	• Climate change • Bush fire regime change • Weeds and pathogens
5. Impact assessment	How much *T. juncea* habitat has already been lost? What areas of *T. juncea* habitat are currently conserved in perpetuity? What area of conservation land is required to secure the protection of the species? What is the potential loss under current committed or likely land use change? What risks and uncertainties exist? What is the management viability of areas with *T. juncea* on protected public land, and on private land zoned for environment protection?	• Consideration of options • Time scale of impact • Reversibility of impact • Consequences of projected losses • Acceptability of projected losses
6. Potential ameliorative measures	When are offsets acceptable? What should be the scale of offsets?	• Offset requirements • Acceptable offset mechanisms • Conservation reserves
7. Strategic assessment	What future can be anticipated for *T. juncea*? What measures can be taken to change or improve this? How should future land use planning take this into account?	• Identify planning objectives for *T. juncea* • Determine management objectives

Map B1 shows the spatial distribution of *T. juncea* habitat and *T. juncea* habitat records within Lake Macquarie LGA, and identifies the potential *T. juncea* habitat within the City as modelled by Driscoll (2013). This relates only to the Central Coast Metapopulation, which comprises most of the known population, and is used to underpin the impact assessment of current and potential land use change and development. A geographically separate North Coast Metapopulation with limited records occurs further north, is not well described and not subject to development pressure, and has not been considered in the strategic assessment.

Map B1: Lake Macquarie LGA and modelled *T.juncea* habitat (Central Coast Metapopulation)



Map Note: Most modelled *T. juncea* habitat has not been subject to field survey. Concentrations of records exist at locations where development proposals have required flora and fauna surveys. Some single records may represent large plant populations.

Map B1 shows that most (75%) of the distribution of the Central Coast Metapopulation and most of the records for the species occur within Lake Macquarie LGA. The map also shows that records of occurrence exist outside the modelled area of distribution, and that the modelled suitable *T. juncea* habitat is a guide and not a definitive map of potential occurrence. This may be a result of the regional scale data used in the modelling and indicates that further refinement of the modelled habitat may be appropriate over time.

Future impacts on *T. juncea* can be categorised into three types. These types differ in characteristics and governance requirements and also vary in the level of certainty of occurrence, and the potential time scale of the impact:

1. Urban development effects as a consequence of existing plans, policies, programs and projects resulting in habitat loss.
2. Potential development impacts of future plans and programs (eg land use strategies and biodiversity offset programs).
3. Other threats or impacts (e.g. climate change).

These three categories of impacts are discussed in the following sections. Where possible, the assessment has identified impacts spatially and quantified them.

3. Current development policies, programs and projects

3.1 What existing plans, policies and programs affect *T. juncea*?

Past impacts on *T. juncea* populations have occurred primarily as a result of urban development, but also from mining, power stations, agriculture and infrastructure. Such impacts are expected to continue with projected requirements for housing and employment land in the Lower Hunter region.

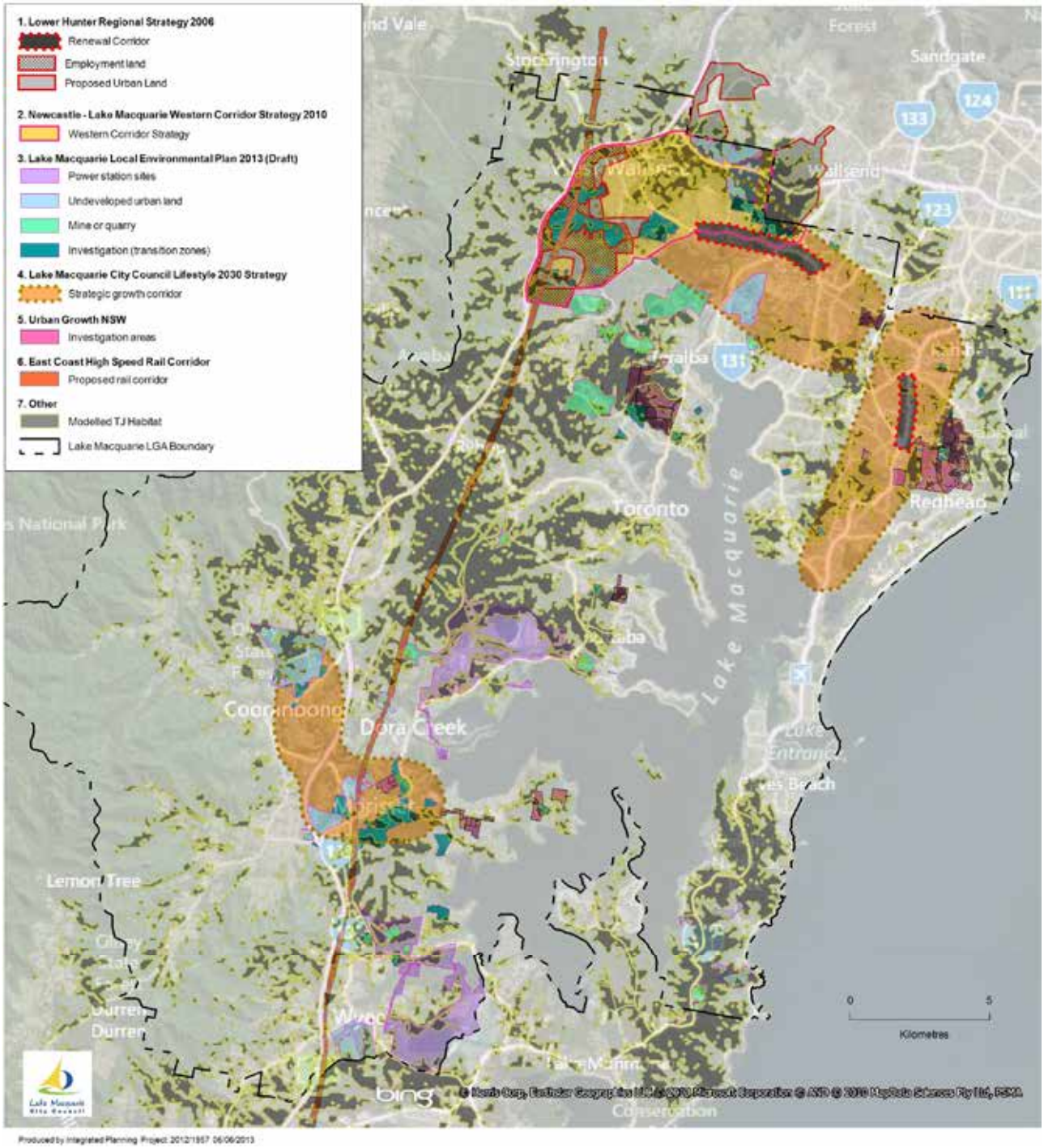
Important strategic land use plans informing land use decision-making affecting areas within the distribution of *T. juncea* include the Lower Hunter Regional Strategy, Morisset Structure Plan, Newcastle – Lake Macquarie Western Corridor Structure Plan and the North-Wyong Structure Plan.

The Lower Hunter Regional Conservation Plan (Department of Environment and Climate Change 2009) provides a broad conservation-planning framework outlining the mechanisms that are available and broad regional values, which should be considered for conservation. It does not include specific assessment or comments on the conservation status or requirements for *T. juncea*.

As well as the land use plans and related policy documents, there are a number of development approvals under Part 3A of the *EP&A Act*, infrastructure plans and other policies that will influence *T. juncea*, including Catherine Hill Bay, Coal & Allied lands and some mining areas.

Likely impacts on *T. juncea* are identified in Table B2, and the estimated spatial and quantitative extent of the impact is identified in the following section. The summary of impacts differentiates between potential impacts and likely impacts, recognising that in some cases on-site offsets, the unsuitability of land for development or uneconomic provision of infrastructure may preclude all the identified land from development. It should be noted that some of the plans or programs overlap in their spatial extent and therefore impact.

Map B2: Identification of plans and programs within Lake Macquarie LGA affecting modelled *T. juncea* habitat



Map Note: Boundaries of some plans and development proposals overlap.

Table B2: Identification of *T. juncea* impacts - existing plans and developments

Plan, policy or program	Potential impact	Expected impact	Comment
Lower Hunter Regional Strategy 2006 (NSW Department of Planning 2006)	15,000 dwellings in new release areas and additional employment lands to be developed	Bushland with *T. juncea* is likely to be cleared for development	A 25 year strategy for growth, identifying urban development areas. Currently being reviewed and updated
Lower Hunter Regional Conservation Plan 2009 (NSW Department of Environment and Climate Change 2009)	New conservation reserves established, and concept conservation corridors identified	Identifies West Lake Macquarie as high value for investigation for conservation on public land.	Complements Lower Hunter Regional Strategy 25 year framework. Identifies regional conservation priorities for investment. No specific reference to *T. juncea*
Newcastle – Lake Macquarie Western Corridor Strategy (NSW Department of Planning 2010)	Identifies additional residential and employment land for investigation and possible freight rail corridor	Identified *T. juncea* habitat to be investigated for development suitability	Complements Lower Hunter Regional Strategy by identifying detail of preferred land uses
Lake Macquarie LEP 2004 & draft LEP 2013 (Lake Macquarie City Council)	Identifies *T. juncea* habitat which is able to be developed	Based on current LMCC policy, some areas with known *T. juncea* populations should be conserved	Statutory planning framework in LEPs provides no guide to planning objectives for *T. juncea* or offset or ameliorative measures
Lake Macquarie City Council Lifestyle 2030 Strategy	Identifies strategic growth corridors, some of which will impact on *T. juncea*	Implemented through LEPs	20 year local strategic land use planning framework
North Wyong Shire Structure Plan (NSW Department of Planning and Infrastructure 2012)	No direct impact in Lake Macquarie LGA. However, urban development of nearby *T. juncea* habitat will occur	Impact on long term population and further fragments habitat in south Lake Macquarie LGA	Plan identifies desirable conservation corridor links and habitat networks extending into Lake Macquarie LGA
Morisset Structure Plan (Connell Wagner 2008)	Identifies *T. juncea* populations in an area identified as an urban growth centre	Substantial loss of *T. juncea* population likely on residential zoned land and investigation areas. Important populations in council reserves and on conservation zoned land	Included in within urban areas identified in Lower Hunter Regional Strategy
Major development proposals – Western corridor			
Northlakes	127 clumps to be removed (638 retained)	Immediate impact which will continue into medium term	Area of impact recognised by current urban zonings
Cameron Park/ Pambulong	91 clumps to be removed (1,540 retained)	Immediate impact which will continue into medium term	Area of impact recognised by current urban zonings
West Wallsend	0 clumps removed (74 retained)	Immediate impact which will continue into medium term	Area of impact recognised by current urban zonings
Coal & Allied (Minmi and Black Hill)	10 clumps removed (352 retained)	Immediate impact which will continue into medium term	Area of impact recognised by current urban zonings
Major development proposals – Wallarah Peninsula 2010 estimate of total of 49,000 clumps in development areas with approx 30,000 in secured offset lands and reserves			
Coal & Allied (Middle Camp and Nords Wharf)	1,282 clumps to be removed (13,529+ retained)	Permanent loss of *T. juncea* habitat and connectivity. Some areas of *T. juncea* are protected in reserves	Impact reviewed as part of approval process
Rosecorp (Catherine Hill Bay)	189 clumps to be removed (1,000+ retained)	Permanent loss of *T. juncea* habitat and connectivity. Some areas of *T. juncea* are protected in reserves	Impact reviewed as part of approval process
Wallarah Stockland	15,147 clumps masterplanned to be removed (9,988 retained)	Permanent loss of *T. juncea* habitat and connectivity. Some areas of T. juncea are protected in reserves	Impact reviewed as part of approval process

Plan, policy or program	Potential impact	Expected impact	Comment
Major development proposals – other			
Coal mining areas and quarries	Ongoing impact from current approvals. Areas may be rehabilitated to suitable habitat in long term	Reduction in *T. juncea* habitat, with some areas on mining leases conserved as consent conditions or other agreements	Assessed as part of development approval
Awaba Waste Treatment Facility expansion	871 clumps to be removed (12,809 retained)	Very high density population, with retained *T. juncea* protected in secure conservation arrangement	Assessed as part of development approval

3.2 What are the potential and likely impacts of existing plans, policies and programs on *T. juncea*?

The spatial distribution and quantification of likely loss of *T. juncea* habitat has been reviewed in a GIS assessment. For each of the plans or policies identified in Table B2, potential development areas were identified based on published information, or publicly available draft strategies or other information. Map B2 identifies the location of planned and foreseeable development impacts and the type of these impacts. The extent of possible development gives a likely maximum development footprint and is useful for estimating the potential loss of *T. juncea* habitat that could occur. For mining projects or extractive industries, the extent of impacts was estimated based on mining company existing land ownership and is likely to overestimate the extent of loss.

In addition, there are some specific large approved development proposals not included in the plans (e.g. Awaba waste treatment facility upgrade, Cameron Park, Catherine Hill Bay and Nords Wharf) where an accurate assessment of impacts has been undertaken and are known to result in the loss of *T. juncea* clumps.

The methodology used to produce the maps supporting the strategic assessment was:

1 Prepare separate GIS layers for the development envisaged by each plan or strategy, using available maps or diagrams for each plan. Where investigation areas were identified, the whole of the area was determined to be potentially developable.

2 Remove potential development areas from the modelled *T. juncea* habitat area to show *T. juncea* habitat likely to remain undeveloped.

3 Calculate the area of *T. juncea* habitat loss and the area to be retained.

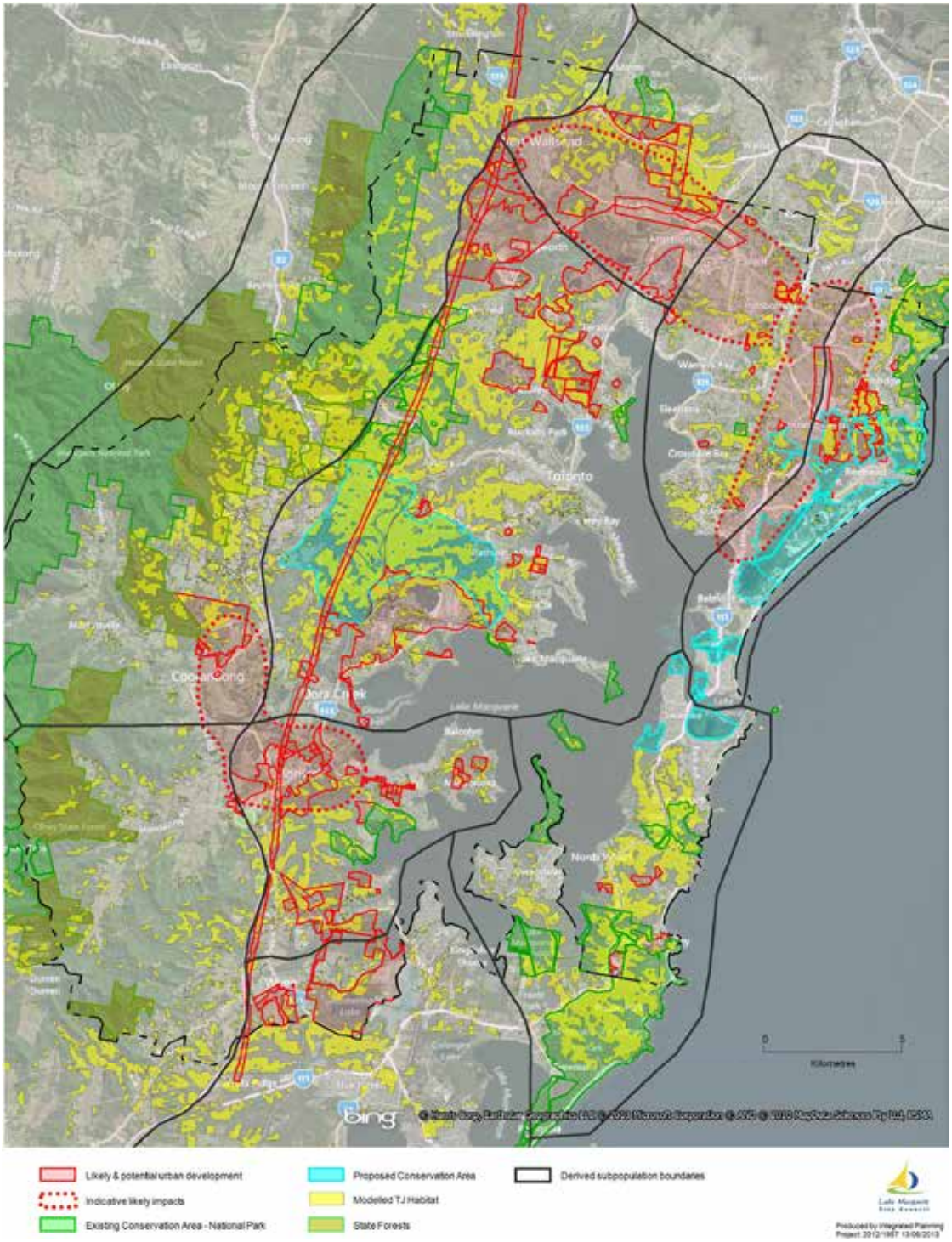
4 Where known, calculate total loss of *T. juncea* species records, based on Lake Macquarie City Council records of *T. juncea*.

5 Prepare a planning map to summarise ecological planning settings for *T. juncea*.

Two maps identify the results of the analysis, the first shows the spatial extent of likely and potential development impact and existing and proposed conservation areas (Map B3). It also shows the boundaries between important *T. juncea* populations within the City based on connectivity considerations, and the quantification of impacts in the strategic assessment is based on the potential development areas outlined on this map.

Table B3 summarises the results of the impact assessment, including quantification of *T. juncea* habitat that has potential to be affected and an estimated number of individual plant clumps that might be impacted where known. This shows that around 24% of the modelled *T. juncea* habitat within the Lake Macquarie LGA, and around 18% of the total habitat for the species over the distribution of the Central Coast Metapopulation is likely to be affected by future development that can be reasonably anticipated in Lake Macquarie alone.

Map B3: Indicative future urban development and land use change in Lake Macquarie LGA to 2050, conservation areas and conservation proposals



Map Note: Derived sub-population boundaries represent barriers for pollinators and movement of genetic material. This indicates that plant genetic material will not be shared across boundaries and may evolve separately. Sub-population boundaries are based on identified important populations (DSEWPaC 2011).

Note that this is the map on which statistics have been generated. It is important to note on the map that modelled habitat may not contain *T. juncea* populations and that the density of *T. juncea* plants varies extensively across its range. Note also that these impacts have only been identified for Lake Macquarie LGA and statistics are only based on the Central Coast metapopulation.

Table B3: Assessment of *T. juncea* impacts - existing plans and developments

Plan, policy or program	Spatial extent of impact	Staging and time scale of impact	Reversibility	Potential ameliorative measures (avoid, mitigate or offest)
Lower Hunter Regional Strategy 2006	464 ha of *T. juncea* modelled habitat projected to be impacted upon. Approximately equivalent to the loss 3% of total modelled habitat area within LGA	Short and medium term	Clearing of *T. juncea* habitat for urban development is irreversible. Strategy is policy only and subject to changes in land demand	No specific measures proposed, except as included in Lower Hunter Regional Conservation Plan. Watagan – Stockton Green Corridor land added to the public conservation estate
Lower Hunter Regional Conservation Plan 2009	No direct impact on *T. juncea*	Short and medium term	Policy only, and is easily changed	Identifies mechanisms available, but no measures proposed
Newcastle – Lake Macquarie Western Corridor Strategy	860 ha of *T. juncea* modelled habitat to be investigated for potential development	Medium and long term, although no time frames are included in the Strategy	Where urban development is to occur, clearing is not reversible. Policy only, and subject to further investigation	States that "rezoning proposals should attempt to conserve key habitat areas for threatened species" and that where impacts cannot be avoided, mitigation and offset measures are to be investigated.
Lake Macquarie LEP 2004 & draft LEP 2013	1,440 ha of *T. juncea* modelled habitat zoned urban or urban investigation	Short and medium term	Statutory framework difficult to change. Some areas are power station sites, mines and extractive industries where some biodiversity will be retained	Ameliorative measures may be included in proposals to change zones or development projects seeking approval under plan
North Wyong Shire Structure Plan	Identifies significant areas along LGA southern boundary for investigation to define conservation requirements and development potential	Medium and long term (15+ years) impact	Urban development impacts are not reversible	Identifies that investigation is required to determine extent of biodiversity loss and offset areas to compensate for losses
Morisset Structure Plan	Urban growth has the potential to impact on approx 70 ha of *T. juncea* habitat, with approx 2,000 clumps. Also will contribute to fragmentation of habitat. About 100 ha of suitable habitat with potential for development was not surveyed	Short to long term	Urban development impacts are not reversible	Morisset Structure Plan has considered *T. juncea* issues. Offset arrangements may need to be made for loss of population
Major development proposals – Western corridor				
Northlakes	Habitat and 127 clumps lost and	Short to medium term	Approval has been given and development is proceeding	Protected habitat but no offsets for loss
Cameron Park/ Pambulong	Habitat and 91 clumps lost	Short to medium term	Approval has been given and development is proceeding	Protected habitat and offsets for loss

Plan, policy or program	Spatial extent of impact	Staging and time scale of impact	Reversibility	Potential ameliorative measures (avoid, mitigate or offest)
West Wallsend	Some habitat loss but no loss of clumps	Short to medium term	Approval has been given and development is proceeding	Habitat protected
Coal & Allied (Minmi and Black Hill)	Habitat and10 clumps lost	Medium to long term	Approval has been given and development is proceeding	Protected habitat and offsets for loss
Major development proposals – Wallarah Peninsula				
Coal & Allied (Middle Camp and Nords Wharf)	Habitat and 1,282 clumps lost	Medium term	Approval has been given	*T. juncea* habitat protected in national park transfers
Rosecorp (Catherine Hill Bay)	Habitat and 189 clumps lost	Medium to long term	Approval has been given	Alternative non *T. juncea* habitat dedicated as national park
Wallarah Stockland	Habitat and 15,147 clumps lost	Short to medium term	Approval has been given	Loss of *T. juncea* clumps to be offset by protecting *T. juncea* habitat in national park
Major development proposals – other				
Coal mining areas and quarries	Ongoing impact from current approvals. Some areas protected by conservation agreement	Short to long term	Approval has been given and additional extensions likely	Some offsets for habitat loss
Awaba Waste Treatment Facility expansion	871 clumps to be removed (12,809 retained)	Short term	Approval has been given	Impact to be offset by reservation and management of *T. juncea* habitat

Note: Areas of impact are based on maximum loss of *T. juncea*. Documents referred to have variable levels of confidence and some may not be implemented as envisaged. Major developments have been subject to detailed site surveys and therefore populations are known while areas of habitat in plans have not been surveyed.

Review of the spatial distribution of potential habitat losses shows that most of the expected loss is in the north and east of the City, and around the Morisset area.

The estimates of area and number of plant clumps lost (where these have been surveyed) are reasonably accurate. While there may be doubt about the exact timing or staging of the urban development identified, at some stage some land clearing and development shown on Maps B2 and B3 appears inevitable and is likely by 2030 and almost certain by 2050.

4 Projected and potential development policies, programs and projects

4.1 What potential plans, policies and programs may impact on *T. juncea*?

Potential plans, policies and programs are those that have been foreshadowed, are under investigation or are reasonably likely to be considered over the next 20 to 80 years. They relate to land use change, development and infrastructure developments that can be reasonably anticipated and are identified in Table B4.

This review is limited to state and local policies and programs, and considers the potential impacts of these programs in relation to *T. juncea*. This review is based on information available to Lake Macquarie City Council including discussions with a range of government agencies and a workshop discussion involving key stakeholders. It should be noted that some of the potential plans, policies or projects overlap which current plans included in Tables B2 and B3. This recognises that long lead times in the development process mean that progressive plans necessarily adapt and change over time. The major difference relates to the timing and level of certainty of impacts. These plans, policies or programs are subject to change.

Table B4: Identification of *T. juncea* impacts - projected and potential plans and developments

Plan, policy or program	Description of potential impact	Expected impact	Comment
Draft Lake Macquarie Biodiversity Offsets Policy	Draft policy for local offsets.	Uncertain	Would require offsetting of *T. juncea* impacts through compensatory measures
Proposed Awaba Conservation Area	An area of 2,311 ha identified as a possible future conservation reserve in strategic planning documents	Uncertain. Subject to mining impacts. About 1,565 ha or two thirds of proposed reserve is *T. juncea* habitat	Primarily Crown land
Lake Macquarie Coastal Wetlands Park proposal	A 1,882 ha reserve proposal with 308 ha of modelled *T. juncea* habitat within it	Uncertain. Some *T. juncea* population on Council land within the park proposal is protected	Primarily public land. Investigation of part of area for potential urban development
T. juncea Recovery Plan (under relevant NSW or Commonwealth threatened species legislation)	A recovery plan potentially could include funds or actions for protection and establishment of reserves	No impact	Recovery plans are a program of actions to protect a species. A plan for *T. juncea* has not been proposed but is a remote possibility. At NSW state level the actions for the species are included in the Priority Actions Statement (PAS) document
Major development proposals			
Urban Growth NSW homesites program	7 different sites affecting 412 ha of *T. juncea* habitat. Depending on extent of development, would cause loss of plants and affect population connectivity	Permanent loss of *T. juncea* habitat and connectivity. Extent of impact depends on land and housing demands, but some development likely over long term. Subject to further investigation	Some sites have strategic development advantages including location close to existing urban areas and infrastructure. Some areas of *T. juncea* may be protected as offset areas
East Coast High Speed Rail link	270 ha of *T. juncea* modelled habitat zoned urban or urban investigation	Potential for a major impact on habitat connectivity and pollination	Feasibility undertaken and route alignment identified. Route alignment modification or tunnelling would mitigate impacts
Western Newcastle Freight Rail link	No route has been identified for a link. Would be likely to affect *T. juncea* habitat and fragment populations	Uncertain	Alternative railway corridor option between Glendale Kurri Kurri and Maitland which would have lower impact

Plan, policy or program	Description of potential impact	Expected impact	Comment
Hunter Development Corporation western corridor investigation	Part of Western Corridor Strategy where 860 ha of *T. juncea* modelled habitat to be investigated	Uncertain	Further investigations being undertaken
Other proposals	Potential for many development proposals ranging for small to large to impact on *T. juncea* habitat in the medium to long term	Very uncertain	While proposals are subject to strategic plans, a range of other development or infrastructure proposals are possible

Note: Areas of impact are based on maximum loss of *T. juncea* from a site. Development proposals are conceptual or preliminary and subject to change, and therefore cannot be reliably used to quantify impact.

Although the impacts noted in the table have a relatively high degree of uncertainty, they can be used to identify and estimate the consequences of the reasonable worst-case development impacts. This is important when considering potential conservation reserves and also when considering requirements for maintaining habitat connectivity.

4.2 What are the potential and likely impacts of projected or anticipated plans, policies and programs on *T. juncea*?

The impacts of potential or anticipated plans and programs on *T. juncea* are very uncertain, generally occur over the medium to long term and are reversible. In contrast, the major development proposals that are anticipated are likely to proceed, but the exact scale and nature of the development has the ability to be significantly modified to reduce *T. juncea* impacts if this was identified as a priority.

Direct impacts of projected or anticipated plans or policies have been reviewed using a similar approach to that used in Section 3. These are summarised in Table B5. No assessment has been made of the relative priority of either projects or the significance of impacts.

The plans outlined in Section 3 provide for urban land supply of at least 15 to 30 years based on current rates of demand, and there are currently no land use plans that can be envisaged which provide for additional development areas. There are a number of long-term development proposals can be anticipated, and there are also a number of proposed and potential policy measures that primarily aim to respond to adverse impacts of development and are ameliorative measures.

Table B5 reviews the consequences of each of the projected and potential plans and developments. The projected developments are included on Maps B2 and B3. The review shows that the spatial impact of the potential development proposals can be reasonably accurately identified, although the timing is extremely uncertain and that opportunities exist to substantially modify these proposals to avoid or mitigate impacts. However, their consequences and indirect effects are very significant and important to the long-term future of *T. juncea*.

In contrast, all the policy proposals are ameliorative measures, which would either contribute to the conservation of biodiversity within the LGA or would mitigate or compensate for the impacts of development.

Table B5: Assessment of *T. juncea* impacts - projected and potential plans and developments

Plan, policy or program	Spatial extent of impact	Staging and time scale of impact	Reversibility	Potential ameliorative measures (avoid, mitigate or offest)
Draft Lake Macquarie Biodiversity Offsets Policy	Applies to whole LGA	Short term	Can easily be reviewed and updated	Would implement a mechanism for offsetting development impacts
Proposed Awaba Conservation Area	Possible future conservation reserve shown on Map B3	Uncertain but possibly medium term	Boundaries identified but proposal subject to change	Creation and management of reserve may form part of an offsetting arrangement
Lake Macquarie Coastal Wetlands Park proposal	Conservation reserve proposal shown on Map B3	Short to medium term	Boundaries identified but proposal subject to change	Creation and management of reserve may form part of an offsetting arrangement
T. juncea Recovery Plan	State and national scale plan, but mostly applies within Lake Macquarie LGA	No current proposal, although legislative framework exists	Relatively easy to prepare and update	Plan could provide for offset arrangements
Major development proposals				
Urban Growth NSW homesites program	Shown on Map B3	Short to medium term	Development impacts are not reversible	Options exist for avoiding and mitigating impacts through reduced development footprint. Offsets would be necessary if development proceeds
East Coast High Speed Rail link	Shown on Map B3	Long term	Irreversible direct impact, plus major secondary impacts	Mitigation and offset measures are availability including route variation to avoid proposed Awaba Conservation Area and/ or tunnelling to maintain habitat connectivity
Western Newcastle Freight Rail link	Route not identified, but limited options exist. Would impact on	Long term	Development impacts are not reversible	Ameliorative options available
Hunter Development Corporation western corridor investigation	Shown on Map B3	Medium to long term	Development impacts are not reversible	Ameliorative options available
Other proposals	Unknown	Could be proposed at any time	Unknown	Unknown

The spatial area of direct impact of the proposals outlined in Sections 3 and 4 is shown on Map B3 which compiles all information on proposed and potential plans and developments to determine likely and potential urban development and areas of indicative impact to 2050.

5. Non development threats

There is potential for *T. juncea* to be affected by threats other than those posed by the direct effects of urban development. This section reviews threats or impacts other than those directly resulting from development and land use change that could potentially occur over the timescales being assessed and what the risks and consequences of these may be for *T. juncea*.

Given that the environmental limits and specific habitat requirements of *T. juncea* are not really understood, this review is indicative only. Many threats are also interrelated and are likely to be systemic rather than the result of a single cause. Threats to be considered are not limited to direct impacts on *T. juncea* plants, but also need to consider those affecting pollinators (primarily native bees).

Identified threats in their likely order of importance are weed or pest invasion, diseases, bush fires, and climate change. These are discussed in more detail below. Other as yet unknown and probably unlikely threats should also not be discounted and could include major catastrophic events or incremental change.

5.1 Weed or pest invasion

Probably the most likely non-development threat to *T. juncea* populations is the likelihood of increased weed invasion, and an associated reduction in bush fire frequency. One of the main reasons for weed invasion is landscape disturbance, and the spread of weeds generally is an indirect consequence of urban development.

Specific weeds which currently exist within the Lake Macquarie LGA, which have been observed to spread in relatively undisturbed *T. juncea* habitat and known populations, include Lantana, Bitou Bush, and Camphor Laurel. Since spread of weeds can be associated with changes in natural bush fire regimes and increased nutrients associated with human activities, it is likely that roadsides, bush fire asset protection zones and electricity easements represent key areas from which weed invasion is likely to occur into areas of *T. juncea* habitat.

5.2 Diseases

Plant pathogens especially fungi have the potential to be introduced into local populations. While there have been no reports of disease affecting *T. juncea* plants to date, this has not been subject to research and may also be a response to separate environmental or climate change.

Monitoring programs for *T. juncea* within conservation reserves should review plant condition over time to enable potential diseases to be identified.

5.3 Bush fires

Although available evidence suggests that *T. juncea* populations are adapted to bushfires, long-term changes to bushfire frequency and intensity could potentially affect the vegetation communities in with the species occurs, and lead to ecological changes, which adversely affect the suitability of its habitat for survival. For example, infrequent fire may lead moist vegetation communities to expand and change the species composition. It is likely that such changes would be over relatively long time periods, but could become evident within the time frame of this strategic assessment. This is likely to become a particular issue at the bushland – urban interface and in conservation reserves surrounded by urban development.

5.4 Climate change

Climate changes predictions for Lake Macquarie local government area foreshadow sea level rise of around 1 metre within a century and more frequent extreme weather events, including heat waves and storms. Sea level rise will not affect any *T. juncea* habitat, and the species has coped with weather extremes in the past, indicating that the frequency of these extremes is not likely to limit its distribution. Indirect effects of climate change may be more consequential, including more high bush fire days leading to altered bush fire regimes, and may enable more opportunities for weed dispersal and colonisation arising from severe weather events.

6. Impact assessment

This section reviews the LGA wide environmental, social and economic consequences of the impacts and threats outlined in Sections 3, 4 & 5. It also summarises projected land use planning impacts on *T. juncea*.

The scope of the assessment is limited to reviewing the area of impact, population impacts (i.e. number of plant clumps affected), and barriers to habitat connectivity (ie effects on long term population genetics). Planning considerations are summarised in terms of ecological planning settings and risks are also considered.

While a range of other tools is available for assessing impacts, sufficient data are not available to effectively use them. These tools include:

1 Biodiversity core area analysis (to highlight which areas are most important)

2 Habitat change analysis (to review the suitability and quality of habitat – on a species specific basis)

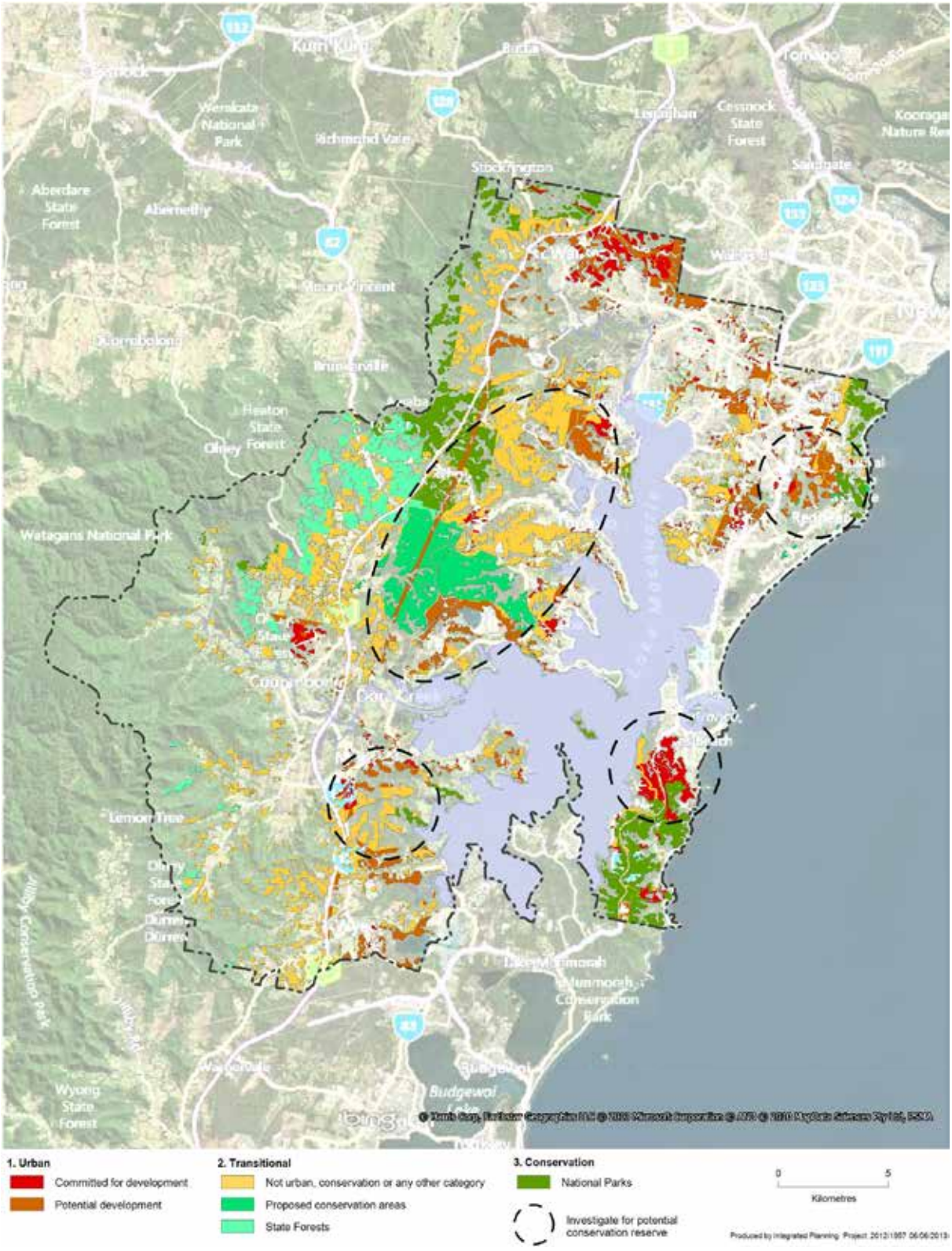
3 Population viability analysis (to review the adequacy of the options in terms of maintaining species population)

4 Prioritisation of offsets (to identify the most cost effective places for offsetting)

In particular, lack of information about genetic variability across the full range of the population, scale and uncertainties associated with the assessment, the apparent longevity of plants, and the variability of future land use means that these tools would be unlikely to provide reliable information to inform future planning.

The ecological planning settings map for *T. juncea* (Map B4) shows the long-term land-use planning context for *T. juncea*. This map identifies three planning settings for *T. juncea*, namely (1) existing conservation areas (i.e. national parks and nature reserves), (2) anticipated areas of habitat loss as a result of development, and (3) a transitional area within which *T. juncea* habitat exists outside areas of secure land tenure and where no intensive development is currently anticipated. Within this transitional setting the conservation of *T. juncea* is not necessarily assured and options are available for conservation or alternative land uses, and for maintaining ecological connectivity between *T. juncea* populations. However, there is also a relatively high degree of uncertainty about the occurrence of the species on land within the transitional setting, primarily because of a lack of consistent and/or detailed survey.

Map B4: Ecological planning settings for *T. juncea* habitat, and areas to be investigated for potential conservation reserves



Map note: Urban, Transitional and Conservation ecological settings are broad categorisations based on land zoning and indicative potential development in planning documents. Areas identified for conservation reserve investigation are locations where establishment of additional reserves to protect different sub-populations would contribute to the conservation of *T. juncea* and would be feasible.

The ecological planning settings map shows that of the 15,400 ha of modelled *T. juncea* habitat within the LGA:

1. 24% (approx 2,500 ha) is in the urban setting, and is reasonably likely to be affected by development in the medium to long term
2. 60% has a transitional setting
3. 16% is in a conservation setting

When it is recognised that 75% of the Central Coast metapopulation is within Lake Macquarie LGA and that few records are known from the northern metapopulation, it is clear that the potential loss of nearly a quarter of the modelled *T. juncea* habitat in the LGA is likely to have a significant affect on the population viability of the species. Table B6 summarises likely key impacts on *T. juncea*.

Table B6: Impact assessment summary for *T. juncea* in Lake Macquarie LGA

Impact	Summary
Area of modelled *T. juncea* habitat potentially affected by current and future development - Approx 2,500 ha	Current impacts are mostly within the western corridor and Wallarah Peninsula and this will continue into the medium term. Future impacts will be west of Lake Macquarie, particularly around Morisset. Some sub-populations will be significantly reduced and will not be conserved in reserves unless new reserves are created
T. juncea plant clumps potentially affected by current and projected development – 50,000 – 150,000+ clumps	If the current average density of *T. juncea* of 40 clumps/ha is applied to the area lost, this would be around 100,000 clumps affected. Direct impacts can be avoided or mitigated in many cases, and the impact will be reduced but may affect urban structure and infrastructure provision, settlement form and structure, and development economics
Habitat connectivity impact	Fragmentation of habitat and ongoing loss of connectivity between sup-populations is a significant ecological issue. These impacts occur at the site scale and cannot be estimated with any accuracy. However, in the long term this could contribute to the local extinction of sexually reproducing *T. juncea* populations in small areas (say 500 plants or less) and leaves these populations vulnerable to extreme events such as bush fires, weather, or weeds or pathogens

A number of potential risks should be considered in the impact assessment. Anticipated risks are as follows:

1. Data uncertainty – The assessment is based on modelled habitat. However, the modelled habitat area excludes about 30% of all *T. juncea* records within the LMCC flora database and is likely to underestimate total *T. juncea* habitat within the LGA. It is also important to note that the number of records does not represent the actual number of plant clumps as one record may refer to an area of habitat or a number of clumps. Much of the modelled habitat area has not been surveyed, and the LMCC flora database does not accurately represent the total number of *T. juncea* clumps recorded within the LGA but this is estimated at anywhere between 25,000 and 150,000+. However, the density of *T. juncea* is highly variable with densities of up to 340 clumps/ha having been recorded.
2. Variation in rate of development - Changes in the rate of urban development may reduce or increase the area of land affected by development.
3. Non development threats are unpredictable – The potential threats to *T. juncea* identified in Section 5 are unknown and unpredictable. In particular, environmental risks such as major weather events or climate change are also a potential risk, which may affect the assessment, but the impacts of these cannot be estimated, and may affect the species over part or all of its distribution.
4. Extent and success of ameliorative measures – Measures to mitigate or offset impacts may affect impacts, however their consequences are unknown at this time.

In addition to impacts on *T. juncea*, the presence of the plant on sites has impacts on development. These impacts may include reduction in development yield, the cost of providing offsets, impacts on urban form and structure through protecting *T. juncea* populations

on-site in reserve areas. These lead to increased development costs and unviable development in certain situations, with economic and social consequences. Many of these impacts only become significant where land use planning has failed to adequately consider *T. juncea* impacts early in the process and development expectations cannot be met, resulting in costs because opportunities are unable to be realised.

7. Review of potential ameliorative measures

This section reviews avoidance, mitigation and offset measures that are available. Consideration of options is outside the scope of the review because of the uncertainties associated with the geographic and time scales assessed. Nevertheless, it provides a basis for developing options as planning progresses.

Under the current policy adopted by Council (Payne 2000), 75% loss can occur from any development site, with minimal consideration given to connectivity. The consequence of this approach has been the retention of 25% of plant clumps on development sites where *T. juncea* occurs, but this has not been able to effectively consider the context of the site, and the importance of adjoining populations including their size and connectivity. While it has been consistently applied, it has resulted in the protection of *T. juncea* populations enclosed by urban development and where the long-term survival of the plants cannot be assured as a result of urban impacts.

There is also no specific offset requirement currently in place to compensate for the loss of plants, although this is considered on a case by case basis. Some individual development proposals have included offset measures for *T. juncea*, such as the Wallarah Peninsula development where around one third of plants were retained. However, most offset outcomes are not well documented and long land tenure arrangements are not necessarily secure. The Office of Environment and Heritage Biobanking Assessment Methodology is one tool available for assessing compensatory measures, but has been difficult to apply in practice. The Council's draft Biodiversity Offets Policy calculator is intended to be used to determine the acceptability of offset arrangements, and proposed a replacement ratio of 5:1 for threatened plants, including *T. juncea*. Based on the anticipated loss of habitat and the plant clumps that may be affected by development, the draft proposal could require up to 12,500 ha of offset land to be protected for *T. juncea* or in the order of 500,000 plant clumps to be protected in reserves. At this time, it is hard to determine if this could be achieved in practice.

A strategic approach to *T. juncea* conservation would be best achieved through a local biodiversity offset policy and accompanying strategy. This would also identify proposed conservation reserves, the achievement of which could be progressed through offset measures.

Measures to be implemented to ameliorate impacts would include the following:

- Ensuring detailed flora surveys (and *T. juncea* counts) are undertaken at the strategic planning stage of development prior to rezoning of land
- Adopting a biodiversity offsets policy and consistently applying offset measures (e.g. replacement ratio) to compensate for development losses
- Consideration of options to avoid *T. juncea* habitat loss at all stages of the planning process
- Improving the security of land on which *T. juncea* occurs, including enlargement and establishment of new conservation reserves to protect habitat
- Undertaking management and monitoring measures to improve land management practices on Council reserves and other land with *T. juncea* plant clumps.

It could be expected that if the above measures were implemented, impacts on *T. juncea* within the Lake Macquarie LGA would be substantially less than if all the potential development currently envisaged was to occur with no regard to avoidance, mitigation and offset measures in place.

8. Strategic assessment

Notwithstanding uncertainties about potential development affecting *T. juncea* habitat, and its biology and population, it is possible to review both the scale and potential impacts that could occur on this species over the next 50 years. This timescale is the minimum necessary to be able to effectively plan for the conservation of the species within developing urban areas.

Around 25% of *T. juncea* habitat within the Lake Macquarie LGA is potentially directly affected by development, as indicated by its urban ecological planning setting in Map B4. Accurate population numbers affected cannot be determined due to inadequate and inconsistent surveys across its range, and an inability to determine site-specific impacts early in the planning and development process. Estimated annual loss of *T. juncea* habitat at current rates is

probably approximately 10 – 25 ha per year in the LGA. This means that over 50 years the loss is likely to be up to about 1,000 ha of habitat and approximately 40,000 plants. While the future of the 60% of *T. juncea* habitat in a transitional ecological planning setting is not assured, existing populations on that land are not expected to be significantly reduced unless a substantial change to current land use or management practices occurs.

Around 15% of modelled *T. juncea* habitat is in conservation reserves, but this represents an unknown proportion of the actual population, and is not representative of the species across its full range. There are no reserves in the areas of highest development, other than small populations retained on Council reserves, on which long term survival is not assured. A priority should be to establish more conservation reserves containing *T. juncea* habitat to meet relevant targets in the Lower Hunter Regional Conservation Plan 2009.

The largest single projected development impacts on *T. juncea* habitat appear to be:

- Urban development in the Western Corridor (much of which is currently approved, but some is subject to further investigation)
- Urban development in the Wallarah Peninsula (most of which is currently approved or already committed)
- Urban Growth NSW projects (affecting over 400 ha of *T. juncea* habitat)
- East Coast High Speed Rail (affecting about 270 ha of *T. juncea* habitat, and potentially resulting in significant habitat fragmentation and loss of connectivity)

Land use planning measures have the potential to substantially avoid development impacts on *T. juncea* development and there is also scope for mitigation of impacts. Given longer term certainties over a 50 – 100 year timeframe it is important to determine what further losses of habitat can be tolerated, and what biodiversity criteria should be applied in determining the long term urban structure and the potential options and necessity for future greenfield development.

Conservation reserves can be pursued separately to development planning, but investigations early in the development process are much more likely to achieve effective reserves. Areas where there is a higher priority for new or extended reserves are indicated on Map B4, and it appears that adequate suitable land is potentially available at present to be able to establish reserves of a suitable size and in appropriate locations to effectively conserve the species.

The fragmentation of *T. juncea* populations and long-term impact of this on the viability of small sub-populations is unknown but could expect to negatively impact on overall genetic diversity. This issue requires further investigation over time, and guidelines for retaining habitat connectivity should be considered in land use planning proposals.

Offsetting arrangements, such as a *T. juncea* specific offsetting program within Lake Macquarie LGA would contribute substantially to the ability to provide adequate conservation reserves that can protect the species in the long term. Without a biodiversity offsetting framework for *T. juncea*, it is likely that some development in strategic locations would be prevented from occurring, or urban structure and layout would be adversely affected. Furthermore, without this, establishment of large, viable conservation reserves with appropriate boundaries may be more difficult to achieve.

It can be concluded that *T. juncea* has a long-term future in the Lake Macquarie landscape, although it can be expected that in some areas of the LGA where habitat fragmentation and urban development is significant, it will become locally extinct and only small, isolated non-viable patches will persist in the foreseeable future.

While there are socio-economic consequences of foregone development opportunities as a result of avoiding impact on *T. juncea* populations, much of this can be avoided through effective strategic planning. The major impact would arise from a small increase in development costs attributed to the provision of biodiversity offsets where impacts cannot be avoided or mitigated. Development industry estimates included in the socio-economic assessment of the draft Lake Macquarie Biodiversity Offsets Policy in 2011 indicated that offsets (where required) could be contribute to between 2 - 5% of the overall land cost in a new development and are relatively insignificant when compared to other factors influencing development costs.

The information contained within this strategic assessment is current at the time of preparation. Review and updating of the conclusions of this strategic assessment should occur over time having regard to new *T. juncea* data and updated land use planning information.

Appendix C

Lake Macquarie City Council Flora and Fauna Survey Guidelines for *T. juncea*

Section 8.7.1 of the Lake Macquarie City Council Flora and Fauna Survey Guidelines (LMCC 2013) includes specific survey guidelines for *T. juncea* which are reproduced below:

Survey

The location and number of plant clumps on the site is to be documented and accurately mapped as this is used to estimate the size of the population on site and assess development options. Plant clumps are defined by using the Technical Note prepared by Payne, Stevenson and Wellington (2002). However, this counting method has been shown to under predict the real number of individual plants or non-genetically related ramets for a group of plants at Awaba Bay (Jones 2011). Further research is being conducted in order to determine a more accurate counting technique. Until this research is available, the Payne, Stevenson and Wellington (2002) method will continue to be used.

All plant clumps within 500 m of the development site also require assessment and mapping. This is required to assess:

- the spatial arrangement of the plant clumps,
- likelihood of pollinator movement, and
- whether the loss of certain plant clumps would jeopardise long-term viability of plant clumps over a wider area.

The accepted method of assessment for *T. juncea* is to conduct one survey during the peak flowering period that has now been confirmed to be mid September to mid-October (C Driscoll pers. comm. 2012).

Any survey conducted outside this period will be unable to locate and map all the plant clumps occurring on a site. Habitat suitability can be mapped and assessed, however, this is considered inadequate for the purposes of determining the disturbance footprint for a development unless all the habitat is avoided.

Survey procedure should be conducted in accordance with the Australian Government referral guidelines for the vulnerable Black-eyed Susan, *Tetratheca juncea* (http://www.environment.gov.au/epbc/publications/pubs/black-eyed-susan-referral-guidelines.doc, DSEWPaC 2011a), and the SPRAT profile for Black-eyed Susan (www.environment.gov.au/cgi-bin/sprat/public/sprat.pl) without the determination of peak flowering period.

T. juncea Assessment

The Lake Macquarie*T. juncea* Conservation Management Plan indicates that to adequately conserve a population on a site, approximately 75% of plant clumps must be conserved, with a native vegetation corridor linking the plant clumps to be conserved to other native vegetation. Plants within a 20 m buffer are not counted as being conserved.

Should substantially more than 25% of plant clumps be lost, this is considered to have a significant impact and a SIS likely to be required.

Other matters that need to be considered are:

- The spatial relationship and connectivity of plant clumps within 500 m of the development site
- Number of individuals affected
- The patch size of the native vegetation that the plant clumps occur within
- Whether the plant clumps occur at the edge of suitable habitat ie near a barrier that is unlikely to be able to be regularly crossed by native bees

Research on *T. juncea* is on-going. It is likely that the *T. juncea* Conservation Management Plan (adopted by Council on 12 June 2001) will be updated. Council will use a combination of the Conservation Management Plan, the latest research and the approach adopted by the Australian Government (DSEWPaC 2011a) in undertaking assessments and making decisions about this species until the Conservation Management Plan is reviewed.

Appendix D

Standardised Method for Counting Black-eyed Susan Populations (from Payne et al. 2002)

The Black-eyed Susan may form simple clumps which are a series of flower stems that all emerge from a singlet rootstock at a point. These morphological types create no difficulty in counting plant clumps. However, in some more exceptional circumstances complex plant clumps of the species exist that are large and/or have large rhizome systems which can be extensive. The rootstock in these circumstances may form subsidiary vegetative shoots, known as ramets, which rise above the ground adjacent to the main plant, but at separate nearby points on the ground. It is these more 'complex plant clump' forms which are causing some difficulty with censusers.

It is often not possible to determine whether the adjacent plant clumps are joined or are separate plant clumps, without extracting the plants from the soil. Therefore, to standardise the methodology for the census of a sub-population and decrease the discrepancy in estimating sub-population size, it is proposed that a standard distance measure between clumps be employed. Not all error will be eliminated by this procedure but the census process can thus be standardised.

For the purpose of standardising any future census, it is proposed that a distance of 30 centimetres be adopted to delineate between adjacent clumps. Any distance greater than 30cm would mean that the clumps would be considered to be separate plant clumps. Clumps which appear to be separate plant clumps (ie stems converging to a single rootstock) but which are within a distance of 30cm of other adjacent clumps should be counted as a single plant clump. What should be considered a single plant clumps is illustrated in the figure.

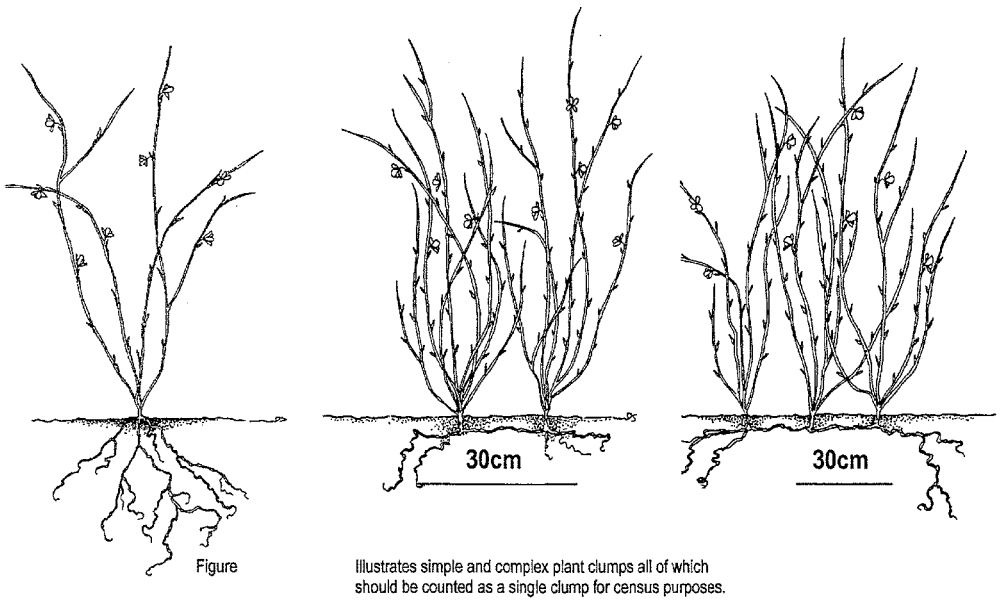


Figure Illustrates simple and complex plant clumps all of which should be counted as a single clump for census purposes.

Appendix E

Outline of process of preparing the guidelines and scientific workshops

The planning and management guidelines follow a review of information about the science and distribution of *T. juncea.* Key steps were:

- Lake Macquarie City Council commissioned a review of scientific knowledge of the species from Colin Driscoll (2009)
- A scientific workshop in 2009 reviewed the information and resulted in published referral guidelines (SEWPaC 2011)
- A scientific workshop was held on 3 April 2012 to consider updated survey guidelines and planning and management requirements
- Draft planning and management guidelines prepared by Lake Macquarie City Council in August 2013
- Draft Lake Macquarie *Tetratheca juncea* Planning and Management Guidelines were publicly exhibited from September to November 2013. Consultation also took place with the development industry and ecological consultants.
- A technical review workshop to review the exhibited document was held in October 2013

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