Appendix A

Desktop Searches

National Recovery Plan for *Acacia attenuata*

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Australian Government

Queensland Government
Environmental Protection Agency
Queensland Parks and Wildlife Service

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Cover photograph: *Acacia attenuata* (Sippy Creek, Maroochy Shire. 2005). Inset - distinguishing features of *Acacia attenuata* (persistent bipinnate foliage and phyllodes) (Judy Henzell Park, Caloundra Shire. 2005). Photos by Heather Brownlie.

Contents

Executive Summary

Species description
Acacia attenuata belongs to the Family Mimosaceae and is a slender, perennial shrub that is endemic to south-east Queensland. The species is distinguished by the retention of juvenile bipinnate foliage that persist in the presence of adult phyllodes.

Current species status
Acacia attenuata is listed as 'Vulnerable' under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Queensland Nature Conservation Act 1992* (NCA).

Habitat and Distribution Summary
A. attenuata is confined to high rainfall areas on the coastal lowland sand plains of southeast Queensland. The species grows on seasonally waterlogged, infertile sandy soils or peat swamps and typically occurs in wet heathland and layered eucalypt open forest ecotones. *A. attenuata* has a restricted geographic range and is currently known from 24 wild populations and two established *ex situ* populations. Of these, 11 populations occur on State and Local Government-managed reserves. In the southern reaches of the species range, *A. attenuata* is scarce, being known only from a single isolated population. In contrast, populations are more frequent in the central region but are generally small, confined to urban areas and are threatened by human disturbance, the potential for land clearing on private land and small population size. In the northern region, five known populations exist and four are secured on protected land.

Threats summary
Based on current knowledge of the biology, ecology and distribution of *A. attenuata,* the persistence of this species is mainly threatened by the loss and fragmentation of suitable habitat through urban development along the coastal plains of southeast Queensland. Other known threats include inappropriate fire regimes, habitat degradation from conflicting land use activities in urban areas, weed invasion and competition and damage inflicted by site maintenance operations. Potential threats include modification of hydrological regimes and small population size.

Recovery objectives
The primary objective of this recovery plan is to ensure the long-term persistence of *A. attenuata* in the wild by preserving (restore, maintain or enhance) known populations through the management of identified threats. The specific objectives aim to determine the species distribution, maintain or enhance known populations through the abatement of identified threats, increase the number of populations on protected land, promote public awareness of *A. attenuata* and increase knowledge of the species biology and ecology.

Summary of actions
The recovery actions relate specifically to the threats identified for *A. attenuata.* For example, field surveys, database assessments and habitat modelling will allow for verification of the species distribution and improved conservation and management of populations. Actions focusing on improved habitat management will enable threats posed by inappropriate fire regimes, invasive weeds and site maintenance operations to be addressed. Negotiating conservation agreements will help secure populations on private land and reduce the threat of habitat loss, whilst the species inclusion in revegetation projects will assist in the enhancement of population fragments. Establishing public education programs will increase awareness of and promote involvement in the recovery of *A. attenuata*. Population monitoring programs will provide knowledge relevant to the species recovery.

1. General information

1.1 Conservation Status

Acacia attenuata is listed as 'Vulnerable' under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and under the Queensland *Nature Conservation Act 1992* (NCA).

1.2 International obligations

A. attenuata is not listed under any international agreements. This recovery plan is consistent with Australia's international obligations.

1.3 Consultation with Indigenous people

Aboriginal Land Management Facilitators from two Natural Resource Management (NRM) regional bodies (South East Queensland Catchments and Burnett Mary Regional Group) were consulted in the development of this recovery plan. Representatives of indigenous groups from southeast Queensland were provided with the draft recovery plan for comment. No responses were received. Involvement from indigenous groups in the implementation of this recovery plan will be encouraged where appropriate.

1.4 Benefits to other species or communities

The implementation of this recovery plan will assist in the protection of habitat occupied by other associated threatened flora and fauna species, listed threatened ecosystems and habitat that acts as important vegetation corridors (Table 1).

Table 1: Associated threatened flora and fauna species listed under the NCA and EPBC Act (Status: R, Rare; V, Vulnerable; E, Endangered), threatened ecosystems listed under the *Vegetation Management Act 1999* (VMA) (Status - OC, 'Of Concern'), other habitat areas.

Other Classes	Examples	NCA	EPBC
Associated threatened flora species	• *Acacia baueri* (tiny wattle)	V	-
	• *Blandfordia grandiflora* (christmas bells)	R	-
	• *Boronia rivularis* (Wide Bay boronia)	R	-
	• *Boronia keysii* (Key's boronia)	V	V
	• *Eucalyptus conglomerata* (swamp stingybark)	E	E
	• *Melaleuca cheelii*	R	-
	• *Schoenus scabripes*	R	-
Associated threatened fauna species	• *Crinia tinnula* (acid frog)	V	-
	• *Litoria olongburensis* (acid frog)	V	V
	• *Litoria freycineti* (acid frog)	V	-
	• *Pezoporus wallicus* (ground parrot)	V	-
	• *Rallus pectoralis* (lewins rail)	R	-
	• *Phascolartos cinereus* (koala*)	V	-
		VMA	
Threatened regional ecosystems	▪ 12.2.13 (Open/Dry Heath on Quarternary coastal dunes)	OC	
	▪ 12.3.13 (Closed heathland on seasonally waterlogged Quaternary alluvial plains - coastal lowlands)	OC	
	▪ 12.3.14 (*Banksia aemula* woodland on alluvial plains)	OC	
Other significant habitat areas	• Vegetation corridors along watercourses, road and rail verges that link areas of suitable or similar habitat, maintain connectivity and promote gene flow (i.e. habitat adjacent to Mooloolah NP, Mouth of Kolan River CP).		

* *Phascolartos cinereus* (koala) listed as 'Vulnerable' in the southeast Queensland bioregion only

1.5 Social and economic impacts

Implementation of this recovery plan is unlikely to cause any significant adverse social or economic impacts. Of the 24 known wild populations, 11 occur on State or Local government managed reserves. Protection of populations and habitat on private land will be negotiated via voluntary conservation agreements.

1.6 Affected interests

Acacia attenuata exists over a range of land tenures and implementation of this recovery plan may affect and/or require involvement from the following stakeholders (Table 2).

Table 2: Stakeholders (organisations/individuals) that may be affected by or participate in, the implementation of this recovery plan.

Stakeholder Groups	Examples
Environmental Protection Agency/ Queensland Parks and Wildlife Service (EPA/QPWS)	• Queensland Herbarium • EPA/QPWS - Gold Coast District, Sunshine Coast District, Great Sandy District, Wide Bay / Burnett District
Natural Resource Management (NRM)	• NRM South East Queensland (NRM SEQ) • Burnett Mary Regional Group (BMRG)
Local councils	• Gold Coast, Caboolture, Caloundra, Maroochy, Noosa, Cooloola, Maryborough, and Burnett Councils
Private landholders	• Caloundra, Maroochy, Noosa and Burnett Shires
Educational Institutions with on-site populations	• Golden Beach • Mountain Creek Schools • University of the Sunshine Coast (USC)
Research Groups	• University of the Sunshine Coast (USC)
Development / Property Groups	• Stockland and other relevant Property groups
Natural Resources Mines and Water (NRMW)	• South East Queensland
Service Providers	• Energex / Ergon • Queensland Department of Main Roads (Wide Bay/Burnett branches and contracted works teams)
Interested Community groups	• Wilderness Preservation Society of Queensland (WPSQ) • Cooloola Coastcare • Society for Growing Australian Plants (SGAP) • Waterwatch
Conservation groups	• Greening Australia Queensland

2. Biological Information

Biological and ecological information for *A. attenuata* has been derived from a review of published and unpublished literature (i.e. Herbarium and Wildnet collection notes, species profiles, honours thesis, and local council and consultant reports), personal communications, and field observations.

2.1 Species description

Acacia belongs to the Family Mimosaceae and is a cosmopolitan genus comprised of over 1350 species that worldwide, inhabit tropical, subtropical and warm temperate regions (Maslin *et al.* 2003). In Australia, *Acacia* is the largest genus of vascular flora. *Acacia attenuata* belongs to the subgenus *Phyllodineae,* section *Phyllodineae* (Maslin 2001). The species was first described by Maiden and Blakely in 1927 from specimens collected in the Beerwah area by C.T. White in 1922 (Pedley 1987).

A slender, glabrous (hairless) shrub, *A. attenuata* grows up to 3-4m and is distinguished by the retention of juvenile bipinnate foliage that persist in the presence of adult phyllodes and when reproductively mature (Maslin 2001; Figure 1). Branchlets may be red in colour during the juvenile life stage and are generally terete (circular in cross-section) and glabrous. The blue-green glabrous phyllodes exhibit a prominent midrib, are 10-14cm long and 0.7-1.6cm wide, straight to shallowly curved, obtuse or acute at the apex and attenuated at the base (Maslin 2001; Figure 1). The glands immediately above (1-5mm) the pulvinus (enlarged portion of leaf stalk) are not prominent (Stanley and Ross 1983). Inflorescences (flower clusters) are cream to pale yellow, consist of 20-35 globular flowers arranged in 6-14 branched axillary racemes (Stanley and Ross 1983). Fruit development may commence around June / July and pods reach maturity in Spring (October-November). The glabrous seedpods are slightly flat, narrowed between the seeds and are dark brown and approximately 8-10cm long and 1.3-1.4cm wide at maturity (Figure 1). The hard-coated seeds are dark brown, 5-6mm long and encircled (1/2-3/4) by a dry funicle (attachment).

A. attenuata is most closely related to and resembles *Acacia rubida,* the latter being distinguished by its phyllodes that dry a reddish colour, glands 1-4cm above the pulvinus and narrower pods (Maslin 2001). The species may be confused with the widespread, common species *Acacia falcata* although the narrower, almost straight phyllodes and broader pods of *A. attenuata* distinguish it from this species (Queensland CRA/RFA Steering Committee 1998).

2.2 Distribution

A. attenuata is endemic to south-east Queensland and is confined to high rainfall areas on coastal lowland sand plains in the South-east Queensland Bio-region and the South-East Queensland and Burnett Mary NRM regions (Appendix 1). *A. attenuata* has a restricted geographic range of approximately 400km, which extends from Littabella National Park north of Bundaberg to Burleigh Heads on the Gold Coast (Figure 2). The species is rarely found more than 30km inland and is absent from offshore islands (Stanley and Ross 1983). *A. attenuata* is distributed across eight Local Government Areas (LGA), and three population clusters, referred to as the southern (Gold Coast to Caboolture Shire), central (Caloundra to Cooloola Shire) and northern (Maryborough to Burnett Shire) regions (Figure 3).

Based on Queensland Herbarium (EPA/QPWS) collection records, 50 collections had been made from approximately 30 sites between 1922 and 2003. Field studies conducted in 2005 confirmed that 24 populations remain in the wild and two *ex situ* populations (revegetation plantings) have been established (Brownlie 2005) (Table 4, Secure Appendices). These populations occur across various land tenures including:

EPA/QPWS reserve estates (National Parks, NP; Conservation Parks, CP; Forest Reserves, FR), Council Reserves (CR), State land and freehold land. Of the 24 wild populations, 11 occur on protected land and are located at Littabella NP, Littabella FR, Burrum Coast NP, Poona NP, Cooloola NP, Mooloolah NP, Palmview CP, Tewantin FR (2), Kalana Road CR and Burleigh Knoll CP (Table 4).

A. attenuata is now extremely scarce in the southern region, being known only from a single, small and isolated remnant at Burleigh Knoll CP (Pedley 1987, Brownlie 2005). Populations are more frequent (20) in the central region although many are small (<100 plants) and are confined to fragments in urban areas. The persistence of these populations is uncertain due to the frequency of anthropogenic disturbances and the potential for land clearing on private land. In the northern region, five known populations exist and four are secured in National Parks and Forest Reserves (Table 4). Queensland Herbarium records (EPA/QPWS), field observations and local knowledge (Tomlins *pers. comm.* 2005), suggest that a larger network of populations may exist on private land and council-managed land (i.e. Meadowvale Nature Park) between Moore Park and Littabella NP.

2.3 Identification of important populations

Important populations have been identified using preliminary assessments based on genetic distinctiveness, population size, habitat type and geographic location.

Genetic distinctiveness: Genetic assessment of 14 *A. attenuata* populations revealed comparable levels of genetic diversity within populations and low inter-population differentiation (Brownlie 2005; See Section 2.6). However, the detection of private and uncommon alleles (alternative form of a gene) in several northern and central region populations highlights these as being potentially significant (Appendix 2). The preservation of unique genotypes is important for maximising the species' adaptive capabilities and therefore its evolutionary potential.

Population size and viability: The largest populations of *A. attenuata* occur in the northern region (Littabella NP, Moore Park. Table 4). Larger size may confer greater demographic stability and viability. In addition, the existence of multiple *A. attenuata* subpopulations at several sites in the northern (Littabella NP, Burrum Coast NP) and central (Mooloolah NP, Palmview CP) region may enhance gene flow potential, reproductive success and ultimately the long-term viability of these populations.

Habitat variability: *A. attenuata* is known from several vegetation communities and representative populations of each are considered important. For example, populations are found in the ecotone between wet heathland and open eucalypt forests at Mooloolah NP, and in open woodland and open forest communities at Moore Park and Mountain Creek, respectively. Conservation of each of these ecological variants may facilitate this species adaption to environmental and climatic change.

Geographic location: Populations representative of each geographic region and those at the extremities of the species geographic range (i.e. Littabella NP/FR, North; Burleigh Knoll CP, South) are important for the conservation of this species. Inter-population differences (biological and ecological) would be expected due to spatial variation in environmental and ecological conditions and localized selection pressures (across this range).

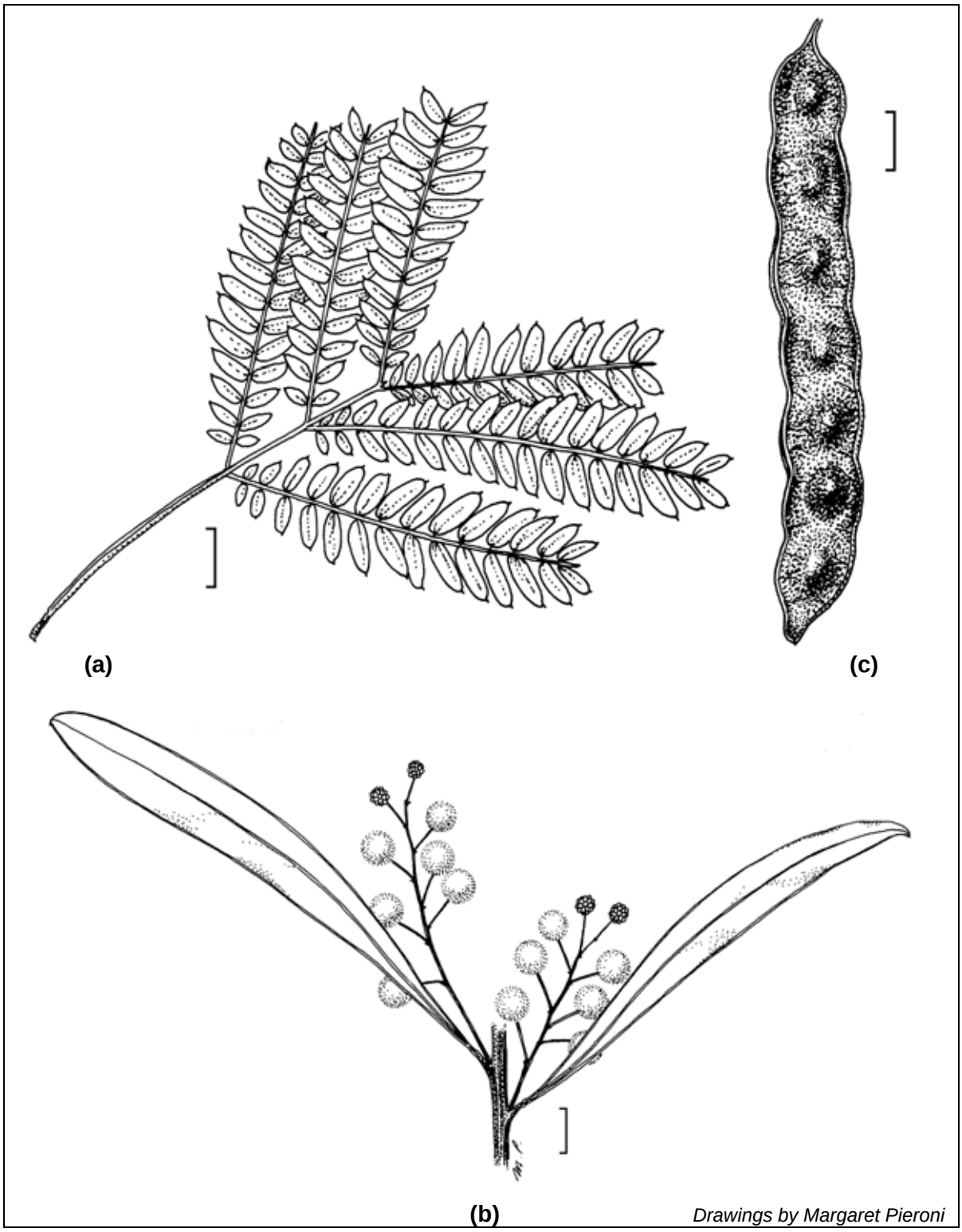

Figure 1: (a) Bipinnate foliage, (b) phyllodes and flowers and (c) seed-pod of *Acacia attenuata*. Illustration copyright Australian Biological Resources Study, previously published in Flora of Australia Volume 11A. Reproduced with permission of the artist Margaret Pieroni and ABRS.

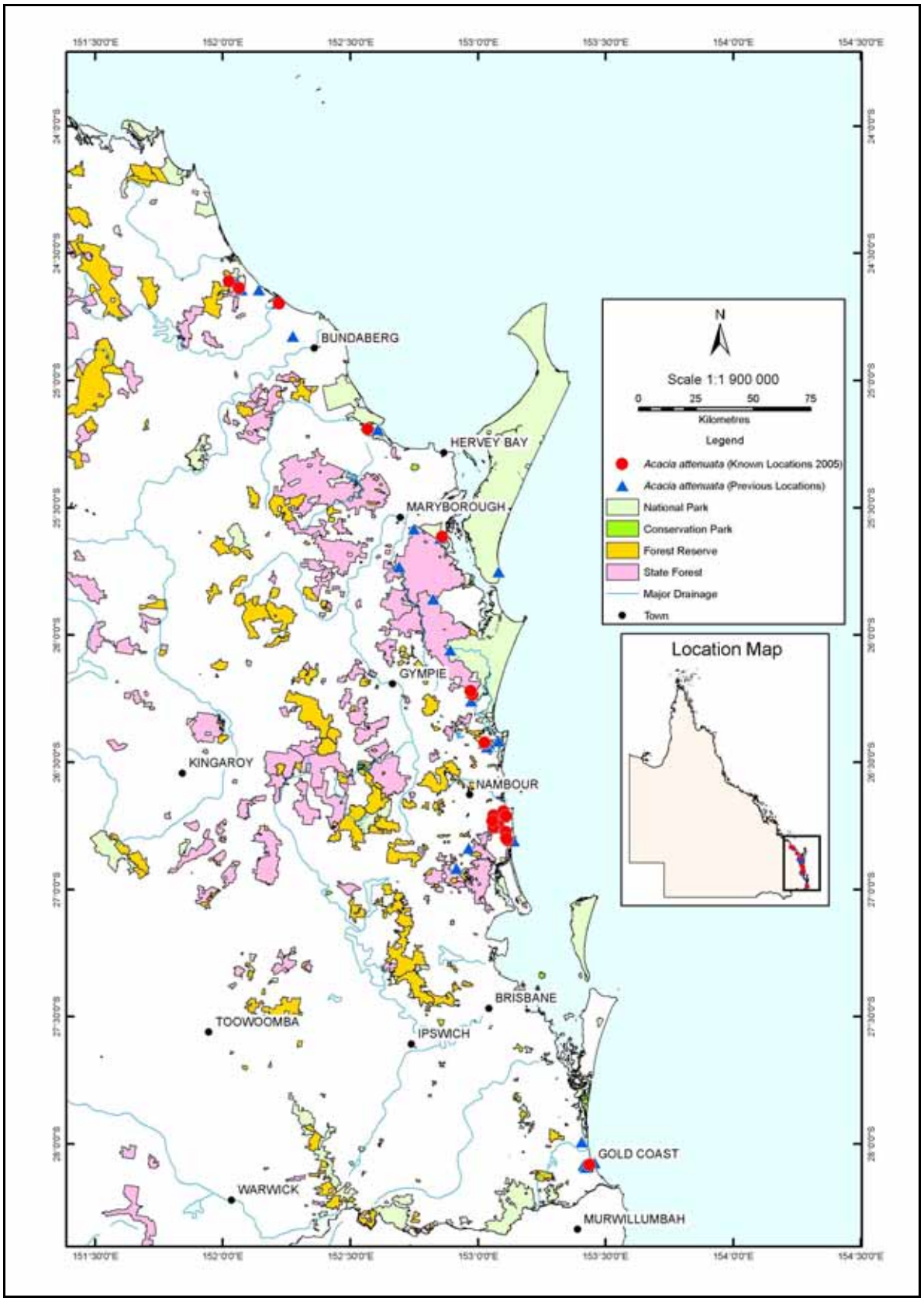

Figure 2: Locations of previous (Source: Queensland Herbarium Herbrecs database 2003) and currently known (Source: Brownlie 2005) collection sites for *Acacia attenuata.* Map produced by Spatial Systems, Technical and Support Unit, Parks Division (EPQ/QPWS).

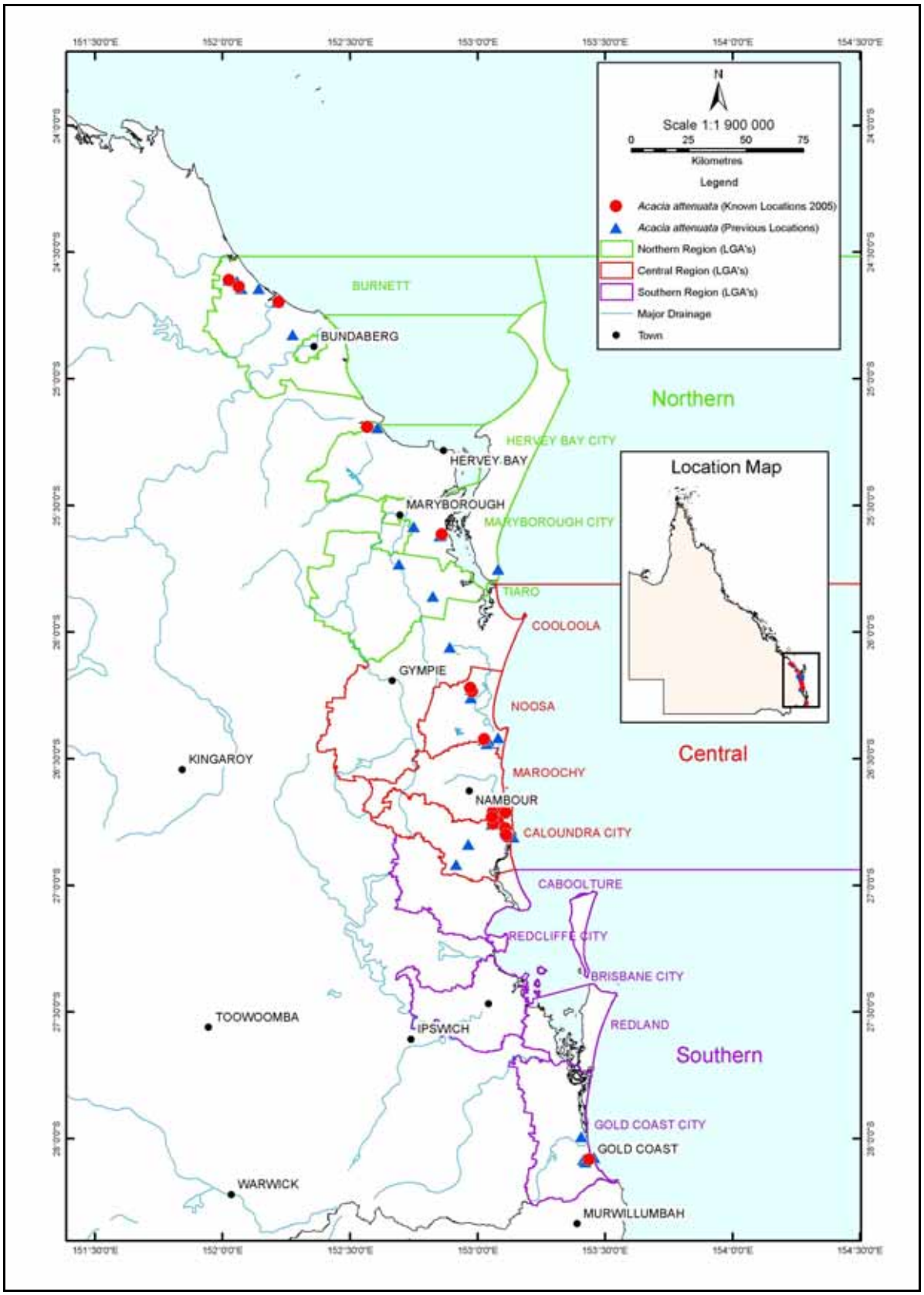

Figure 3: Distribution of previous and currently known *A. attenuata* collection sites within the southern, central and northern regions of the species known geographic range. Local Government Area's (LGA's) are identified within each region. Map produced by Spatial Systems, Technical and Support Unit, Parks Division (EPQ/QPWS).

2.4 Habitat description

A. attenuata is restricted to flats and low rises on coastal lowland plains, at altitudes less than 30m above sea level (Queensland CRA/RFA Steering Committee 1997). Queensland Herbarium (EPA/QPWS) collection notes and field observations (Brownlie 2005) indicate that the species typically occurs in seasonally waterlogged areas consisting of poorly drained and infertile sandy soils or peat swamps. The species occurs in several vegetation communities including wet heathland, layered eucalypt open forest, open woodland and shrublands (see Secure Appendices). *A. attenuata* is associated with Quarternary coastal dunes and sand plains (Open Heath), coastal Cainozoic alluvial plains (Closed Wet Heath) and Cainozoic to Proterozoic sediments and remnant tertiary surfaces (Open forest and Woodland) (Young and Dillewaard 1999).

A. attenuata is more commonly associated with the margin between wet heathland and open eucalypt forest communities. In heathland, *A. attenuata* occurs in association with *Banksia aemula, B. robur* and *Leptospermum liversidgei;* in woodland with *Eucalyptus robusta* and *Banksi oblongifolia;* in layered eucalypt open forest, with *Eucalyptus pilularis, E. racemosa, E. conglomerata* 'Endangered' (NCA, EPBC Act) and *Melaleuca quinquenervia*; in open woodland with *Eucalyptus umbra* and *Banksia oblongifolia* and in shrublands with *Baeckea frutescens, Eleocarpus reticulatus* and *Leptospermum whitei.*

As a pioneer species and heliophyte (adapted to high light environments), abundances are usually greater in areas of high light intensities such as along forest margins and in open heathland plains. Although *A. attenuata* tolerates shaded sites, it is generally less abundant at these sites. The species has been observed at sites recently cleared of native vegetation, along power line easements and disturbed by slashing and road grading and as an emergent at newly logged sites and on soil stock piles. Although cleared areas and roadsides are not the preferred habitat, the species' ability to tolerate some level of disturbance has enabled it to persist in these areas.

Regional Ecosystems containing *A. attenuata* include: 12.2.13 (Open or Dry Heath, *Vegetation Management Act 1999* (VMA) status in 2005*:* Of Concern); 12.3.13 (Closed heathland on seasonally waterlogged Quarternary alluvial plains along coastal lowlands; VMA Status - Of Concern); 12.9-10.4 (Open Forest to Woodland dominated by *Eucalyptus racemosa;* VMA Status - Not of Concern); 12.3.14 (*Banksia aemula* woodland on alluvial plains; VMA Status - Of Concern) and 12.3.5 (*Melaleuca quinquenervia* open-forest to woodland; VMA Status - Not of Concern) (see Secure Appendices).

2.5 Habitat critical to the survival of the species

Based on current knowledge of the geographic distribution and area occupied by *A. attenuata*, it is evident that the species shows a close association with the ecotone between wet heathland and open eucalypt forest communities (See Section 2.4 for habitat descriptions based on Regional Ecosystem classifications). In these low-lying coastal habitats, soils are sandy / peaty and sites are seasonally waterlogged. These conditions and respective communities are considered essential for the survival of this species as they represent potential habitat for population expansion and corridors for pollinator movement. Due to the restricted extent of communities such as heathland in southeast Queensland (Queensland CRA/RFA Steering Committee 1997), Mary Maher and Associates (1998) proposed that all remaining areas of heathland should be afforded protection from the impacts of land clearance and habitat degradation.

2.6 Life history and ecology

Reproductive biology

A. attenuata flowers from April to August and inflorescences (flower clusters) consist of both male and bisexual flowers on the same plant (Maroochy Shire Council 2001). Similar to other *Acacia* species, pollination is likely to be by non-specific insects (New 1984, Queensland CRA/RFA Steering Committee 1998). No specific pollinators have been identified although exotic honey bees (*Apis mellifera*) have been observed as floral visitors (Brownlie 2005).

Seed pod development may commence around July and pods reach maturity in mid-Spring (October - November) to early Summer (Deanne *pers. comm.* 2006). Seed dispersal is primarily over a short distance and is effected by gravity or possibly forcible ejection from dehisced (open spontaneously when ripe) pods (Queensland CRA/RFA Steering Committee 1998). The presence of a dry funicle encircling the seeds may promote secondary seed dispersal by ants. Fruits are not usually retained on the parent plant and are mostly dispensed during the season of production. No information is currently available on the period of seed viability.

Reproduction occurs mostly from seed (Queensland CRA/RFA Steering Committee 1998) although vegetative regeneration from damaged stems and surface roots has been observed in response to mechanical disturbance (slashing, road grading, soil cultivation) (Brownlie 2005). The period of viability for soil stored seed is unknown, however observations of pods containing seed and retained on plants until late in the fruiting season (December to January) revealed heavy insect infestation and a reduction in the quantity of viable seed in comparison to mature pods observed early in the fruiting season (October to November) (Deanne *pers. comm.* 2006). Collection and propagation of seed by Greening Australia Queensland indicated seed dormancy, a common trait among other hard-seeded *Acacia* species (Vanbeek *pers. comm.* 2006, New 1984)

Longevity and population dynamics

A. attenuata is a perennial shrub and field observations suggest a life span of between five and ten years (Brownlie 2005). Previous reports estimated the period of longevity to be up to 20 years (Department of the Environment and Heritage 2006). As a fast growing pioneer species, *A. attenuata* reaches heights of up to 2m within the first year, has a juvenile period of approximately two years (three years at most) and senescence (process of aging and decline) may commence after approximately five to six years (Brownlie 2005).

Early reproductive maturation enables the accumulation of a persistent soil seed bank, which in other *Acacia* species, has been associated with an ability to successfully establish in bushland (Morgan *et al.* 2002). It also concurs with theories that obligate seeders maximize their fitness by investing in early reproduction, to ensure progeny are produced before the next fire (Knox and Morrison 2005). Consistent with other *Acacia* species, fire appears to play an important role in the recruitment patterns of *A. attenuata* (Brownlie 2005). As an obligate-seeder, parent plants are typically killed by fire and observations of dense, predominately juvenile stands at sites approximately one year after fire were indicative of mass recruitment events and an ability to accumulate large persistent soil seed banks (Brownlie 2005). Seedling recruitment from soil mounds has also been observed and is associated with physical damage to seed coats through soil cultivation.

Population Genetics

The results from a genetic assessment of 14 *A. attenuata* populations, representative of the species known geographic range, revealed high levels of genetic diversity in the species (Brownlie 2005). Genetic diversity at the population level was high in *A. attenuata* in comparison to the means reported for other endemic and widespread *Acacia* species. High levels of genetic diversity within populations and low levels of inter-population genetic differentiation, suggest that *A. attenuata* had a once wider, more continuous distribution within the species geographic range. In addition, the results indicated high historical gene flow rates, indicative of previous migration (i.e. seed/pollen dispersal) patterns. The genetic profiles of these populations suggest either: 1/ that gene flow is ongoing despite habitat fragmentation resulting from clearance of large tracts of suitable coastal lowland habitat in southeast Queensland over the last 30 to 40 years or: 2/ that time in isolation has been insufficient for the genetic consequences of reduced population size and increased isolation to be expressed. Higher resolution genetic analyses (eg using microsatellite markers) would be required to distinguish between these two alternatives.

Although surveyed populations do not appear to be at genetic risk, this may become a threat in the future due to the small size of many central region populations and *A. attenuata's* disjunct population system (Brownlie 2005).

3. Threats

3.1 Biology and ecology relevant to threats

As a pioneer species, *A. attenuata* favours environments of high light availability and is often confined to forest margins. At sites close to or adjacent to residential areas, vegetation along forest margins is often subject to anthropogenic (human-induced) disturbances (i.e. clearing, disposal of garden refuse, slashing). Such disturbances and the potential for soil nutrient enrichment from residential run-off, encourages the establishment of invasive weeds and promotes high inter-specific competition. This in turn limits the expansion and reduces local abundances of native species.

A. attenuata grows on poorly drained sandy soils or peat swamps. The species appears to be sensitive to changes in soil moisture as it is absent from permanently waterlogged or slightly elevated and dry areas. Drainage of coastal lowland habitats for urban development may lead to the displacement of native species adapted to wet environments by those adapted to drier conditions. There is also the potential for long distance flood dispersal of seed to be impeded through drainage operations.

Similar to other *Acacia* species, *A. attenuata* requires disturbance, primarily from fire, to promote recruitment from soil stored seed banks (Brownlie 2005). Although the species responds to both natural (i.e. wild fires, damage from borers and animals) and anthropogenic (i.e. fires, clearing, slashing, road grading, soil cultivation) disturbances, sustainable recruitment patterns are dependent on appropriate disturbance regimes that account for the species juvenile period, longevity and seed viability period. Inappropriate regimes can adversely affect recruitment patterns and reduce population viability (See Section 3.2).

Small population size can have significant ecological and genetic impacts and influence population dynamics. Small populations may be vulnerable to chance demographic (i.e. disease epidemics) and environmental (i.e. fires, floods) events. Further, persistent small population size may erode genetic variation and reduce population viability.

3.2 Identification of threats

Based on current knowledge of the biology, ecology and distribution of *A. attenuata,* the following known and potential threats have been identified (1. Greatest threat; 7. Least threat).

Known Threats

1. Habitat loss and fragmentation.
2. Inappropriate fire regimes.
3. Habitat degradation from conflicting land use activities.
4. Damage from site maintenance operations (i.e. slashing, grading).
5. Weed invasion and competition.
6. Modification of hydrological patterns through drainage operations (Potential).
7. Small population size (Potential).

1. Habitat loss and fragmentation

The loss, fragmentation and degradation of native habitat in Queensland in response to human population growth, has placed major pressures on the State's biodiversity (Francis *et al.* 2003). The immediate effects of land clearing include the loss of biodiversity and connectivity (Chenoweth 2001). Many *Acacia* species exhibit naturally disjunct distributions due to specific edaphic (soil conditions) and climatic requirements (New 1984). However it is likely that the disjunct distribution of *A. attenuata* has been exacerbated through the reduction of suitable habitat by human activities (i.e. clearing for urban, agricultural and forestry development). For example by 1987, extensive clearing for urban development in southeast Queensland resulted in the loss of 71.5 percent of coastal lowland vegetation (Catterall *et al.* 1996).

Habitat fragmentation can adversely affect ecological and genetic processes and population dynamics (Frankham *et al.* 2003). For example plant reproductive processes may be altered through the reduction in size and change in spatial arrangement of plant and pollinator populations. This may in turn affect specialized plant-pollinator interactions, reduce pollinator efficacy and lead to declines in outcrossing rates and reproductive output (Mustajarvi *et al.* 2001, Rymer *et al.* 2005). Changes in mating system parameters (i.e. outcrossing rates) may promote inbreeding and reduce genetic diversity and eventually the fitness of populations (Young *et al.* 1996).

2. Inappropriate fire regimes

Fire is an integral factor in Australian ecosystems and many species and communities are dependent on and adapted to fire (Specht 1994). Field observations of 14 *A. attenuata* populations and assessment of site disturbance records indicated that prolonged fire intervals ($\geq$10 years) promote high inter-specific competition and greater canopy cover, limiting the species expansion beyond the first 10m to 20m of forest margins and reducing plant densities (Brownlie 2005). Population decline at the Springs site (Site 12, Table 4) was associated with fire exclusion for at least 15 years, an absence of seedling recruitment and recent high mortality due to senescence. Such low frequency regimes favour late successional species over disturbance-dependent species, as recruitment will be insufficient to compensate for losses due to senescence (Keith 2004).

High frequency fire regimes that are less than the juvenile period are detrimental as the current generation is lost and seed bank depleted without replenishment through recurrent germination (Regan and Auld 2004). For example, localised extinction of *A. attenuata* at Burleigh Knoll CP appears imminent as frequent wildfires (at least every two years) due to arson (Kennedy *pers. comm.* 2006), restricts the reproductive output of this predominately juvenile population. In the case of *Acacia latisepala,* a close

congener of *A. attenuata*, population declines were predicted for both short (< five years) and prolonged fire intervals (>20 years) (Clarke and Fulloon 1997). Many obligate seeding species of coastal heathlands in southeast Queensland are at risk from too frequent fires (Watson 2001). For coastal heathland and woodland habitats in southeast Queensland, fire regimes between seven and 20 years, with an emphasis on the eight to 12 year range, have been recommended for optimizing biodiversity (Watson 2001).

3. Habitat degradation

Clearing, waste disposal, arson and recreation: Damage to and destruction of native vegetation is particularly common along tracks within and along the edges of bushland in residential areas. Clearing of native vegetation (e.g. to extend suburban yards), dumping of waste (particularly garden refuse), damage from recreation activities (e.g. 4WD driving, horse riding, hiking off trails) and regular spot fires (e.g. arson), degrades native vegetation and reduces habitat integrity. Disturbance to native vegetation often creates bare soil, allowing for the establishment of weeds, which in turn compete with and may eventually displace native species.

Nutrient run-off: Residential run-off (enriched with fertilizer and pollutants) into native bushland, alters soil micro-environments and readily degrades native habitats such as heathland where vegetation is adapted to infertile (low in phosphorus and nitrogen) and acidic soils (Low 1997, Specht and Specht 1999). Nutrient enrichment favours the establishment of environmental weeds over native species (Low 1997). Although studies have found that heathland species may initially experience increased growth in response to nutrient enrichment, this is followed by an accelerated life cycle and early mortality (Specht 1963).

4. Damage from site maintenance operations

Damage to plants, disease and mortality have been observed at *A. attenuata* populations along roadsides and power line easements that are subject to road grading and slashing (Sites 6, 16, 18. Table 4). Road grading was identified as a factor responsible for the persistence and growth of roadside populations of *Acacia pycantha, A. montana* and *A. decora* (Spooner *et al.* 2004). Disturbance intervals of five years were responsible for promoting a 6.2 percent population increase in these species, over a three-year period (Spooner 2005). In contrast high frequency road grading (1-6 months) and slashing (1-12 months) regimes at *A. attenuata* sites may be detrimental to recruitment patterns and too frequent to promote population growth. For example, population decline at Tewantin FR (Site 16, Table 4) over a two-year period (2003–2005) was associated with the frequent loss of *A. attenuata* plants to slashing along power line easements (Moran *pers. comm.* 2006).

5. Weed invasion and competition

Threats posed by environmental weeds tend to be greater at sites where *A. attenuata* populations are confined to disturbed forest margins such as in urban areas and along power line easements. The establishment and spread of aggressive weeds threatens the integrity of ecosystems. For example, weed invasion has been identified as a key threat in the central region, particularly in damp eucalypt forests adjacent to housing developments where dumped garden waste re-sprouts, form thickets and alters micro-environments (Low 1997).

Weed species identified at *A. attenuata* sites that are listed as Declared Plants of Queensland and targeted for control under state legislation (*Land Protection (Pest and Stock Route Management) Act 2002*) include, asparagus fern (*Asparagus* sp), balloon vine (*Cardiospermum grandiflorum*), groundsel bush (*Baccharis halimifolia*), lantana* (*Lantana camara*: * Weed of National Significance) and singapore daisy (*Sphagneticola*

trilobata). Other environmental weeds include: cadaghi (*Corymbia torelliana*), wandering jew (*Tradescantia albiflora*) and umbrella tree *(Schefflera actinophylla)*. Lantana and cadaghi may however, not pose immediate threats to *A. attenuata,* as these do not tolerate being waterlogged (Hassall *pers comm. 2006).*

6. Modification of hydrological patterns and drainage operations (Potential)

A. attenuata occurs in poorly drained and seasonally waterlogged habitats, in lowland coastal areas where water tables are high. The species may be adversely affected by drainage operations in several ways. For example, increased drainage dries soil profiles and redirection of water could lead to prolonged waterlogging. Both outcomes could initiate the displacement of *A. attenuata,* which requires a stable moisture regime (Hassall 2002). Population dynamics may also be affected as growth periods and growth rates in *Acacia* species are often correlated with moisture regimes (New 1984). Furthermore, impediments to natural drainage patterns could adversely affect long distance flood seed dispersal of seed.

7. Small population size (Potential)

Small or declining populations may be more susceptible to stochastic factors (demographic and environmental) and the cumulative effects of inbreeding depression and genetic drift (Ellstrand and Elam 1993, Hedrick and Kalinowski 2000). Although genetic analysis of 14 *A. attenuata* populations showed that these were not genetically depauperate, persistent small population size may have genetic implications in the future, particularly if habitat fragmentation is preventing gene flow among populations. Furthermore, important ecological processes such as plant reproductive processes may in the long-term be adversely affected by small population size.

3.3 Areas under threat

Across the species geographic range, the distribution of threats is uneven. For example, many *A. attenuata* populations in the central and southern regions face greater threats as these are mostly confined to or in close proximity to urban areas. Threats identified at *A. attenuata* sites are summarized in Table 3 below and grouped according to Local Government Area (LGA).

Table 3: Summary of known and potential threats at *A. attenuata* sites. The presence (♦) or absence (—) of these threats in each Local Government Area (LGA) is indicated (see Figure 3 for location of LGA's). * Indicates areas under greatest threat.

Threat Type	Local Government Area and Geographic Region							
	GC* (S)	CL* (C)	MY* (C)	NS* (C)	CO (C)	MB (N)	HB (N)	BN (N)
1. Habitat loss and fragmentation	♦	♦	♦	♦	♦	—	♦	—
2. Inappropriate Fire Regimes	♦	♦	♦	♦	♦	—	—	♦
3. Habitat degradation	♦	♦	♦	♦	—	♦	♦	—
4. Damage from mechanical works	—	♦	♦	♦	—	—	♦	♦
5. Weed invasion and competition	♦	♦	♦	♦	—	♦	—	—
6. Modification of hydrological patterns [P]	—	♦	♦	—	—	—	—	—
7. Small population size [P]	—	♦	♦	♦	♦	—	♦	—

* LGA's: GC, Gold Coast; CL, Caloundra; MY, Maroochy; NS, Noosa; CO, Cooloola; MB, Maryborough; HB, Hervey Bay; BN, Burnett. * Geographic regions: S, southern; C, central; N, northern. [P] Potential threat.

3.4 Populations Under Threat

Specific threats identified at *A. attenuata* sites are summarized in Table 4. The 11 populations on protected land tenure are distributed across the three geographic regions, with most occurring in the central region. Some protected populations in urban centres (i.e. Burleigh Knoll CP, The Springs) are not secure due to habitat degradation from conflicting land use activities (within the reserves and on adjacent land) and arson.

Table 4: Status of the known *A. attenuata* populations [24 wild; 2 established *ex situ*] and a summary of threats identified at sites in 2005. Populations grouped according to geographic region (S, southern; C, central; N, northern, see Figure 3 for locations). See Table 3 for explanation for Type of Threat (1-7).

Site	Population Name	Region (S, C, N)	Population Size (2005)	Land Tenure / Trustee	Site Protection Status	Type of Threat (1-7)	Current actions to reduce threats
1	Burleigh Knoll CP	S	741	Conservation Park / EPA/QPWS	Protected	2, 3, 5	Park patrols and maintenance (fire breaks, weed control, rubbish collection).
2	Judy Henzell Park	C	80	Council Parkland / CCC	Unprotected	1, 2, 4, 6, 7	Unknown
3	Golden Beach School	C	<50	State Land / Qld Government	Unprotected	1, 2, 3, 5, 7	Unknown
4	Caloundra Sportsgrounds	C	<100	Sport & Recreation Reserve / CCC	Unprotected	1, 2, 3, 5, 6, 7	Unknown
5	Duck Hole Creek	C	<100	Bushland Park / CCC	Unprotected	1, 2, 3, 4, 5, 7	Unknown
6	Kalana Road Reserve	C	63	Bushland Park / CCC	Unprotected	1, 2, 3, 4, 5, 7	Unknown
7	Palmview CP	C	153	Conservation Park / EPA/QPWS	Protected	2, 5, 7	Interim Fire Management Strategy, Pest Management Proposal in progress
8	Lot 345 Palmview	C	<100	Freehold / Private	Unprotected	1, 2, 4, 5, 7	Nil
9	Bundilla	C	1474	Freehold / Private	Unprotected	1, 2, 3, 4, 5, 6	Unknown
10	Sippy Creek [R, E]	C	<100	Council Land / MSC	Unprotected	1, 2, 3, 4, 5, 6, 7	Signage (Greening Australia)
11	Mooloolah River NP	C	278	National Park / EPA/QPWS	Protected	2, 5	Interim Fire Management Strategy, Pest Management Proposal in progress
12	The Springs	C	58	Freehold / Private	Unprotected	2, 7	Nil

Trustee: CCC, Caloundra City Council; MSC, Maroochy Shire Council; NC, Noosa Council; Qld Government, Queensland Government. Site Protection Status: * Protected under Local Council law. [R] Revegetation sites. [E] Established *ex situ* populations, all others are wild populations. * Land Tenure - NP, National Park; CP, Conservation Park; FR, Forest Reserve; EP, Environment Park.

Table 4: Continued.

Site	Population Name	Region (S, C, N)	Population Size (2005)	Land Tenure / Trustee	Site Protection Status	Type of Threat (1-7)	Current actions to reduce threats
13	The Springs Reserve [R, E]	C	<100	Council Reserve / MSC	Protected *	1, 2, 3, 7	Signage, information booklets
14	Mountain Creek School	C	62	State Land / Qld Government	Unprotected	1, 2, 3, 5, 7	Fire and Weed Management Plan
15	Buderim Landfill Centre	C	<100	Council Freehold / MSC	Unprotected	1, 2, 3, 5, 6, 7	Nil
16	Tewantin FR (West)	C	153	Forest Reserve / EPA/QPWS	Protected	2, 4, 5, 7	Unknown
17	Scientific Area 37, Tewantin FR (East)	C	<100	Forest Reserve / EPA/QPWS	Protected	7	Unknown
18	Old Hollet Road	C	93	Road Reserve / NC	Unprotected	2, 4, 5, 7	Unknown
19	Walter Hay Drive	C	Unknown	Road Reserve / NC	Unprotected	Unknown	Unknown
20	Cooloola NP	C	161	National Park / EPA/QPWS	Protected	2, 7	Fire Management Plan
21	Dr Pages Road	C	Unknown	Freehold / Private	Unprotected	1, 2, 7	Nil
22	Poona NP	N	485	National Park / EPA/QPWS	Protected	2	Fire Management Plan
23	Burrum Coast NP	N	650	National Park / EPA/QPWS	Protected	3, 4	Fire Management Plan
24	Moore Park	N	2100	Freehold / Private	Unprotected	1, 2, 4, 5	Weed management
25	Littabella NP	N	3848	National Park / EPA/QPWS	Protected	4	Fire Management Plan
26	Littabella FR	N	Unknown	Forest Reserve / EPA/QPWS	Protected	Unknown	Unknown

Trustee: CCC, Caloundra City Council; MSC, Maroochy Shire Council; NC, Noosa Council; Qld Government, Queensland Government. Site Protection Status: * Protected under Local Council law. [R] Revegetation sites. [E] Established *ex situ* populations, all others are wild populations. * Land Tenure - NP, National Park; CP, Conservation Park; FR, Forest Reserve; EP, Environment Park.

4. Recovery Objectives

4.1 Overall objective

The overall objective of this recovery plan is to ensure the long-term persistence of *A. attenuata* in the wild by preserving (restore, maintain or enhance) known populations through the management of identified threats.

4.2 Specific Objectives

The specific objectives for this recovery plan are to:

1. Determine the extent of the species distribution by confirming its presence or absence at pre-recorded sites and in areas of potential habitat.
2. Maintain or enhance known *A. attenuata* populations by providing protection from further decline through the abatement or removal of identified threats.
3. Obtain long-term protection of *A. attenuata* populations and habitat.
4. Promote public awareness of *A. attenuata* through education programs and encourage community involvement in implementing recovery actions.
5. Increase knowledge of *A. attenuata* biology and ecology through the development and implementation of population monitoring programs.

4.3 Performance Criteria

1. Population location records for *A. attenuata* are verified, updated and consistent; and the number and location of extant populations is determined.
2. The number of individuals within populations is maintained or increased.
3. Optimal fire regimes are identified and appropriate fire management plans are developed and implemented.
4. Appropriate weed management plans are developed and implemented; and weed impacts are reduced.
5. Reduced accidental loss of plants through site maintenance activities.
6. The number of protected *A. attenuata* populations is increased.
7. Public education programs are developed and implemented and community awareness is increased.
8. Knowledge of *A. attenuata* biology, ecology and population dynamics is increased; and information obtained is applied to the species recovery.

5. Recovery Objectives, Performance Criteria and Actions

5.1 Description of Recovery Actions

Objective 1: Determine the extent of the species distribution by confirming its presence or absence at pre-recorded sites and in areas of potential habitat.

Performance Criteria 1: Population location records for *A. attenuata* are verified, updated and consistent; the number and location of extant populations is determined.

- **ACTION 1.1**

Collate and verify population location information from various databases including State Government (Herbrecs, Wildnet) and Local Government (Council) Agencies and private firms (i.e. Botanical consultants).

Rationale & Requirements: Inconsistencies in population location information for *A. attenuata* have been detected amongst various databases. Distributional records need to be updated and consistent. Location information collated from various databases with records verified using field surveys (see Action 1.2), information from previous vegetation survey reports (i.e. Local Council, Botanical consultants) and local knowledge. This will assist in locating extant populations in the wild, determining the species status across its potential range (i.e. variation in local abundances) and for identifying priority areas and populations for conservation.

Potential contributors: EPQ/QPWS, Local Councils (e.g. Gold Coast, Caboolture), Universities (e.g. USC Herbarium), Community Groups (e.g. SGAP) and Botanists.

Estimated Cost: Cost equivalent to one staff officer's salary for one month, meetings and administration. To be conducted in first year only: **Total cost: $4300**.

- **ACTION 1.2**

Conduct flora surveys at pre-recorded *A. attenuata* sites and in areas of potential habitat to determine if previously known populations exist and to locate new populations.

Rationale & Requirements: Field surveys conducted to determine whether *A. attenuata* exists at previously recorded sites and for verifying reports suggesting the species presence at new sites (see Section 2.2). Targeted surveys would be conducted during the flowering season and in areas with suitable habitat, such as: the Caboolture to Landsborough rail corridor, Ningi (Caboolture Shire); Beerwah and Australia Zoo area, Beerwah SF, lower Mooloolah River catchment (Caloundra Shire); Sippy Creek (Maroochy Shire); Tin Can Bay (Cooloola Shire); Tuan State Forest (Maryborough Shire); Meadowvale Nature Park and Moore Park region (Burnett Shire).

Data collected during surveys (presence/absence) would be compared to historical records to determine the extent to which the species geographic range has been reduced. If new populations are found, the location and size of these would be recorded. Information obtained from field surveys will contribute directly to Action 1.1, with the necessary information exchange between State and Local Government Agencies, landholders, community groups and botanical consultants.

Potential contributors: NRM (NRM SEQ, BMRG), EPQ/QPWS, Local Councils (e.g. Caboolture), Botanical consultants, Community Groups (e.g. Cooloola Coastcare, SGAP)

Estimated Cost: Field surveys (allow 16 days): $6400. Compilation of data and report writing: $2000. **Total Cost: $8400**.

- **ACTION 1.3**

Use habitat modelling to identify and map known and potential *A. attenuata* habitat, and 'essential habitat' for incorporation into Biodiversity Planning Assessments.

Rationale & Requirements: Habitat modelling facilitates the identification of known and potential habitat, which can be used to locate targeted search areas for field surveys. In addition spatial data representing *A. attenuata* populations can be used in conjunction with habitat information to identify and map 'essential habitat' for this species, which to date has only been described. To avoid duplication of effort and expenditure, communication between potential contributors will be essential.

Modelling exercises would be based on the Biodiversity Assessment and Mapping Methodology (BAMM), which provides a consistent approach for assessing biodiversity values at the landscape level in Queensland. BAMM is used by EPA/QPWS to generate habitat suitability maps (which define the known/possible extent and importance of habitat for flora and fauna) for use in Biodiversity Planning Assessments (BPAs). BPAs can be used by State and Local Government Agencies and members of the community to advise on a range of planning decision-making processes such as Regional Vegetation Management Plans, identifying off-reserve conservation priorities, Local Government planning schemes and approvals for development assessments under the *Integrated Planning Act 1997* (IPA). Core or essential species habitat as identified through the BAMM forms the basis for Essential Habitat for threatened Species. This data layer is supplied to NRMW for use in assessing clearing applications under the *Vegetation Management Act 1999*.

BAMM optimises the use of existing data and information and therefore requires sufficiently detailed vegetation maps, updated population location records and prior knowledge of a species distribution and preferred habitat. In targeting areas of potential habitat, location data for *A. attenuata* populations could be plotted over current Regional Ecosystem mapping to determine whether the latter is predictive.

Potential contributors: NRM (NRM SEQ, BMRG), EPQ/QPWS, Local Councils, NRMW and Community Groups (e.g. Cooloola Coastcare).

Estimated Cost: Allow approximately 10 days. **Total Cost: $3000**

Objective 2: To maintain or enhance known *A. attenuata* populations by providing protection from further decline through the abatement or removal (where possible) of identified threats.

Performance Criteria 2.1: The number of individuals within populations is maintained or increased and management plans that address identified threats are developed or reassessed (where required) and implemented (Applies to all Objective 2 Actions).

Performance Criteria 2.2: Optimal fire regimes are identified through fire trials and appropriate fire management plans are implemented at *A. attenuata* sites.

- **ACTION 2.2.1**

Implement interim fire management plans that prescribe fire regimes between eight and 10 years for *A. attenuata* sites affected by inappropriate fire regimes.

Rationale & Requirements: The viability of many *A. attenuata* populations is threatened by inappropriate fire regimes. Preliminary investigations into the species response to fire and assessment of site disturbance histories concluded that fire regimes between six and 10 years would be suitable for this species (Brownlie 2005). Based on these findings and recommendations for coastal heathland and woodland habitats in

southeast Queensland that emphasise eight to 12 year intervals (Watson 2001), interim fire management plans that prescribe regimes between eight and 10 years should be implemented at *A. attenuata* sites affected by inappropriate fire regimes. Where suitable fire management plans appear to be already in place (i.e. Littabella NP), these would be maintained in the interim.

This action will apply only until optimal fire regimes for this species have been identified through Action 2.2.2.

Potential contributors: EPA/QPWS, Local Councils and landholders.

Estimated Cost: Unable to be determined at this stage.

- **ACTION 2.2.2**

Develop and conduct fire trial programs to identify optimal fire regimes for *A. attenuata* and incorporate findings into existing / proposed fire management plans.

Rationale & Requirements: By conducting fire trials, optimal regimes for *A. attenuata* could be identified and results incorporated into the development of new or reassessment (where required) of existing, fire management plans.

Information exchange between land mangers (i.e. EPA/QPWS, local councils, landholders) and research institutes (i.e. Universities, DPI&F) would firstly be required, to determine what management practices have been trailed and the relative outcomes. Existing knowledge of the life cycle, biology and ecology of *A. attenuata* would be considered in developing the trials and plots established at sites containing multiple *A. attenuata* sub-populations, to enable variations in fire intervals, intensity, season and fuel loads to be tested. Aspects such as the role of heat in seed germination, the age of reproductive maturity (relative to the fire interval period) and responses of the soil seed bank to variations in fire history (time since disturbance and intensity) would be assessed. Monitoring will be essential for determining optimal regimes and would be achieved through the implementation of Action 5.1.1.

Fire management plans would be developed in consultation with all relevant land managers and indigenous groups (where necessary). The South-east Queensland Fire and Biodiversity Consortium (SEBFBC) should be engaged in discussions regarding fire regime requirements for *A. attenuata* habitat.

Potential contributors: NRM (NRM SEQ, BMRG), EPA/QPWS, DPI&F, Local Councils, Universities (e.g. USC), SEQFBC, QLD Rural Fire Service and landholders.

Estimated Cost: Controlled burns in first year (three monitoring plots, $2000 per plot). **Total cost: $6000**. Costs for monitoring covered under Action 5.1.1.

Performance Criteria 2.3: Appropriate weed management plans are developed and implemented at *A. attenuata* sites and weed threats are reduced.

- **ACTION 2.3.1**

Assess weed threats, develop and implement appropriate weed management programs and monitor weed infestations to determine if control strategies are effective.

Rationale & Requirements: Control and removal of invasive weeds that compete with native species will ensure that threatened species populations are provided with favourable conditions for population establishment, expansion and persistence.

The impact of environmental weeds on *A. attenuata* populations is greatest at sites in residential areas where infestations along forest margins overlap with the species area of occupancy. Maintenance of these populations will be dependent on the development and implementation of programs aimed at identifying, controlling (halt the spread of established weeds and introduction of new weed species) and where possible, eradicating environmental weeds. This will require:

- collaborations with and involvement from landholders to implement weed eradication programs on properties containing *A. attenuata* or adjacent to *A. attenuata* habitat. Landholders would be provided with information resources and access to extension officers for advice (i.e. NRMW, EPA/QPWS, Local Council).

- a public education component to promote awareness (i.e. of the environmental economic and social impacts of weed infestations) and to discourage irresponsible behaviour (i.e. disposal of garden refuse in native bushland). To be achieved through the implementation of Action 4.1.1.

- a monitoring program to assess the effectiveness of weed control strategies. To be achieved through the implementation of Action 5.1.1.

Potential contributors: NRM (NRM SEQ, BMRG), NRMW, EPA/QPWS, Local Councils (e.g. Caboolture, Caloundra), landholders, Schools (e.g. Mountain Creek), Conservation Groups (e.g. WPSQ, Landcare, Coastcare).

Estimated Cost: Costs dependent on the extent of infestation and the type and number of weed species involved. Allow $25,000 a year (first two years) and $12,500 a year (following three years). **Total cost - $87,500**.

Performance Criteria 2.4: Accidental loss of *A. attenuata* plants through site maintenance activities is reduced and the number of individuals within populations is maintained or increased.

- **ACTION 2.4.1**

Review site maintenance practices and implement training programs and appropriate strategies to reduce the incidence of accidental damage to and loss of *A. attenuata* plants.

Rationale & Requirements: A review of site maintenance practices could assist in reducing the incidence of accidental damage to and loss of *A. attenuata* plants. This occurs through road grading, slashing and weed control activities. Such activities pose threats to small populations, where frequent losses reduce population size and demographic stability (See Section 3.2). The following actions would be required:

- reassess the timing of maintenance activities (i.e. season) to mitigate impacts to establishing seedlings and juvenile plants.

- develop educational material (i.e. information on identification and the life history and ecology of *A. attenuata* in a format similar to the Species Management Profiles produced by the EPA/QPWS) for distribution to contracted works teams and land managers. To be achieved through the implementation of Action 4.1.1.

- implement training programs for contracted works teams and land managers to provide skills in native plant identification, options for alternative site maintenance practices and targeted weed control strategies. Delivery of such programs would be through experienced groups such as Greening Australia Queensland.

Implementation of this action may require additional consultation at sites where existing maintenance practices are required to fulfil the role of the asset (i.e. fire lines, tracks and powerlines cleared for safety). This could be addressed though strategies that identify alternative routes that avoid damaging *A. attenuata* populations.

Potential contributors: EPA/QPWS, Local Councils (e.g. Caloundra), Main Roads, Energex / Ergon (contractors), Conservation Groups (e.g. Greening Australia Queensland) and landholders.

Estimated Cost: $10,000 a year for first two years (covers training and associated materials). **Total Cost: $20,000.**

- **ACTION 2.4.2**

Devise alternative site maintenance strategies aimed at reducing damage to and loss of *A. attenuata* at Tewantin FR and incorporate into the Environmental Works Plan (EWP) for this reserve.

Rationale & Requirements: Damage to *A. attenuata* plants, mortality and population decline over a two-year period (seemingly) due to site maintenance activities has been observed at Tewantin FR. This is associated with the confinement of *A. attenuata* population to the southern boundary of the FR, bordering a powerline easement that is regularly slashed.

Recommendations for alternative site maintenance strategies would be based on current understanding of the species biology (i.e. life cycle, modes of reproduction) and ecology (i.e. population dynamics, recruitment patterns/triggers). Collaborations between EPA/QPWS (Parks Division) and the mangers of the Forest Reserve (EPA/QPWS - Sunshine Coast District) and powerline easement (Energex) would be required, to negotiate alternative practices (i.e. season and frequency of slashing) that will support the persistence of a viable *A. attenuata* population. Revised site maintenance strategies would be incorporated into the EWP for Tewantin FR. Implementation of Action 2.4.1 will compliment this action through the provision of native plant identification skills to contracted works teams.

Potential contributors: EPA/QPWS and Energex.

Estimated Cost: Cost equivalent to one staff officer's salary for one month, meetings and administration. **Total cost: $4300**.

Objective 3: To obtain long-term protection of *A. attenuata* populations/habitat.

Performance Criteria 3.1: The number of protected *A. attenuata* populations is increased.

- **ACTION 3.1.1**

Encourage landholder participation in off-reserve conservation through the negotiation of Conservation Agreements on private land.

Rationale & Requirements: Collaborations with landholders to secure the protection of *A. attenuata* populations and habitat on freehold land can be achieved through the negotiation of Conservation Agreements such as, Nature Refuges. Such agreements assist landholders in protecting native habitat on private land, encourage the protection of populations *in situ* and helps to maintain connectivity between suitable or similar habitat and the current distribution of *A. attenuata*. This Action is applicable mostly to sites in the central and northern regions.

The Nature Refuge program is administered by EPA/QPWS and provides a means for landholders to formally protect significant nature conservation values on their property. Negotiation of Conservation Agreements takes into consideration the needs of the landholder, the environment and land management practises. Landholders are informed of the various options available and provided with management advice from EPA/QPWS extension officers and incentives such as financial assistance in the form of Transfer Duty and Land Tax reimbursement through the NatureAssist program. Local councils could also encourage landholder participation in off-reserve conservation through similar programs (e.g. Voluntary Conservation Agreements).

Potential contributors: NRM (NRM SEQ, BMRG), EPA/QPWS, Local Councils (e.g. Caboolture), Property developers, landholders and NRMW

Estimated Cost: Cost equivalent to one staff officer's salary for six months, meetings and administration. To be conducted in first year: **Total cost: $26, 000**.

- **ACTION 3.1.2**

Use *A. attenuata* in planned revegetation projects in suitable areas, to enhance existing population fragments and increase the number of potential sites for re-introduction.

Rationale & Requirements

The use of *A. attenuata* in revegetation projects in suitable areas will allow for the enhancement of existing population fragments and promote connectivity between populations and areas of similar habitat (i.e. along riparian zones and road corridors). In addition, populations may be established at sites where the species previously occurred. This has relevance for the Gold Coast where the species historical distributional range (i.e. four populations between Southport and Burleigh) has been reduced to a single site.

As taking and use of protected plants for conservation/revegetation projects is regulated under the *Nature Conservation Act 1992* (NCA), a 'Recreational wildlife harvesting licence (protected plants)' must be obtained from the EPA/QPWS to propagate *A. attenuata*. This licence does not permit the sale or use of protected plants for commercial purposes and cannot be issued over protected areas. Contact the EPA/QPWS Ecoaccess Customer Service Unit for further information.

The collection of plant material and the establishment of *ex situ* populations should be conducted by groups experienced in cultivating native species (e.g. Greening Australia, Local Councils, SGAP). All revegetation projects involving *A. attenuata* would be accompanied with a site management plan detailing the actions and timeframe required for ongoing site maintenance and monitoring until the population is established and self-sustaining. Installation of visible stake markers and interpretational signage will enable identification and recognition of the species presence.

Potential contributors: NRM (NRM SEQ, BMRG), Greening Australia Queensland, Local Councils (e.g. Gold Coast, Caboolture, Cooloola), Main Roads, Property developers and Community Groups (e.g. Waterwatch, Cooloola City Farm).

Estimated Cost: Unable to be determined at this stage as costs are dependent on the number of sites and scale of revegetation required.

Objective 4: To increase public awareness of *A. attenuata* and encourage community involvement in maintaining existing populations.

Performance Criteria 4.1: Public education programs are developed and implemented and community awareness is increased.

- **ACTION 4.1.1**

Develop educational material and install interpretational signage at reserves and along road corridors.

Rationale & Requirements: Community involvement has played a pivotal role in the protection of a number of species as it provides cost and time efficient resources for managing activities required to protect habitats that are otherwise unavailable (Leverington 2000).

Educational material in the form of a web-based fact sheet such as the Species Management Profiles produced by EPA/QPWS and interpretational signage would be developed to mitigate future impacts from human activity by promoting awareness of the conservation values of native bushland. A concise description of *A. attenuata* (i.e. Conservation status, biology, distribution, habitat and threatening processes) and accompanying images would be provided. The ecological consequences of human activities (i.e. waste disposal in bushland, arson and illegal clearing) would also be highlighted to encourage community involvement in the species recovery. To raise further awareness, profiles of other associated threatened species would be included.

Educational material should be directed primarily at users of reserves and residents living in close proximity to native bushland. To target the latter group, Property Developers are advised to incorporate information (as described above) into brochures for current residents and prospective buyers. Information on *A. attenuata* could also be incorporated into existing nature conservation brochures produced by local councils.

Installation of interpretational signage in reserves (along recreational trails) and along road corridors will inform users and site maintenance teams of the presence and significance of threatened species. Addresses for relevant websites (i.e. EPA/QPWS, Local Council) would be provided on signs to direct people to sources of further information (e.g. web-based fact sheets).

Potential contributors: NRM (NRM SEQ, BMRG), EPA/QPWS, Local Councils (e.g. Caboolture, Caloundra), Community and Conservation Groups (e.g. WPSQ, Cooloola Coastcare), Property Developers, Schools (e.g. Mountain Creek) and local residents.

Estimated Cost: Web-based fact sheet (one staff officers salary for one week): $1080. Interpretational signage ($500 a site for 12 sites): **Total cost $7080**.

Performance Criteria 4.2: The incidence of wildfires (due to arson) at Burleigh Knoll CP is reduced and population numbers are maintained or increased.

- **Action 4.2.1**

Develop and implement a public education program aimed at reducing the incidence of wildfires (due to arson) at the site.

Rationale & Requirements: High frequency fire regimes threaten the persistence *A. attenuata* at Burleigh Knoll CP (see Section 3.2). As current fire regimes are primarily influenced by anthropogenic activity (arson), intervention through public education is necessary to prevent the localised extinction of this population.

The development of an interpretational package aimed at informing visitors and local residents of the Park's conservation values and associated threats, is recommended. This would involve the installation of interpretational signage (see Action 4.1.1) and placement of articles in local newspapers on a quarterly basis. Article content could include a brief description of *A. attenuata* (see Action 4.1.1) and an explanation of the potential environmental (i.e. localised extinction of threatened species, reduction in biodiversity and ecosystem function) and social impacts (i.e. threat to human life, damage to neighbouring properties) of frequent wildfires in urban reserves. Local residents are also encouraged to report arson activity and offenders, as prosecution of arsonists is an effective way of deterring illegal fires.

Potential contributors: NRM (NRM SEQ), EPA/QPWS (e.g. Gold Coast District), Queensland Rural Fire Service, Local Council and local residents.

Estimated Cost: Interpretational package (includes newspaper articles and installation of interpretational signage). **Total cost: $5500**

Objective 5: To increase knowledge of *A. attenuata* biology and ecology through the development and implementation of population monitoring programs.

Performance Criteria 5.1: Knowledge of *A. attenuata* biology, ecology and population dynamics is increased; information obtained is applicable to the recovery of this species.

- **ACTION 5.1.1**

Develop and implement population monitoring programs.

Rationale & Requirements: The implementation of population monitoring programs will help to address knowledge gaps regarding *A. attenuata* biology, ecology and population dynamics. Ecological data obtained, will provide a scientific basis on which management strategies aimed at the recovery or protection of a species can be based (Leverington 2000). Population monitoring over successive years will assist in determining the causal factors of population expansion or decline (i.e. natural, anthropogenic) and allow for changes in the status of the species to be detected. To enable comparison, monitoring would be conducted at several sites across the species range.

Parameters to be monitored include: population size, age structure, height classes, reproductive activity (i.e. seed production), recruitment, pollinator activity, habitat conditions and evidence of disturbance. Where possible, acquired data would be compared to pre-recorded ecological data to detect changes in demographic parameters. Clarification of population demographic parameters such as the period of longevity, reproductive age and the age of senescence would assist in determining optimal disturbance regimes for this species and therefore contribute to Action 2.2.2. The inclusion of disturbed and undisturbed populations will enable the impact of threatening processes (i.e. inappropriate fire regimes, weed infestations) to be monitored and the effectiveness of management strategies (i.e. weed control and public education programs) to be assessed and adjusted if deemed necessary.

Populations surveyed in a previous study (Brownlie 2005) should be included in the monitoring program, as detailed ecological data already exists for 14 sites (Table 4, Secure Appendices) and could be used in comparative analyses.

Potential contributors: NRM (NRM SEQ, BMRG), EPA/QPWS, local councils (e.g. Caboolture), Universities (e.g. USC), Schools (Mountain Creek), Community Groups.

Estimated Cost: Population monitoring - allow one day per site for approximately 10 sites (from across the species geographic range) annually. **Total cost: $15 000.**

5.2 Summary of Recovery Objectives, Performance Criteria and Actions

Table 5: Summary of relationship between specific objectives, performance criteria, actions and potential contributors. Priority Levels: 1 = High Priority; 2 = Medium Priority; 3 = Low Priority.

Objective	Performance criteria	Action	Potential Contributors	Priority
Objective 1: Confirmation of Distribution Determine the extent of the species distribution by confirming its presence or absence at pre-recorded sites and in areas of potential habitat.	Criterion 1 Population location records for *A. attenuata* are verified, updated and consistent; and the number and location of extant populations is determined.	Action 1.1 Collate and verify population location information from State and Local Government and Private Databases	EPA/QPWS Local Council, Universities (USC) Botanists	1
		Action 1.2 Surveys conducted to confirm the existence of pre-recorded populations & locate new populations.	NRM, EPA/QPWS, Local Council Community Groups	1
		Action 1.3 Use habitat modelling to identify and map: known and potential *A. attenuata* habitat; and 'essential habitat' for incorporation into Biodiversity Planning Assessments	EPA/QPWS NRM, NRMW Universities Local Council Community Groups	1
Objective 2: Population Management To maintain or enhance known *A. attenuata* populations by providing protection from further decline through the abatement or removal (where possible) of identified threats.	Criterion 2.1 The number of individuals within populations is maintained or increased; management plans addressing threats are developed or reassessed and implemented (applies to all actions under Objective 2).	Action 2.2.1 Implement interim fire management plans that prescribe fire regimes between eight and 10 years for *A. attenuata* sites affected by inappropriate fire regimes.	EPA/QPWS Local Councils Land holders	1
	Criterion 2.2 Optimal fire regimes are identified and appropriate fire management plans are implemented at *A. attenuata* sites.	Action 2.2.2 Develop and conduct fire trial programs to identify optimal fire regimes for *A. attenuata* and incorporate findings into existing or proposed fire management plans.	NRM, EPA/QPWS Local Council Land holders Universities SEQFBC Rural Fire Service	1
	Criterion 2.3 Appropriate weed management plans are developed and implemented at *A. attenuata* sites; and weed impacts are reduced.	Action 2.3.1 Assess weed threats, develop and implement appropriate weed management programs and monitor weed infestations to determine if control strategies are effective.	EPA/QPWS NRM, NRMW Local Council land holders local residents Community Groups	2

Objective	Performance criteria	Action	Potential Contributors	Priority
Objective 2: Population Management (continued)	Criterion 2.4 Reduced accidental loss of plants through maintenance activities. The number of individuals within populations is maintained or increased.	Action 2.4.1 Review site maintenance practices and implement training programs and appropriate strategies to reduce the incidence of accidental damage to and loss of *A. attenuata* plants.	EPA/QPWS Local Councils Energex / Ergon Main Roads Landholders Conservation Groups	3
		Action 2.4.2 Devise alternative site maintenance strategies aimed at reducing damage to and loss of *A. attenuata* plants at Tewantin FR, and incorporate into the Environmental Works Plan for this reserve.	EPA/QPWS Energex	2
Objective 3: Habitat Protection To obtain long-term protection of *A. attenuata* populations and habitat.	Criterion 3 The number of protected *A. attenuata* populations is increased.	Action 3.1 Encourage landholder participation in off reserve conservation through the negotiation of Conservation Agreements.	EPA/QPWS Local Councils Land holders Land managers Property developers	2
		Action 3.1 Use *A. attenuata* in planned revegetation projects in suitable areas, to enhance existing population fragments and increase the number of potential sites for re-introductions	NRM, Greening Australia Local Councils Main Roads Community Groups (SGAP,Waterwatch) Property developers, land holders	3
Objective 4: Public Education To increase public awareness of *A. attenuata* and encourage community involvement in maintaining existing populations.	Criterion 4 .1 Public education programs are developed and implemented and community awareness is increased.	Action 4.1.1 Develop educational material and install interpretational signage at reserves and along road corridors.	NRM, EPA/QPWS Local Councils Main Roads Community Groups Local residents Schools	1
	Criterion 4 .2 The incidence of wildfires (due to arson) at Burleigh Knoll CP is reduced and population numbers are maintained or increased.	Action 4.2.1 Develop and implement a public education program to reduce incidence of wildfires at Burleigh Knoll CP	NRM, EPA/QPWS Local Councils Local residents Rural Fire Service	2
Objective 5: Research Increase knowledge of *A. attenuata* biology and ecology through the development and implementation of population monitoring programs.	Criterion 5.1 Knowledge of *A. attenuata* biology, ecology and population dynamics is increased and information obtained is applicable to the recovery of this species.	Action 5.1.1 Develop and implement population monitoring programs	NRM, EPA/QPWS Universities Community Groups Local councils Schools	2

6. Costs for Implementing the Recovery Plan

Estimates for the cost of implementing the recovery actions over a five-year timeframe are provided below. As the cost for all recovery actions cannot be determined at this stage (*), additional costs are expected. (×) denotes years where no recovery action costs apply.

Action	Description of Action	Year 1	Year 2	Year 3	Year 4	Year 5	Total
1	Collate and verify population location information	4,300	×	×	×	×	4,300
2	Field surveys and reporting	8,400	×	×	×	×	8,400
3	Habitat modelling	3,000	×	×	×	×	3,000
4	Implement interim fire management plans that prescribe fire regimes between eight and 10 years.	*	*	*	*	*	*
5 *	Develop and conduct fire trial programs; and monitor populations	6,000	×	×	×	×	6,000
5	Develop and implement weed control programs	25,000	25,000	12,500	12,500	12,500	87,500
6	Review site maintenance activities; conduct training	10,000	10,000	×	×	×	20,000
7	Devise alternative site maintenance strategies for Tewantin FR and incorporate into the Environmental Works Plan for this reserve.	×	4,300	×	×	×	4,300
8	Negotiate Conservation Agreements	26,000	×	×	×	×	26,000
9	Use *A. attenuata* in revegetation projects	*	*	*	*	*	*
10	Develop educational material and install interpretational signage.	4,080	3,000	×	×	×	7,080
11	Develop and implement a public education program to reduce incidence of wildfires at Burleigh Knoll CP	5,500	×	×	×	×	5,500
12	Conduct population monitoring programs	3,000	3,000	3,000	3,000	3,000	15,000
Total		**95,280**	**45,300**	**15,500**	**15,500**	**15,500**	**187,080**

***** Annual costs for monitoring in Action 5 are covered by the budget allocated for Action 11.

7. Management practices

Management prescriptions necessary for the maintenance and protection of *A. attenuata* habitat include:

- Prevent further loss of coastal lowland vegetation through development activities.
- Promote management practices that favour the protection of *A. attenuata* habitat and natural populations (*in situ*).
- Manage fire regimes (fire frequency, intensity, season) to ensure that recruitment patterns are not adversely affected by disturbance events. This will require the implementation of interim fire regimes based on eight to 10 year cycles, at sites affected by inappropriate fire regimes.
- Manage site maintenance activities (i.e. frequency of road grading, slashing of tracks and power line easements) to ensure that individuals (particularly seedlings and juveniles) are not damaged or killed by maintenance works.
- Manage the impact of environmental weeds through appropriate control programs which stop the spread of and eradicate established weeds and prevent the establishment of new weed species.
- Maintain existing hydrological regimes and avoid alterations to water tables in future development activities on land within the vicinity of *A. attenuata* habitats.
- Prevent disturbance and destruction of native vegetation (i.e. through spot clearing and waste disposal) in native bushland, particularly in urban areas.

8. Evaluation of recovery plan

To ensure the successful recovery of *A. attenuata,* annual reviews of this recovery plan that involve stakeholders, will be conducted. A review of the recovery plan will be conducted five years after adoption.

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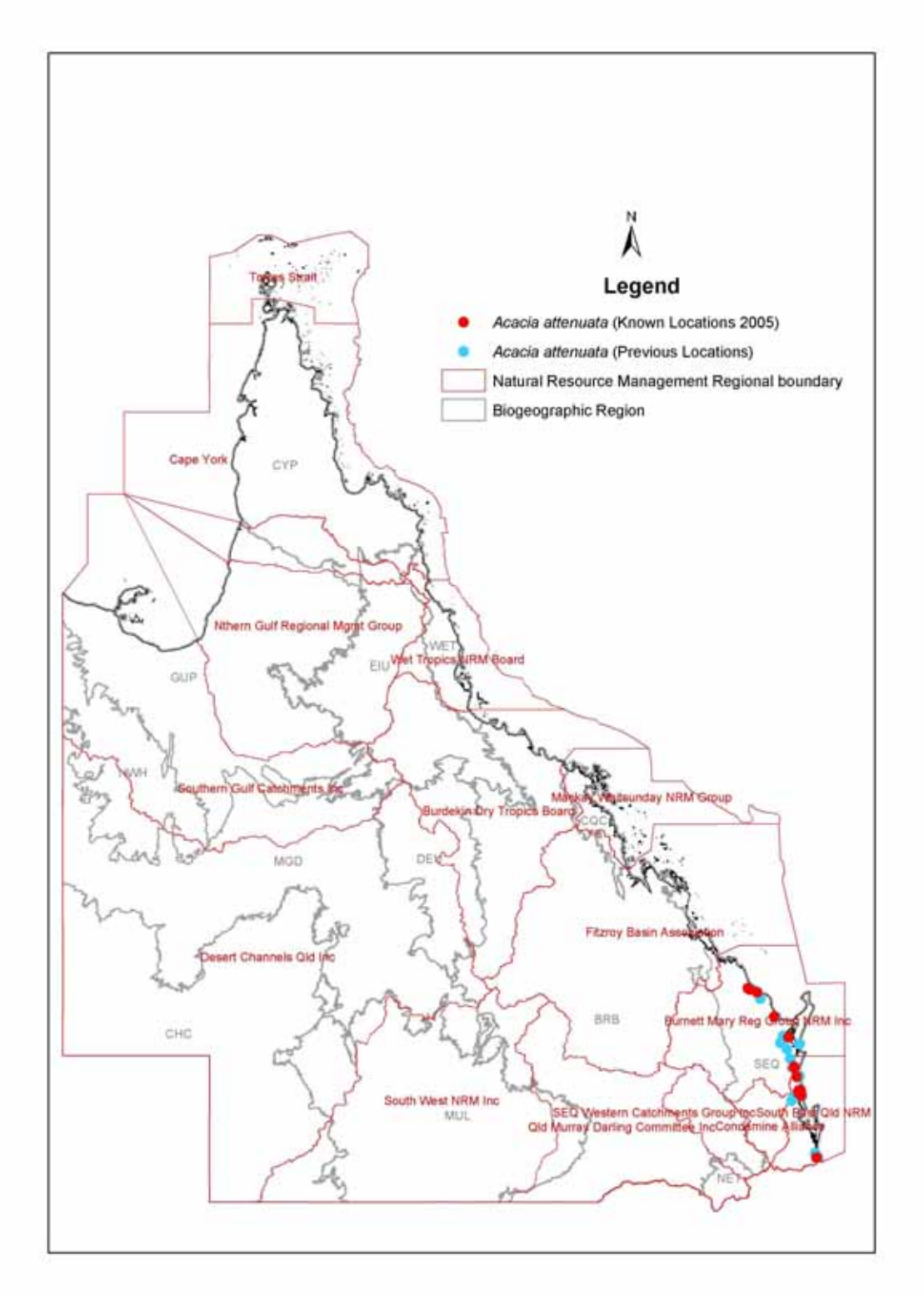
APPENDIX 1: Distribution Map for *Acacia attenuata*

Distribution of previous and currently known (2005) *A. attenuata* collection sites in relation to the Natural Resource Management (NRM) and Biogeographic regional boundaries shown. Map produced by Spatial Systems, Technical and Support Unit, Parks Division (EPQ/QPWS).



APPENDIX 2: List of genetically significant *Acacia attenuata* populations

Populations listed below were identified as potentially significant (genetically) due to the presence of private alleles (i.e. alleles found in only one population) and uncommon alleles (i.e. alleles that occur in no more than three populations, and at relatively low frequencies). These populations should be given consideration when prioritising populations for conservation. The detection of more private and uncommon alleles in the Bundilla population may in part, be the result of increased sampling effort.

Site No.	Population Name	Region (S, C, N)	No. Private Alleles Detected	No. Uncommon Alleles Detected
6	Kalana Road Reserve	C	1	-
9	Bundilla	C	3	2
11	Mooloolah NP	C	1	-
16	Tewantin SF	C	-	1
18	Old Hollet Road	C	1	-
20	Cooloola NP	C	-	2
23	Burrum Coast NP	N	1	2
24	Lot 7 Moore Park	N	-	2
25	Littabella NP	N	-	1

* Geographic Regions: S, Southern; C, Central; N, Northern