



Australian Government

Department of the Environment

Key Threatening Process Nomination Form - For adding a threatening process under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)

Nominated threatening process – summary of eligibility

6. Name of threatening process

Loss of habitat and native flora due to expansion of the weed *Lippia* (*Phyla canescens*)

7. Criteria under which the threatening process is eligible for listing

Identify which criteria the threatening process meets (one or more). Please note that the information you provide in this nomination form should support your claim. For further details on the criteria, please refer to [Part A](#) of the Threatened Species Scientific Committee guidelines attached to this form.

- Criterion A - Evidence that the threatening process could cause a native species or ecological community to become eligible for listing in any category, other than conservation dependant.
- Criterion B - Evidence that the threatening process could cause a listed threatened species or ecological community to become eligible for listing in another category representing a higher degree of endangerment.
- Criterion C - Evidence that the threatening process adversely affects two or more listed threatened species (other than conservation dependant species) or two or more listed threatened ecological communities.

Nomination for listing a threatening process as a key threatening process under the Environment Protection and Biodiversity Conservation Act 1999

1. A name of the threatening process [EPBC Regulation 7.07 2(b)]:

Loss of habitat and native flora due to expansion of the weed Lippia (*Phyla canescens*)

2. A description of the threatening process that distinguishes it from any other threatening process, by reference to [EPBC Regulation 7.07 2(a)]:

(i) its biological and non-biological components.

Lippia (Phyla canescens (Kunth.) Greene is an invasive plant in the Family Verbenaceae that is now a significant and increasing problem on the floodplains of the Murray-Darling Basin (Csurhes 1989; McCosker 1994a; Lucy *et al.* 1995; Earl 2003). *Lippia* is widely distributed in temperate to subtropical areas of the world (Lucy *et al.* 1995) but is reported as a severe problem only in Australia. This species was probably introduced to Australia as a garden plant and was later used as a lawn substitute. As recently as 1987 the NSW Department of Agriculture referred to *Lippia* as a ground cover, which, although not generally recommended as a substitute for grasses, was a “success in some districts” and would “wear well if it is looked after” (Beange 1987).

The primary threat from *Lippia* lies in its direct impact on groundcover in floodplain communities. *Lippia* has the potential to cause catastrophic changes to the structure and diversity of floodplain grasslands, sedgeland, woodlands and forests. These changes will result not only in a loss of diversity in floodplain groundcover plants but also in loss of diversity in floodplain fauna as a result of changes to habitat structure and resource availability. The major impacts of *Lippia* on floodplain communities are in:

- *Reduced recruitment of threatened or at risk groundcover species*

Lippia can, under favourable conditions, spread rapidly. This species typically forms a dense mat of vegetation with a lawn-like appearance in which few if any other plants occur (McCosker 1994a). *Lippia* plants are long-lived and often persist during drought. In a river system such as the Murray-Darling where the availability of water is unpredictable in timing and duration, opportunities for recruitment of herbaceous species are few. In these circumstances a species which can rapidly colonise bare ground is likely to prevent germination of other species or to out-compete the few which do germinate. Several rare plant species in the Murray-Darling Basin (e.g. *Swainsona murrayana*), are annuals; for these species failure to recruit could have a severe impact on population sizes by

drastically reducing seed bank replenishment with potentially severe follow-on effects on the next season's cohorts. There would also be impacts on perennial species through reduced recruitment.

- *Reduced recruitment of woody plants.*

The mat-like growth of newly colonising Lippia plants also has the potential to prevent recruitment of floodplain eucalypts such as Coolibah (*Eucalyptus coolabah*) and River Red Gum (*Eucalyptus camaldulensis*) and of other woody plants such as lignum (*Muehlenbeckia cunninghamii*). Competition with existing groundcover species.

- *Smothering and competition.*

Lippia mats appear to have a negative competitive effect on perennial species such as grasses and sedges through a combination of shading, competition for soil resources and inhibition of growth through production of allelopathic chemicals.

- *Domination of the propagule bank.*

Lippia has the ability to disperse rapidly on floodwater and to colonise bare ground as floods recede. Floodwaters appear to be the principal agent of dispersal of both vegetative propagules and seeds. Flooding results in the massive production and dispersal of stem fragments. There is some evidence to suggest that this species, in common with many other weeds, has the capacity to form a persistent seed bank.

- *Reduction in food resources for threatened fauna species.*

Replacement of floodplain grasses with Lippia has a direct impact on threatened birds such as the Superb Parrot that feed on grass seeds. Loss of grass tussocks removes nest habitat and refuge for species such as the Stripe-faced Dunnart.

- *Reduction of habitat for threatened fauna species.*

Invasion and expansion of Lippia has the potential to change the structure and complexity of both the groundcover and woody plant cover components of floodplain and wetland habitat for threatened fauna. Loss of grass tussocks reduces nesting habitat and refuges for threatened reptiles (e.g. Grassland Earless Dragon) and for species such as the Stripe-faced Dunnart. Loss of sedges and clumps of tall emergent wetland plants removes nesting sites and refuges for threatened fauna such as Southern Bell Frog and Australian Painted Snipe.

Reduced regeneration in floodplain eucalypts and shrubs such as Lignum has the potential to change the structure of floodplain communities in the long term by reducing tree and shrub cover. A reduction in tree cover could have a flow-on effect to threatened fauna such as the Red-tailed Black-cockatoo by reducing food supply and habitat for shelter and nesting. Lignum is a community already under threat from clearing and cultivation and the shrubs themselves are nesting substrate for a number of bird species. Replacement of the grassy groundcover in lignum communities with Lippia may have an impact on recruitment of lignum seedlings as well as on groundcover diversity.

- *Impacts on soil structure*

Lippia has a negative affect on soil stability on stream banks. Crumbling stream banks then reduce soil cracks and other refuges for threatened fauna.

Lippia is estimated to be present across 5% of the Murray-Darling Basin, a total area in the order of 53,000 km². Lippia was first recognised as a potential problem in the Condamine River catchment in Queensland over 50 years ago (Csurhes 1989; Lucy *et al.* 1995) and now appears to be most common where flooding regimes and hydrology have been substantially altered (Earl 2003). The worst affected catchments are the Condamine, Border Rivers, Gwydir, Namoi, Lachlan, Murrumbidgee and Murray (Earl 2003). Lippia is also present along the banks of the Murray and on Murray River floodplains and floodplain wetlands in Victoria and South Australia and there are unconfirmed reports of its presence along the Darling (Earl 2003).

Lippia occurs predominantly on the clay soil floodplains of the inland river system in the 500–800mm annual rainfall zone of Queensland and NSW although it also occurs in Victoria and South Australia (Earl 2003). It is a seriously invasive weed in River Red Gum (*Eucalyptus camaldulensis*) forests, Coolibah (*Eucalyptus coolabah*) and Black Box (*Eucalyptus largiflorens*) woodlands, Brigalow (*Acacia harpophylla* communities), some Poplar Box (*Eucalyptus populnea*) and Belah (*Casuarina cristata*) woodlands and in Carbeen (*Corymbia tessellaris*) Forests (McCosker 1994a; Earl 2003; J. S. Benson pers. comm. 2003). Lippia has also been reported as a serious invader of *Cyperus* and *Bolboschoenus* sedgeland (J. S. Benson pers. comm. 2003), Water Couch (*Paspalum distichum*/*Eleocharis plana*) meadows and lignum swamps (McCosker 1994a), in some *Dicanthium* grasslands and in native grasslands of the Liverpool Plains (Earl 2003).

Biology and ecology

Habit

Lippia is a much-branched perennial herb with numerous ascending flowering branches (stems) and a central taproot up to 2 cm in diameter. Roots may reach more than one metre in depth; branches grow up to a metre in length and roots establish at each node (Lucy *et al.* 1995). Vegetative spread from seedlings or fragments is usually rapid. Although Lippia sometimes forms a component of groundcover communities, it is most often present as a monoculture (Earl 2003).

Although Lippia is not common in frequently inundated areas, it survives flooding for weeks to months (McCosker 1994a) and appears resistant to drought (McCosker 1994a; Mawhinney 2002). During dry times, Lippia is often the only green plant visible in grazed areas although a severe drought also reduces Lippia cover (Earl 2003).

Vegetative spread and seed production

Inundation of established Lippia plants encourages fragmentation and vegetative reproduction. Inundated Lippia plants produce shorter and thicker internodes are more fragile; fragmentation occurs readily with disturbance by currents (McCosker 1994a; Taylor 2003). Fragments float on floodwater, become stranded as floods recede and take root to form new mats.

Seed production is reported to be small possibly due to lack of pollinators (McCosker 1994b). Despite the small seed set Lippia seeds can form a substantial proportion of seed banks and it is likely that this species forms a persistent seed bank (McCosker 1994b; John Duggin pers. comm. 2003). Seeds are small; flotation and transport on mud are the probable modes of dispersal. Dispersal of seeds or fragments on vehicles, on agricultural machinery and on the feet of water birds and the hooves of domestic

stock is also likely. Seeds may also be transported in the guts of sheep and other grazing animals (John Duggin pers. comm. 2003).

The spread of *Lippia* appears related to flood events (Earl 2003). *Lippia* invasion apparently occurs on bare ground exposed after floods, by drought, by grazing or by a combination of these factors. A strip of bare ground characteristically surrounds *Lippia* plants and mats. This phenomenon is thought to be due to the effect of allelopathic chemicals and allelopathy in *Lippia* has been demonstrated experimentally (Elakovich 1987).

Projected future extent

Lippia may potentially spread across the whole of the MDB floodplains. As a result of the present drought the amount of bare ground present over much of the inland floodplain region of the MDB provides ideal conditions for a widespread *Lippia* establishment event. In the event of a significant flood in any of the MDB catchments, it is likely that *Lippia* will spread across the entire floodplain of that catchment. *Lippia* also occurs in areas infrequently inundated and has been reported spreading onto higher ground (Earl 2003).

Extent and severity of overseas impacts

Phyla canescens thought to be native to South America and occurs in southern Ecuador, throughout Peru, Chile, Argentina, Uruguay, Paraguay and Bolivia. (Kennedy, 1992). Worldwide it also occurs in California, Utah, Nevada and North Carolina in North America, Hawaii, Mexico, Spain, France, Italy, South Africa, Senegal, Algeria, Afghanistan, Botswana, Egypt, Guam and New Zealand.

The paucity of literature referring specifically to *Phyla canescens* suggests that *Lippia* does not generally present any significant problem where it occurs. However, confusion over nomenclature makes assessment of overseas reports difficult. Some of the previous names for *Phyla canescens* are *Lippia canescens*, *Phyla nodiflora* and *Lippia nodiflora* var. *canescens* although *Phyla nodiflora* is now recognised as a separate species (Munir 1993). However, *Phyla canescens* has been reported as becoming an increasing problem in waterways in France (Spenceley pers. comm. 2003). Mans & Hattingh (1992) refer to the rapid growth rate of *Lippia canescens* [*Phyla nodiflora*] and to its ability to effectively compete with trees for nitrogen, and *Phyla nodiflora* is listed as an invasive species presenting an environmental threat in Honolulu (Space *et al.* 2003). However, the characteristic of invasiveness, at least in Australia, is more often associated with *Phyla canescens*.

(ii) the processes by which those components interact (if known).

Alteration to water regimes

River regulation in the Murray-Darling Basin has reduced flows and altered flooding regimes to floodplains and floodplain wetlands (Kingsford 2000). *Lippia* is now a severe problem in, for example, the Gwydir wetlands, Gingham and Big Leather watercourses and this problem could be related to substantial reductions in flows to these wetlands (Ward and Stanford 1995; Earl 2003). Invasion and success of exotic species is facilitated by changing water regimes and especially by the loss of wet-dry cycles (Bunn and Arthington 2002). In addition, the establishment of contour banks and narrow channels is thought to have accelerated the spread of *Lippia* from the Condamine to catchments further south. Now that a large and extensive source of

Lippia propagules is present, it is only a matter of time before seeds and fragments are spread to the rest of the Murray-Darling floodplains (Earl 2003). Lippia often occurs on the walls of dams and water storage facilities such as Lake Keepit Dam indicating that dispersal of seeds or fragments by waterbirds is frequent and successful (Earl 2003).

In floodplain wetlands, Lippia was out-competed by other established perennial semiaquatic plants such as Water Couch (*Paspalum distichum*) at higher water levels (Roberts 2002) but less frequent floods and shorter periods of inundation place wetland communities such as Water Couch meadows and sedgeland at considerable risk.

Grazing

The ability of Lippia to persist during dry conditions is enhanced by its unpalatability to domestic stock particularly to cattle. However, the impact of grazing especially during droughts often results in substantial areas of bare ground in floodplain grasslands and especially on stream banks. The risk of Lippia invasion on these bare areas is high.

Impact on stream banks

The root system of Lippia appears less effective than that of grasses in binding cracking clay soils and this is most apparent on stream banks and on roadsides (Earl 2003). Lippia mats therefore exacerbate the instability of the soil on steep banks and reduce the likelihood of soil cracks and other semi-permanent refugia for fauna. The low growth form of Lippia and the absence of tall grasses may result in increased overland flow during rainfall events. This rapid movement of water also results in increased erosion of stream banks.

3. Name any species or ecological communities listed as threatened under the EPBC Act that are considered to be adversely affected by the threatening process [EPBC Regulation 7.07 2(d)]:

Communities

Brigalow (*Acacia harpophylla* dominant and co-dominant) (Endangered)

Amphibians

Litoria raniformis Southern Bell Frog (Vulnerable)

Reptiles

Furina dunmalli Dunmalls Snake (Vulnerable)

Tympanocryptis lineata pinguiocolla Grassland Earless Dragon (Endangered)

Birds

Rostratula australis Australian Painted Snipe (Vulnerable)

Plants

Amphibromus fluitans (Vulnerable)

Brachyscome muelleroides (Vulnerable)

Brachyscome papillosa Mossgiel Daisy (Vulnerable)

Callitriche cyclocarpa Western Water-starwort (Vulnerable)

Eleocharis obicis (Vulnerable)

Eriocaulon australasicum Southern Pipewort (Endangered)
Lepidium monoplocoides Winged Peppercress (Endangered)
Senecio behrianus Stiff Groundsel (Endangered)
Stipa wakoolica (*Austrostipa wakoolica*) (Endangered)
Swainsona murrayana Slender Darling-pea, Slender Swainson, Murray Swainson-pea (Vulnerable)
Swainsona plagiotropis Red Darling-pea, Red Swainson-pea (Vulnerable)

4. Name any species or ecological community, other than those that are listed under the EPBC Act, that could become eligible for listing in one of those categories because of the threatening process:

Ecological communities

Coolabah-black box woodland of the northern riverine plains in the Darling Riverine Plains and Brigalow Belt South bioregions (Preliminary listing TSC)

Carbeen Open Forest in the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions (TSC Endangered)

Native vegetation on the Cracking Clay Soils of the Liverpool Plains (TSC Endangered)

Lignum Communities

Reptiles

Anomalopus mackayi Five-clawed Worm-skink (TSC Endangered, NCR Endangered)

Hemiaspis damelii Grey Snake (NCR Endangered)

Pseudechis guttatus Spotted or Blue-bellied Black Snake

Mammals

Sminthopsis macroura Stripe-faced Dunnart (TSC Vulnerable)

Birds

Botaurus poiciloptilus Australasian Bittern (TSC Vulnerable)

Burhinus grallarius Bush Thick-knee (TSC Vulnerable)

Calyptorhynchus banksii Red-tailed Black-cockatoo (TSC Vulnerable)

Oxyura australis Blue-billed Duck (TSC Vulnerable)

Rostratula benghalensis Painted Snipe (TSC Vulnerable)

Stictonetta naevosa Freckled Duck (TSC Vulnerable)

Plants

Desmodium campylocaulon (TSC Endangered)

Sida rohlenae (TSC Endangered)

Solanum papaverifolium (NCR Endangered)

Aristida leptopoda

Asperula charophyton

Picris barbarorum

Pluchea dentex

Phyllanthus lacerosus

Phyllanthus lacunarius

Rorippa eustylis

Teucrium sp. A (*Teucrium* sp. (Pittsworth A.R. Bean 18338))

5. Provide justification for listing the threatening process as a key threatening process under the EPBC Act, with particular reference to [EPBC Regulation 7.07 2(e)]:

Nominated Listed threatened species or ecological communities

Communities

Brigalow (*Acacia harpophylla* dominant and co-dominant) is listed as an endangered community under the EPBC Act. Regrowth and degraded Brigalow are included in this listing. Around 90% of this community has been destroyed. Although groundcover is often sparse in Brigalow, invasion of weeds must be considered as a threat to this community. Lippia has been reported as a weed in over 45 hectares in Brigalow/Belah country north of Toobeeah in Queensland (Earl 2003). It is likely that all those component communities in lower country or on clay plains ie communities with *Acacia harpophylla* and/or *Casuarina cristata* are at risk of Lippia invasion.

Nominated Biota

Nominated fauna

The replacement of native floodplain groundcover with a monotypic Lippia groundcover will reduce food resources (seeds, whole plants, tubers, invertebrates that inhabit grasses, sedges) and habitat (nest sites, refugia) for threatened fauna (Table 1). Reduced recruitment of eucalypts and other woody species e.g. Lignum and negative impacts on stream bank soil structure also reduce fauna habitat (Table 1).

Table 1. Threats to threatened listed fauna: types of resources lost or degraded by Lippia invasion and expansion.

Species	EPBC Status	Food	Habitat	
			Nest sites	Refugia
Southern Bell Frog	Vulnerable	N/A	N/A	Water Couch meadows, wetland edge vegetation
Dunmall's Snake	Vulnerable	N/A	N/A	Grass tussocks
Grassland Earless Dragon	Endangered	N/A	N/A	Grass tussocks
Australian Painted Snipe	Vulnerable	Seeds, aquatic plants	On the ground amongst tall reed-like vegetation	tall grass and reeds

Nominated frog

The Southern Bell Frog is at risk from habitat destruction and isolation. This frog is restricted to inland southeastern Australia (Sadler *et al.* 1996) and is threatened by spread of Lippia across grassy floodplains along the Murray and Murrumbidgee Rivers and their tributaries. There are two main Southern Bell Frog populations in NSW, one in an irrigation area and the second in the Lowbidgee region between Maude and Balranald (S. Wassens pers. comm.). This frog shelters and forages in these floodplains during (and probably outside of) the breeding season (Oct-Mar)

following periods of rainfall (M. Bannerman pers. comm. 2003). Water couch (*Paspalum distichum*) and spike-rush (*Eleocharis plana*) are very important habitat for Southern Bell Frogs in both irrigation and wetland systems. Tadpoles seem to favour areas with water couch as it provides them with some protection during metamorphosis. These frogs over-winter in dense well-structured vegetation along the edges of wetlands and canals under species such as *Paspalum* and *Juncus* (S. Wassens pers. comm.). Any loss of diversity or structural changes to these vegetation types will have long-term impacts on the Southern Bell Frog.

Any use of herbicides to control the Lippia may threaten the Southern Bell Frog, as, like all frog species, it can absorb toxins through the skin. Herbicides may be life threatening to these animals, depending on the toxins used (M. Bannerman pers. comm. 2003).

Nominated reptiles

Much of Lippia habitat is gray or black cracking clays and alluvials (e.g. on the Condamine River Floodplain) and many floodplain fauna use soil cracks for refuge and hunting (R. Hobson pers. comm. 2003). When these areas are flooded much of these fauna are forced to the surface as cracks close when wet clays expand. Grass tussocks then provide critical refugia and shelter from predators for these species. Since Lippia itself provides very limited cover, invasion of Lippia and loss of floodplain grasses exposes these species to predators. Species considered at risk include Dunmall's Snake (*Furina dunmalli*) and the Grassland Earless Dragon (*Tympanocryptis lineata pinguicollis*). The Grassland Earless Dragon is a specialist inhabitant of temperate native grassland. Extant populations are known from the Canberra-Queanbeyan regions of the ACT and the Monaro region of NSW (Robertson and Cooper 2000). However, one lizard was collected in grassy woodland near Toowoomba in 1978 (Robertson and Cooper 2000); this population is confined to a small area of the Darling Downs and is considered to be at risk of Lippia invasion (R. Hobson pers. comm. 2003). Dunmall's Snake also has a limited distribution which includes black cracking clays in SE Queensland and is also considered at risk of Lippia invasion (R. Hobson pers. comm. 2003).

Nominated bird

The habitat of the Australian Painted Snipe (*Rostratula australis*) is shallow inland wetlands and includes the fringes of swamps and shallow freshwater swamps with rushes. This cryptic bird shelters in tall grass or reeds during the day and feeds at night; food includes invertebrates, seeds and aquatic plants (Ayers *et al.* 1996; NPWS 1999a; EPBC retrieved 2003). Clearing of the reeds around wetlands is considered an action likely to have a significant impact on this species (EPBC retrieved 2003).

Other threats to listed fauna

Control methods such as cultivation are also a threat to many rare species. Cultivation of floodplain grasslands and wetland edge vegetation is a threat to the Five-clawed Worm-skink and the Stripe-faced Dunnart because it destroys soil cracks and eliminates perennial groundcover (Ayers *et al.* 1996). Cultivation removes Lignum for Australian Bittern roosting sites and removes Painted Snipe habitat.

Nominated plants

11 herbaceous plant species listed in the EPBC Act are nominated as likely to have populations at risk as a result of Lippia invasion and expansion. All nominated

species occur in floodplains in grasslands and other communities that may be wholly or partly replaced by *Lippia*. All are threatened by clearing and habitat encroachment by *Lippia* poses a serious additional threat. Some species are known only from the Murray River or its environs, others are restricted to clay soils of floodplains or on dam walls and others grow in or on the margins of floodplain wetlands already at risk from river regulation and grazing (Table 2).

Table 2. Major threats to threatened listed flora: ranked probable impacts of *Lippia* invasion and expansion. Recruitment impact includes both loss of safe sites and negative impacts of seedling competition. A: annual; P: perennial. All are herbaceous species.

Species	EPBC Status	A/P	Habitat	Recruitment	Competition	Seed bank
<i>Eriocaulon australasicum</i>	Endangered	? P	Murray R.	2	1 (small size)	2
<i>Lepidium monoplocoides</i>	Endangered	A	floodplains	1	2	1
<i>Senecio behrianus</i>	Endangered	P	Murray R., banks, drains	?	1 (Alexander 1999)	?
<i>Stipa wakoolica</i>	Endangered	P	Murray R. floodplains	2	1	2
<i>Amphibromus fluitans</i>	Vulnerable	P	permanent swamps	2	1	2
<i>Brachyscome muelleroides</i>	Vulnerable	A	damp areas, margins of lagoons and claypans	1	2 (small)	1
<i>Brachyscome papillosa</i>	Vulnerable	P	intermittent lakes, irrigated paddocks	2	1	2
<i>Callitriche cyclocarpa</i>	Vulnerable	P	damp mud or shallow water	2	1 (small, mat-forming)	2
<i>Eleocharis obicis</i>	Vulnerable	P	ephemerally wet situations	2	1	2
<i>Swainsona murrayana</i>	Vulnerable	P	heavy soils, depressions, dams and levee banks	2	1	2
<i>Swainsona plagiotropis</i>	Vulnerable	P	Grassland, table drains	2	1 (prostrate)	2

Eriocaulon australasicum is a very rare small tufted herbaceous plant that has been recorded from the Murray River (Conn 1993). *Lepidium monoplocoides*, a very rare annual forb, is more or less confined to the Murray and its immediate environs and is considered at risk from *Lippia* invasion (N. Walsh, pers. comm. 2003).

Stiff Groundsel (*Senecio behrianus*) is a perennial forb or subshrub, which has been recorded at only a few sites along the Murray River in Victoria and South Australia and on the Darling River (Ayers *et al.* 1996). There is only one known wild population near Corop on a roadside reserve where scattered River Red Gum once grew. Plants occur on a constructed bank, on clay soil in a drain and in the road reserve (Alexander 1999). Little is known of the ecology of this species but it is thought to require periodic flooding. In planted populations, Stiff Groundsel appears

to prefer absence from competition. No recruitment from seed has been observed. The preferred habitat of this species is also Lippia habitat and the Draft Recovery Plan for Stiff Groundsel (Alexander 1999) lists weed invasion as a threat to this species.

Stipa wakoolica is a dense tufted perennial grass that grows in open woodland floodplains of the Murray Riverina tributaries on grey silty clay or sandy loam (Ayers *et al.* 1996) and is considered at risk from Lippia invasion (C. Gross pers. comm. 2003). *Amphibromus fluitans* is a perennial stoloniferous grass that grows mostly in permanent swamps on the southwest slopes and plains of NSW and in Victoria and Tasmania (Jacobs and Hastings 1993a).

Brachyscome muelleroides is an annual herb that grows on the margins of lagoons and claypans in mud and water in inland watercourse floodplains and discharge areas of NSW and Victoria (Ayers *et al.* 1996). *Brachyscome papillosa* is a perennial herb that has been recorded on soils of intermittent lakes and irrigated paddocks (Ayers *et al.* 1996). *Swainsona plagiotropis* and *Swainsona murrayana* are perennial plants of inland floodplains (Thompson and James 1991; Ayers *et al.* 1996; Hunter & Earl 1999). *Swainsona murrayana* grows on inland floodplains and discharge areas and is mostly seen on dams and levee banks (N. Walsh pers. comm. 2003), a habitat where Lippia is common seen. *Brachyscome papillosa*, *Swainsona plagiotropis* and *Swainsona murrayana* grow in similar habitats (Ayers *et al.* 1996). Competition from weeds is a threat for *Swainsona murrayana*.

Callitriche cyclocarpa is a rare aquatic and possible amphibious herb of scattered distribution from western Victoria and the southwest plains of NSW. This species occurs on damp mud or shallow water in wet and swampy places (Walsh and Entwistle 1999). *Eleocharis obicis* is a perennial herb of ephemeral wet habitats such as roadside drains and on heavy clay soils (Ayers *et al.* 1996). Both are considered at risk of Lippia invasion (N. Walsh, pers. comm. 2003).

Native species or ecological communities likely to become eligible for listing

Communities

The major threat to rare communities is severe loss of diversity in understoreys followed by reduced recruitment of over-storey species.

Coolabah-black box woodland has a preliminary listing as an endangered ecological community under the NSW TSC Act. This community is found in periodically waterlogged floodplains, swamp margins, ephemeral wetlands and stream levees of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion in New South Wales (NPWS 2003a) and in the Mitchell Grass Downs, Channel Country, Mulga Lands and Brigalow Belt bioregions of Queensland. More than two-thirds of this community in New South Wales is estimated to have been cleared (NPWS 2003a). The conservation status of Coolabah communities in the Channel Country, Mulga Lands and Brigalow Belt bioregions of Queensland are described as of concern (Sattler and Williams 1999). In New South Wales this community is threatened by weed invasion; Lippia and African Boxthorn are listed as weeds of particular concern (NPWS 2003a).

Carbeen Open Forest in the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions and Native vegetation on the Cracking Clay Soils of the Liverpool Plains are listed as endangered communities under the NSW TSC Act. Carbeen Open Forest occurs on sands of various types, including clayey sands, and occurs on the

riverine plains of the Mehi, Gwydir, MacIntyre and Barwon Rivers as well as at Moree and Walgett. Although this community does not occur on heavy clay soils, some areas adjacent to river and creek banks are included in its distribution. The listed community includes degraded remnants. Although *Lippia* is not listed in the TSC Act as a possible weed threat to Carbeen Forests, *Lippia* is known to occur in this community (Earl 2003), therefore those Carbeen forests or woodlands adjacent to rivers and creeks must be deemed at risk from *Lippia* invasion.

Native vegetation on the Cracking Clay Soils of the Liverpool Plains occurs within catchments that drain into the Namoi River. The Namoi catchment is one of the worst affected catchments from *Lippia* invasion in the Murray-Darling Basin (Earl 2003). The distribution of this community includes areas that remain waterlogged after heavy rainfall or floods. Invasion by weedy species is listed a threat to this community. *Lippia* has reported to be widespread along Cox's Creek at Mullaley and is common along roadside reserves in the Namoi catchment, therefore this endangered community must be considered a risk from *Lippia* invasion.

Lignum Communities include low shrublands dominated by Lignum (*Muehlenbeckia florulenta*) (Westbrooke *et al.* 2002) and woodlands such as *Eucalyptus coolabah* with *Acacia stenophylla* woodlands (Wilson 1999a; Wilson 1999b) and *Casuarina cristata* and *Eucalyptus coolabah* grassy open woodland (Young *et al.* 1999) where Lignum occurs as a component of the understorey. Lignum communities are at present under threat from cultivation and clearing (Wilson 1999a; Wilson 1999b; Young *et al.* 1999) and are important nesting sites for a variety of birds including Freckled Duck. There is the potential for the complete replacement of the groundcover of native herbs and grasses with *Lippia* in these communities with a catastrophic effect on diversity. A *Lippia* dominant groundcover may also prevent Lignum recruitment.

Fauna

Nine fauna species are nominated as likely to become listed: three reptiles, one mammal and five bird species (Appendix, Table A - 1).

The Five-clawed Worm-skink (*Anomalopus mackayi*) is a rare floodplain species that is considered vulnerable nationally (Sadler *et al.* 1996). This reptile requires good grass cover on cracking clay soils (Phil Spark pers. comm. 2003, Ayers *et al.* 1996) and is particularly susceptible to loss of soil structure since loose soil and soil hollows are used as habitat and for moving from area to area (Sadler *et al.* 1996). Clearing of fallen timber is also a threat for this species. Fallen timber could be disturbed or removed and soil structure disrupted during cultivation to control *Lippia*. Observations suggest that *Lippia* mats also causes changes to soil structure.

The Stripe-faced Dunnart (*Sminthopsis macroura*) is widespread though sparse through inland central and northern Australia but populations in the north-eastern parts of the Western Division of NSW have declined although there are recent recordings from northern floodplains (Ayers *et al.* 1996). Although primarily an arid zone species, Stripe-faced Dunnart habitat includes denser vegetation along drainage lines (Ayers *et al.* 1996). This species shelters in cracks in the soil, in tussock grasses and under logs. Cultivation is a threat to this species. *Lippia* invasion and subsequent control measures could have an impact on this species over part of its range.

The Spotted or Blue-bellied Black Snake (*Pseudechis guttatus*) is one of the apical predators of black cracking clays in southeastern Queensland and northern NSW

(Queensland Museum retrieved 2003). While larger adults would not be much affected by *Lippia*, juveniles hunt in cracks for the many smaller reptile species that depend on cracks for survival. As well as smothering soil cracks, *Lippia* invasion would also result in the loss of grasses crucial for refuge when soil cracks disappear on flooding. Impacts by *Lippia* on these smaller prey animals could severely disrupt the food chain of juvenile *P. guttatus*. This snake has almost disappeared from areas east of the Divide in southeastern Queensland and the black cracking clays of the *Lippia*-infested Condamine floodplain are now its stronghold (R. Hobson pers. comm. 2003). The Grey Snake (*Hemiaspis damelii*) also depends on soil cracks as habitat.

Two bird species (the Australian Bittern, Freckled Duck) are not listed under the EPBC Act but are considered at risk nationally (Smith *et al.* 1995). The Australian Bittern requires dense tall beds of bulrushes or spikerushes surrounding permanent wetlands for cover but also occurs in flooded pastures (Marchant & Higgins 1990, Smith *et al.* 1995; Ayers *et al.* 1996). Dense reed beds are used for nesting. These habitats are threatened by changes to water regimes and burning, *Lippia* invasions after droughts could have severe impacts on vegetation structure in these wetlands.

The Freckled Duck feeds at the edges of swamps and other wetlands at night and its habitat includes heavily vegetated swamps and the shores of large lakes, rivers and creeks (Ayers *et al.* 1996; NPWS 1999b). The Western Division of NSW is an important breeding area and nests are typically found in temporary wetlands with dense *Lignum* and in bulrush beds. Encroachment of *Lippia* onto swamps and swamp margins may have an impact on food sources for these birds and may also prevent recruitment of *Lignum* and other species used for habitat and nesting. The Blue-billed Duck feeds in large deep permanent wetlands but nests densely vegetated swamps and marshes e.g. in *Lignum*, *Lippia* invasion may reduce recruitment of swamp species and thus reduce nesting habitat.

Three other bird species (Bush Thick-knee, Red-tailed Black-cockatoo and Blue-billed Duck) are at present not considered at risk nationally but may become eligible for listing as a result of *Lippia* invasion. Two of these are floodplain ground-feeders, the Bush Thick-knee, which feeds and nests in grassy open woodlands including those of river flats, and the Red-tailed Black-cockatoo which feeds on eucalypt seeds and fruit (Ayers *et al.* 1996). The Bush Thick-knee has declined markedly in Southern Australia (Smith *et al.* 1995) and threats include habitat degradation. Clearing and overgrazing are threats to the Red-tailed Black-cockatoo as well as reduced regeneration of River Red Gums due to river regulation.

Lippia may also threaten other species because of reduced recruitment of River Red Gum and other riparian woodland and forest species. Threatened species which require riparian forests include the Pale-headed Snake (*Hoplocephalus bitorquatus*), the Greater Long-eared Bat (*Nictophilus timoriensis*), the Square-tailed Kite (*Lophoictinia isura*), the Grey Falcon (*Falco hypoleucos*), and the Red-tailed Black-cockatoo (Marchant & Higgins 1993; Ayers *et al.* 1996). The Superb Parrot (*Polytelis swainsonii*) nests in River Red Gums and box woodlands, food includes fruits, blossoms and seeds of eucalypts and acacias. This species also forages on the ground for seeds (Ayers *et al.* 1996).

Plants

13 plant species are nominated as likely to become listed as a result of *Lippia* invasion (Appendix, Table A - 2). All occur in floodplains in grasslands and other communities that may be wholly or partly replaced by *Lippia*. Habitats include clay

soils on floodplains, floodplain grasslands, the edges of wetlands, ephemeral wetlands, creek banks and the banks of dams and levees.

Desmodium campylocaulon is a herb of brown soil plains (Hunter and Earl 1999). *Sida rohlenae* is a species of ephemeral wetland areas (NPWS 2003b) and of flood-outs and creek banks (Hunter & Earl 1999). *Solanum papaverifolium* is an erect or sprawling perennial herb that grows on heavy clay soils. This species occurs in Northern NSW and southern Queensland (Harden 1992).

Aristida leptopoda, *Phyllanthus lacunarius* (Hunter and Bruhl 1997), *Phyllanthus lacerosus* (Hunter and Bruhl 1997), *Pluchea dentex* and *Rorippa eustylis* are all rare floodplain species of western NSW (Hunter and Earl 1999; McGann *et al.* 2001) considered at risk under Lippia invasion. *Asperula charophyton*, *Picris barbarorum* and *Teucrium* sp. A (*Teucrium* sp. (Pittsworth A.R. Bean 18338) are rare floodplain plants of the Condamine catchment considered to be at risk under Lippia invasion (R. Fensham pers. comm. 2003).

White Speargrass (*Aristida leptopoda*) is a densely tussocky perennial grass from NSW and Queensland that grows on heavy soils and flowers in response to rain (Jacobs and Hastings 1993b). *Phyllanthus lacunarius* is an annual herb that grows on river and creek beds, along banks and on flood plains (Harden and Murray 2000). *Phyllanthus lacerosus* has an extensive but sporadic distribution and occurs on black cracking clay soils in grasslands (Hunter and Bruhl 1997). Both species are considered at risk from Lippia invasion (J. Hunter pers. comm.)

Rorippa eustylis is a groundcover herb with lax stems that occurs in lignum communities (McGann and Bell 2001; Thoms *et al.* 2002). *Pluchea dentex* is a herb found in flooded areas or open riparian forest communities (McGann *et al.* 2001; Thoms *et al.* 2002). Both occur in all mainland states but are at risk because of threat to floodplain habitats.

Asperula charophyton is a rare herb known from only a few locations in NSW and from creek banks or floodplains in heavy soil country in Queensland (J. Hunter, R. Fensham pers. comm.). *Picris barbarorum* is a rare and possibly threatened herbaceous plant from northern NSW, Queensland and possible Victoria (RBGSYD retrieved 2003). *Teucrium* sp. A is a perennial, often scrambling herb that grows in heavy clay-rich soils in northern NSW and Queensland (Conn 1992).

There are unconfirmed reports of Lippia on the Darling River (Earl 2003). If Lippia becomes invasive on the Darling River floodplain then other plant species would be under threat. Examples are; *Dysphania platycarpa* (TSC Endangered), *Dentella minutissima* (TSC Endangered), *Atriplex sturtii* (TSC Endangered), *Solanum karsense* (TSC Vulnerable) and *Ipomoea polymorpha* (TSC Endangered) (Westbrooke *et al.* 2001; Hunter 2000) and *Mukia micranthia* (Ian Telford pers. comm. 2003)

6. Additional information on a Threat Abatement Plan

The information provided in this nomination demonstrates that Lippia has had, and will continue to have significant impacts on Australia's wildlife and ecosystems, especially in newly-colonised areas, and satisfies the eligibility criteria for listing as a Key Threatening Process. The listing of Lippia invasion as a key threatening process, and development of a national threat abatement plan would facilitate a more coordinated approach to actions to mitigate this threat, and promote increased efforts to ensure that the impacts of Lippia can be managed in a cost-effective manner.

WWF Australia contends that a Lippia Threat Abatement Plan is a feasible, effective and efficient means to develop and implement a coordinated national response to the nominated key threatening process.

Given that Lippia will significantly expand its range while this nomination is being considered by the Threatened Species Scientific Committee, governments could proactively develop an action plan informed by the proposed elements below.

A. Strategic Containment

Conserving sites and species habitats of national environmental importance

B. Integrated Biocontrol

Biological control

The confusion surrounding the identification of *Phyla canescens* and *Phyla nodiflora* is also likely to create problems for biological control. Taxonomic clarification is particularly crucial to the development of biological control agents since predators and pathogens of overseas *Phyla* species may not be effective on the Australian problem species.

There are a number of species of butterfly larvae that utilise *Phyla* spp. as a food host. The Phaon crescent *Phyciodes phaon* which deposits eggs in clusters on the undersides of the leaves of its host plant *Phyla* (*Lippia nodiflora*) (Hanife-Genc and Nation, 2002). Locally the Meadow Argus butterfly, *Junonia villida* utilises *Phyla canescens*, and a wide range of other native and introduced forbs, as a larval food host (Grund 1999).

Control methods

Current control methods include the use of herbicides such as Lantana DP600 and 2,4-D Amine although few landholders report success with this method (Earl 2003). There are issues relating to risks to threatened species and to river health where spraying occurs close to waterways.

Many farmers believe cultivation is the cheapest and most effective method of control followed by sowing with various grass cultivars. There are issues here in direct risks to threatened plant species and regarding loss of vegetation structure and litter particularly for fauna species requiring native groundcover, logs, sticks of grass tussocks for habitat. Risk to the stability of stream banks can also occur when landholders cultivate close to banks grazing in an attempt to control Lippia where these areas have previously been uncultivated and managed for grazing.

The reported occurrence of Lippia on and around the high water level of upland dams and streams would suggest dispersal by waterbirds. This dispersal may come from pieces of Lippia being transported by attachment or ducks for example foraging on Lippia may ingest the seeds. The seeds may retain viability in the gut of birds and establish on dam banks.

C. Research

Taxonomy

In view of the many synonyms for *Phyla canescens* and the confusion over its identity worldwide, future work in phytochemistry, allelopathy and biological control require that the relationships between the taxonomic entity *Phyla canescens* in Australia and other *Phyla* species overseas be clarified.

The name, *Phyla canescens*, was used in Australia for the first time by Munir (1993) who published a taxonomic revision of *Phyla*. Other synonyms include *Phyla nodiflora* var. *canescens*, *Lippia canescens*, *Lippia nodiflora*, *Lippia nodiflora* var. *rosea*, *Zapania canescens* and *Zapania nodiflora* var. *rosea*. Lucy *et al.* (1995) cite the first official recording as Lake Torrens Adelaide SA in 1927 and in Queensland at Tummaville in 1944. However, the most commonly mentioned species at that time for example, in surveys of the Condamine River catchment by Mann in 1960 and Csurhes in 1989, was *Phyla nodiflora*. Both *Phyla canescens* and *Phyla nodiflora* occur in Australia (Munir, 1993) but *Phyla canescens* appears to be the invasive species.

Phyla nodiflora is thought to be common in coastal areas from NSW, Qld. NT and WA, whereas *Phyla canescens* is the species spreading throughout the MDB floodplain region.

There is some conjecture over the native status of *Phyla nodiflora*. The first collections of *Phyla* were made in 1802, and the first published record of *Zapania* was in 1810. All recent records until at least 1993, refer to *Phyla nodiflora* (Munir, 1993). The earliest record of 19 specimens of *Phyla canescens* listed on the Royal Botanic Gardens, Sydney, database was 1949 from Burrumbuttock on the SW slopes of NSW. The Royal Botanic Gardens, Melbourne, list 30 specimens of *Phyla canescens* on its database with the earliest collections from Williamstown, a suburb of Melbourne, in 1914.

There appears to be some overlap in the habitat of *Phyla canescens* and *Phyla nodiflora*. A specimen of *Phyla canescens* held by the Royal Botanic Gardens Herbarium, Sydney was collected from the NSW Central Coast in 1976 and at least two specimens collected in 2003 in a study by Earl (2003) are thought to be *Phyla nodiflora*. Both species have been reported as occurring in Tasmania and Western Australia.

Outside of the MBD *Phyla canescens* is reported to occur in Murgon, Queensland, in gardens of Hobart, Tasmania and areas around Perth in Western Australia. A specimen was also collected from the banks of the Broughton River west of Yacka in South Australia and *Lippia* was reported to occur around Adelaide.

The confusion in the literature between these two closely related species adds to the difficulty of accurately assessing information and data relating to *Lippia*. Kennedy (1992) states that *Phyla canescens* is easily distinguished from other *Phyla* species by its low growth habit and dense cover. However, this species exhibits a degree of morphological plasticity (Earl 2003). Where litter cover and depth is high, branches are elongate. In dense pasture, branches are short and erect (Earl 2003).

Ecology

The ecology of *Lippia* (*Phyla canescens*) is not fully understood and further work is required on seed production, dispersal of seeds and seed bank dynamics and on the interactions between *Lippia* and other key floodplain and wetland species. Information is needed on possible pollination agents of *Lippia* flowers. Since dispersal of *Lippia* seeds by water birds appears likely, further work could include the mechanisms and relative success of this dispersal method. *Lippia* is still a common garden species in parts of the MDB and a possible mechanism for dispersal is via disposal of garden waste. Investigations into the dormancy characteristics and the

longevity of *Lippia* seeds in the soil may provide information on the ability of *Lippia* to regenerate from the soil seed bank.

A number of recent studies have focused on the tolerance of *Lippia* to inundation regimes which vary according to the depth, duration, timing and variability of flooding (Hobson 1990; Taylor 2003). Given that *Lippia* has been observed on higher ground, information is required to determine thresholds of tolerance for *Lippia* for other environmental variables e.g. soil moisture. Taylor (2003) found that sites dominated by *Lippia* were differed significantly to those dominated by *Sporobolus mitchellii* in type of vegetation community, soil EC and soil texture. Further work is needed to quantify these differences and to establish causal relationships between *Lippia* and soil characteristics.

Further work is need on interactions with other plant species. The native grass *Sporobolus mitchellii* is able to compete with *Lippia* (Taylor 2003) as is Water Couch (*Paspalum distichum*) and *Eleocharis plana* under flooded conditions (Hobson 1999; Roberts 2002).

Although the extent of *Lippia* is known and its future extent predicted, no published accounts exist of the long-term dynamics of *Lippia* communities.

Phytochemistry

Anecdotal evidence exists on the allelopathic effect of *Lippia* on other plant species; many observers report a bare area surrounding *Lippia* mats. However, the bare area may also represent a further patch of bare ground not yet colonised. This issue needs to be explored. Elakovitch (1987) notes that *Lippia nodiflora* contains sesquiterpenes and monoterpenes and that these chemicals are allelopathic. Tomas-Barberan *et al.* (1987) refer to *Lippia nodiflora* and *Lippia canescens* as containing the same flavenoid pattern and possessing flavenoid sulphates, a characteristic absent from other species in this genus. *Phyla* (*Lippia*) species have been widely used in traditional medicine in eastern countries with plant oils being used for various disorders as well as for seasoning of food (IMP, 1995). Essential oils (phenolics and flavenoids) are assumed to be the active components (Pascual *et al.* 2001). Flavonoids are common in higher plants and some have antifungal and antibacterial properties (Anon. 2003). An investigation of the phytochemical composition of local ecotypes versus overseas ecotypes of *Phyla canescens* is therefore an essential component of a biological control program.

D. Capacity building and Education

An effective public awareness and action campaign should be developed to provide information on the environmental and economic costs of *Lippia* invasion.

The campaign should include information about *Lippia*'s impacts on native flora, associated wildlife habitats, water quality and wetland, floodplain and riverine ecosystems.

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Appendix

A - Table 1. Conservation Status of fauna nominated as likely to become listed.

Species	Common Name	Act	Conservation Status
<i>Anomalopus mackayi</i>	Five-clawed Worm-skink	TSC (NSW) NCR (Queensland)	Endangered Endangered
<i>Hemiaspis damelii</i>	Grey Snake	NCR (Queensland)	Endangered
<i>Sminthopsis macroura</i>	Stripe-faced Dunnart	TSC (NSW)	Vulnerable
<i>Botaurus poiciloptilus</i>	Australasian Bittern	TSC (NSW)	Vulnerable
<i>Burhinus grallarius</i>	Bush Thick-knee	TSC (NSW)	Vulnerable
<i>Calyptorhynchus banksii</i>	Red-tailed Black-cockatoo	TSC (NSW)	Vulnerable
<i>Oxyura australis</i>	Blue-billed Duck	TSC (NSW)	Vulnerable
<i>Stictonetta naevosa</i>	Freckled Duck	TSC (NSW)	Vulnerable
<i>Pseudechis guttatus</i>	Spotted or Blue-bellied Black Snake		

A - Table 2. Conservation Status of flora nominated as likely to become listed.

Species	Common Name	Act	Conservation Status
<i>Desmodium campylocaulon</i>	Creeping Tick-foil	TSC (NSW)	Endangered
<i>Sida rohlenae</i>		TSC (NSW)	Endangered
<i>Solanum papaverifolium</i>		NCR (Queensland)	Endangered
<i>Aristida leptopoda</i>			
<i>Phyllanthus lacunarius</i>			
<i>Phyllanthus lacerosu</i>			
<i>Pluchea dentex</i>			
<i>Asperula charophyton</i>			
<i>Picris barbarorum</i>			
<i>Teucrium</i> sp. A			