

Listing Advice

Biodiversity decline and habitat degradation in the arid and semi-arid Australian rangelands due to the proliferation, placement and management of artificial watering points

Name and location of the nominated threatening process

‘Biodiversity decline and habitat degradation in the arid and semi-arid Australian rangelands due to the proliferation, placement and management of artificial watering points’.

The nomination was originally made in 2007 as: ‘*habitat degradation in the Australian rangelands resulting from increased grazing pressure due to the proliferation and placement of artificial watering points*’.

Biodiversity decline and habitat degradation in the arid and semi-arid Australian rangelands due to the proliferation, placement and management of artificial watering points is not currently listed as a threatening process by any state or territory government.

Location of arid and semi-arid Australian rangelands

The area for which this process is assessed is the arid and semi-arid Australian rangelands. There is no single definition of rangelands and the Australian rangelands have no clearly defined boundaries. They are based around climatic conditions and the boundaries therefore change as conditions change. They typically include the low rainfall and variable climate arid and semi-arid areas of Australia, and some seasonally high rainfall areas north of the Tropic of Capricorn and cover approximately 80 per cent of Australia’s land area (NRMMC, 2010a). The arid and semi-arid rangelands are defined by the presence of desert vegetation and land forms as well as by low rainfall. They are bound by median annual rainfalls of about 250 mm in the south but up to 800 mm in the north and about 500 mm in the east (Williams and Calaby, 1985; CSIRO, 2011).

Description of artificial watering points

Artificial watering points assessed here are any watering points that are not naturally occurring and are accessible to wildlife in the landscape. These can include but are not limited to bores, bore drains, wells, piped reticulation systems, troughs, walk-in dams and storage tanks. Artificial watering points have been mostly provided for domestic livestock to drink, particularly cattle and sheep. Artificial supplies of water have now been provided over vast areas of arid and semi-arid Australia through the tapping of various forms of underground water, the pooling of surface run-off water in tanks and dams, and reticulation of water by pumping (Landsberg et al., 1997).

Landsberg et al. (1997) describe three sources of water used to provide permanently available drinking water in arid and semi-arid areas of Australia:

- Unconfined aquifers. When these are pumped to the surface from a bore these become artificial watering points.
- Artesian and sub-artesian aquifers. Where these are pumped to the surface from a bore, or purposefully drilled to form an artesian well (the water surfaces as a result of natural pressure), these are considered to be artificial watering points.

- Stored surface run-off. Where the storage has been artificially created (e.g., dams), these are artificial watering points.

Any of these water sources can be piped to additional storage and access points.

Description of 'proliferation' and 'placement' of artificial watering points

Prior to European settlement, water sources in the arid and semi-arid lands existed only in the form of rock-holes, soaks, impoundments, gilgais and claypans, mound springs (Bayley, 1999) as well as creeks and desert lakes. While there is a lack of information on the number and location of pre European watering points, other than through traditional knowledge and historical documents, natural water sources appear to have been depleted following European settlement. Changes to natural springs are an example. Before the 1880s, there were more than 3000 springs in about 600 groups, including thirteen major complexes (Rolf, 2008). Ogilvie and Edwards surveyed springs of southern Queensland around 1912 and noted that two-thirds had been modified in some way prior (Fairfax and Fensham, 2003). Modification were made to springs to improve flow or in order to make water more accessible to stock or humans and take the form of excavations such as dredging, conversion to dams, wells, draining, excavation by explosives and construction of raised concrete structures that limit water flow (Fensham and Fairfax, 2003). Of the active spring-groups of the Great Artesian Basin surveyed by Fensham and Fairfax (2003), 26 per cent had suffered major or total damage as a result of excavation by 2002; only 36 per cent of the original 300 spring groups in recharge areas had springs still active and 80 per cent of spring-complexes in the discharge area had become completely or partly inactive (Fensham and Fairfax, 2003).

There is difficulty in accurately clarifying a baseline to determine what quantity and the locations of watering points were prior to European modification and what 'proliferation' would mean. While the number of natural watering points is likely to have been depleted, it is generally accepted that the total number of watering points has increased relative to pre-European settlement as a result of the formation of artificial watering points which are more regularly spaced across the landscape to provide greater ease of regular access. Bastin and ACRIS (2008) provides an overview of the change in availability of water in the rangelands over the last 100 years.

Grazing leases were established over most of eastern Australia by the mid-1800s but were focused on permanent and semi-permanent waters of major waterways, thus most grazing pressure was based on associated riparian habitats (Landsberg et al., 1997). The development of machinery that enabled excavation of dams, followed by the discovery of artesian water in the 1880s, provided for the development of artificial watering points (Landsberg et al., 1997) and the expansion of pastoral land into more arid areas. The drilling of bores following the discovery in 1878 of the Great Artesian Basin has enabled establishment of the pastoral industry and greater human settlement into otherwise dry environments (GABCC, 1998). By the 1880s, the arid and semi-arid lands of New South Wales and Queensland were considered to be under pastoral settlement as well as much of South Australia (Noble, 1998). In the 1880s, artificial watering points were widely spread, but stocking rates around these were much greater than would currently be considered sustainable. In New South Wales in the 1890s, stock peaked at 19 million.

Pastoral settlement was further extended by 1900, including into much of the Northern Territory and Western Australia (Noble, 1998). By the 1950s, artificial water sources in the form of troughs, dams and bores had increased in number (Landsberg et al., 1997; James et al., 1999) following favourable environmental and economic conditions. Another severe drought in 1959–

1965 saw drought relief bores drilled under a subsidy scheme. From the late 1970s, the national Brucellosis and Tuberculosis Eradication Campaign led to more fencing to form smaller, more manageable paddocks with some additional water supplies (Bastin and ACRIS, 2008). Property sizes were reduced and smaller flocks placed less stress on more numerous individual watering points (Landsberg et al., 1997).

A comparison of watering points between about the time of the Second World War and the 1990s showed, that for a test area examined in the Gascoyne-Murchison of Western Australia, the area of land within 6 km of water increased from 66 per cent to 90 per cent. A general increase in watering point density was found for all but one land type. The increase was most pronounced on highly productive and fragile systems (Watson et al., 2006).

Today, artificial water sources are found at high densities throughout Australia's grazing rangelands, with an average distance between points of less than 10 km (James et al., 1999). In 1998, it was estimated there were about 3000 free flowing artesian bores and 34,000 km of bore drains in place in the Great Artesian Basin (GABCC, 1998).

Proliferation of watering points has been one of the key factors in the development of the pastoral industry throughout much of the Australian arid and semi-arid rangelands (Basin and ACRIS, 2008). The proliferation and placement of artificial watering points provides for increased access to water by native and introduced species including domestic stock, including during dry periods and drought. The broadscale supplementation of drinking water has enhanced densities of sheep (*Ovis aries*), cattle (*Bos taurus*, *Bos indicus*) and goats (*Capra hircus*), and contributed to increased populations of native kangaroos (*Macropus* spp.) since pre-European times (Fensham and Fairfax, 2008).

Description of 'management' of artificial watering points

The name of the process 'Biodiversity decline and habitat degradation in the arid and semi-arid Australian rangelands due to the proliferation, placement and management of artificial watering points' imposes a management component to the threat process under assessment here.

There are a range of management actions that could be included within a definition of management. The management of artificial watering points is the human manipulation of the watering point, but does not also include the formation of the artificial watering point (as formation is included under 'proliferation and placement'). Management could potentially include:

- maintenance of the artificial watering point following its formation,
- adjustments to the distribution, flow, timing, access to, and evaporation of water (e.g., closed vs open drains, pumps) from the watering point,
- management of flow-on effects including management of the surrounding area, and could include access to areas surrounding the watering points, pest and weed management, management of total grazing pressure, or other.

Watering points act as a focal point for biological activity and can have both positive and negative impacts on the landscape. Management activities may be positive or negative relative to biodiversity. Whether the impacts to biodiversity are positive or negative can be argued to be a consequence of this management, and its appropriateness relative to biodiversity, rather than the presence of the watering point itself or their distribution in the landscape.

Describing and defining the potential suite of management activities that may have positive or negative impacts on biodiversity is beyond the scope of this assessment, as these activities

would differ relative to location/ecosystem within the arid and semi-arid rangelands, would continually change in spatial scale, and continually change in response to changing environmental conditions, among other reasons.

Components of the process

- Activity around the formation and placement of artificial watering points can be the cause of direct physical change in the environment (see points 5-6 below).
- The proliferation and placement of artificial watering points may also provide for, or in some instances facilitate other biological process components and threats that in turn have causal links to changes in biodiversity (see 1-4 below).
- Increased access to water as a result of the proliferation and placement of artificial watering points is proposed as a causal link to these other more direct threats, which may be considered to be components of this process.
- However, whether these become threats or not, and the degree of threat, is likely to depend on how artificial watering points and their surrounding areas are managed.

The proliferation, placement and management of artificial watering points can be the cause of incidences of:

- increased and/or focal concentration of:
 1. grazers including domestic livestock, feral and native grazers, which may increase and concentrate grazing relative to locations without artificial watering points, and
 2. predators including native and feral predators, increasing the incidence of predation relative to locations without artificial watering points
 3. change in other species' distribution / area of occupancy of species as a result of the availability of water of introduced (e.g., cane toads, weeds) and native species, or as a result of increased disturbance and traffic around artificial watering points- both animals and maintenance vehicles bringing in foreign plants (native or introduced) or as intentional introduced plants (e.g., athel pine and parkinsonia planted for shade).
- physical change, such as:
 4. compaction and other changes to the soil crust around artificial watering points. This could be as a result of increase in trampling and other physical damage by grazers and/or as a result of compaction/disturbance from maintenance vehicles
 5. draw-down of aquifers as a result of the extraction of water for artificial watering points
 6. anthropogenic modification to the physical surface environment from direct modification of the landscape for the creation and management of watering points, such as modification of natural ephemeral waters to artificial and permanent water collecting sites such as dams and impoundments

These changes are discussed below.

1. Grazing pressure and watering points

Landsberg et al. (1997) documented major changes in biodiversity at different distances from artificial watering points, and found consistent trends in the variation of abundance of species

relative to distance to water. Species associated with sites closest to water consistently showed an 'increaser' pattern of response to the disturbance associated with water, with their abundance significantly increasing with increased proximity to water, while species associated with sites remote from water consistently showed a 'decreaser' pattern of response being the opposite of that of the 'increasers'. Landsberg et al. (1997) provide detailed lists of species categorised in response groups as 'increasers', 'decreasers' (15-38%) or 'not determined' (36-75%). Most of the species that decreased were native species, such as forbs, grasses and shrubs and ground-dwelling and granivorous birds.

Landsberg et al. (1997) note that 'increaser' species are not of high conservation concern because the widespread distribution of artificial sources of water means that most of the rangelands lie within 10 km of water, and is therefore potentially suitable for species that are advantaged or unaffected by the location of water. In contrast, that habitat likely to be suitable for the persistence of 'decreaser' species has been reduced to a very small fraction of its former extent, with possibly as little as 3–8% of pastoral rangelands now remote from water.

Landsberg et al.'s study could not determine the proximate cause(s) of these changes. The provision of water was identified as a likely direct benefit for increaser species such as those that require water to drink, while others may benefit from the introduction of livestock which aid in the dispersal of seed. Other considerations included competition, and increased abundance of carrion. However, Landsberg et al. (1997) noted that most of the indirect changes associated with the provision of water arise from the impact of grazing by large herbivores that focus their activity around sources of drinking water. The increased availability of water since pre-European times has provided for an increase in densities of sheep (*Ovis aries*), cattle (*Bos taurus*, *Bos indicus*) and goats (*Capra hircus*) as well as kangaroos (*Macropus* spp.) (Fensham and Fairfax, 2008) and has enabled virtually all areas to be subject to significant levels of grazing, resulting in declining areas of refugia for grazing-sensitive species (Fisher et al., 2004).

Grazing by livestock (cattle and sheep), feral herbivores (goats, donkeys, horses, camels) and kangaroos affects landscape function and critical stock forage, particularly when total grazing pressure remains high in years of lower seasonal quality (Bastin and ACRIS, 2008). Extremely high and unsustainable stocking rates caused unprecedented land degradation from first settlement to about the middle of the 20th century (Proceeding of the Parliament of South Australia, 1868; Parliament of Western Australia, 1940; New South Wales Government, 1901; cited in Fisher et al., 2004) contributing to declines in biodiversity over this period (Fisher et al., 2004). Drought is likely to have exacerbated these impacts, with Australia's worst drought to date in terms of severity and area occurring during 1895–1903. This drought halved sheep numbers from more than 100 million and also reduced cattle numbers by more than 50 per cent. Less severe but nonetheless major droughts followed in 1911–1916, 1918–1920, 1939–1945 followed by a further severe drought (probably second to the 1895-1903 drought in severity) in 1958–1968 (Australian Bureau of Statistics, 2012).

Grazers in the arid and semi-arid rangelands:

Cattle and sheep: The transformation of the rangelands through the introduction of sheep and cattle and the addition of artificial watering points to sustain and increase productivity has been underway for around 150 years (Landsberg et al., 2003). In the late 1800s, average sheep numbers in the rangelands of New South Wales were nearly twice what they are today (Caughley, 1976 cited in OEH, 2011). The overall number of artificial watering points has been increasing since European settlement and the rate of establishment has intensified in the last few decades (James et al., 1999). 'In the arid and semi-arid rangelands the geographical

distribution of cattle and sheep and hence the impact of their grazing activity, is mostly determined by the placement of artificial watering points' (James et al., 1999). Watering points are a focus for cattle activity in arid environments but habitat use by cattle is also influenced by dispersion of critical forage and shade resources of woodland (Frank et al., 2012). Landsberg et al. (1997) found that areas more than 15 km from a water source are considered to be outside the normal grazing range for cattle, and that cattle generally move within a 4–10 km radius of a water source, and the main grazing impact occurs within a 10 km radius (Landsberg et al., 1997). For sheep, areas more than 9 km from a water source are considered to be outside normal grazing range, the foraging range can be as little as 3 km from water in hot conditions and the main grazing impact occurs within a 5 km radius (Landsberg et al., 1997). Fensham and Fairfax (2008) identify threshold distances from water containing 95 per cent of a population of grazing animals, with the threshold for sheep being 3 km, cattle; 6 km and red kangaroos; 7 km.

Kangaroos: Predominantly four species of kangaroo (red *Macropus rufus*, eastern grey *Macropus giganteus*, western grey *Macropus fuliginosus*, and wallaroo/euro *Macropus robustus*) are grazers that contribute to the total grazing pressure in the rangelands. Their numbers may have increased with the increased availability of water relative to pre-European times. James et al. (1999) suggest that kangaroos will regularly travel 20 km to water. Montague-Drake (2004) found that in Sturt National Park, where pastoral grazing has ceased for more than 30 years, all species of kangaroo used artificial watering points to drink, but kangaroos did not exhibit grazing patterns related to water points, demonstrating no concentration of grazing impacts around watering points. Instead, the study revealed that the distribution of most kangaroos was related to their preference for areas proximate to major drainage channels which offer green herbage and shade.

Feral species may not normally be considered in determining total stocking rates on an area, but their numbers, combined with domestic livestock numbers, may exceed sustainable stocking rates. The impacts of feral species will be most pronounced during drought, when animals compete for declining food and water resources.

Feral goats: Competition and land degradation by feral goats are listed as a key threatening process under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Similarly to other grazing animals, unmanaged goats can affect native flora and fauna by 1) grazing on native vegetation, thereby preventing regeneration; 2) by overgrazing, which causes soil erosion; 3) by competing for food and shelter; 4) by introducing weeds through seeds carried in their dung; and 5) by fouling waterholes (DEWHA, 2008b).

The estimated feral goat population in Australia has grown from 1.4 million in 1997 to 4.1 million in 2008. In 2010, there were an estimated 3.3 million feral goats in the rangelands. An increasing proportion of the feral goat population occurs in New South Wales, comprising 70 per cent in 2010 and in 2011, there were an estimated 2.95 million feral goats in New South Wales (Bastin, 2012).

The distribution of unmanaged goats is limited by several factors, including the availability of water during dry times (DEWHA, 2008b). Thus artificial watering points are likely to provide for further extension of the range of unmanaged goats than would occur without artificial watering points. In the rangelands of New South Wales, feral goat distribution is closely linked to artificial watering points such as tanks and bores and surveys have indicated that goat activity was rare more than 4 km from water (Russell et al., 2011).

Feral camels: Feral camels are recognised as causing broad landscape damage including to vegetation through foraging behaviour and trampling, suppression of recruitment of some plant

species, selective browsing on rare and threatened flora, damage to wetlands through fouling trampling and sedimentation, competition with native animals for food and shelter (NRMMC, 2010b). Edwards et al. (2008) provides detail of the environmental impact of camels, including a list of species affected. Feral camels feed on more than 80 per cent of available plant species and have serious impacts on vegetation at densities of greater than two animals /km² (Dörge and Heucke, 1996 cited in Pavey, 2006).

The need for water coupled with the need to consume salt means that camels frequent wetland habitats across arid Australia and in these areas, the negative impacts of feral camels can be significant (Edwards et al., 2010). Species immediately at risk from camels are plants which are highly preferred food for camels and animals and plants which are dependent on wetland habitats. Edwards et al., (2010) note that the negative impacts of camels are likely to be exacerbated under forecast climate changed scenarios.

Feral camels are present in up to 50 per cent of Australia's rangelands ecosystems, which includes most of the arid regions of Western Australia, South Australia, the Northern Territory and parts of Queensland (NRMMC, 2010b). At 2010, it was estimated that there were over 1 million feral camels in the rangelands and that the population was doubling every 8–10 years (NRMMC, 2010b). In 2013 the population was estimated at 3000,000, following management through the Australian Feral Camel Management Project (McGregor et al., 2013). The magnitude of the negative impacts of feral camels will undoubtedly increase if the population is allowed to continue to increase (Edwards et al., 2010).

While drinking less frequently than most other large herbivores, feral camels need access to sources of water. Camels are observed to drink at intervals of two to eight days in summer if water is available, but may go up to several months without drinking in winter in central Australia (NRMMC, 2010b). Most of central Australia reported below average rainfall during 2002–2006, and at the start of 2007 conditions were very dry in most parts of the region (Edwards et al., 2008). There are reports of influxes of as many as tens of thousands of apparently starving and thirsty camels into pastoral leases and settlements in the 'western deserts' over the summer of 2006-2007 that caused damage to infrastructure and the depletion of stock water reserves (Edwards et al., 2008). It is likely that these artificial watering points provide refuge for camels during long periods of drought, providing for sustained (albeit depleted) populations.

Rabbits: Rabbit populations can survive only if there is access to free water, succulent vegetation, shaded warrens or warrens in calcareous soils (Southgate, 1990). Although they do not exhibit water point focused impacts (James et al., 1999), their presence can still contribute significantly to total grazing pressure in the arid and semi-arid rangelands. Studies in the Broken Hill district of new South Wales by Tatnell and March (1991 cited in DEWHA, 2008a) showed that rabbits were responsible for 5–50% of the total grazing pressure.

Grazing is one example of a pressure that interacts strongly with a range of others. The State of the Environment Committee (2011) describe grazing as part of a complex of interacting processes impacting on the environment: most land clearing is to produce pasture for stock, livestock are a major reason for the introduction of invasive plants like gamba grass and buffel grass, suppression of top predators (e.g., dingos) is primarily to protect stock, watering points for stock in arid areas also encourage feral pest populations, stock remove the fuel that cool fires need, and encourage wooding thickening which can result in stand-replacing fires, catchment-scale soil compaction changes catchment hydrology and selective grazing removes protective cover, changes the composition of vegetation communities and exposes soils to erosion.

Link between grazing, watering points and biodiversity

The relationship between watering points, grazing pressure and biodiversity is often noted, e.g.:

- density of artificial watering points has been considered a surrogate indicator for grazing pressure (Fisher et al., 2007)
- distance from stock water points has been shown to be a useful indicator for pressure on biodiversity in drier rangelands (Bastin and ACRIS, 2008; but see Fensham and Fairfax 2008 for some issues with this assumption)
- a decrease over time in the total area of water-remote land is likely to be an indicator of negative impact on grazing-sensitive biota (Bastin and ACRIS, 2008)
- as grazing pressure increases around artificial watering points, landscape function declines considerably, with a loss in vegetation cover, an increase in erosion, and a decrease in nutrient cycling (Howes and McAlpine, 2008).
- changes to ecological variables and grazing pressures have been directly attributed to proximity to watering points. Variables include degree of defoliation, soil compaction, soil cover (Andrew, 1988).
- removal of grazing pressure can sometimes lead to recovery in some sensitive taxa (Legge et al 2011; but see Silcock and Fensham, 2013).

However, quantifying the impacts of grazing management in relation to watering points has been difficult for two main reasons. First, studies often struggle with weak sampling designs, especially when the density of watering points is now so high that locating areas relatively far (>7 km) from water is unusual on most large pastoral properties (Fensham and Fairfax, 2008). Second, without adequate knowledge of baseline condition and more extensive monitoring data, it is difficult to assess the extent of change (Basin and ACRIS, 2008).

Link between grazing and threatened species

There are many examples of species' declines that have been attributed in various degrees to grazing pressure. Many Australian birds, especially those that dwell or forage mainly on the ground, have grazing pressure identified as a threat (Garnett and Crowley, 2000; Garnett et al., 2011). Habitat change due to livestock and feral herbivores ranked 8th among identified threats to threatened Australian terrestrial mammals (Woinarski et al., 2014), and 3rd for extinct mammals.

Examples where overgrazing, especially during drought, is believed to have contributed to extinctions include:

- *Chaeropus ecaudatus* (pig-footed bandicoot) (Woinarski et al., 2014)
- *Bettongia gaimardi gaimardi* (eastern bettong (mainland)) (Woinarski et al., 2014)
- *Caloprymnus campestris* (desert rat kangaroo) (Woinarski et al., 2014)
- *Notomys robustus* (broad-cheeked hopping mouse) (Woinarski et al., 2014)
- *Notomys longicaudatus* (long-tailed hopping mouse) (Woinarski et al., 2014)

Examples of extant species where declines have been attributed to habitat degradation with livestock and feral herbivores noted as a significant contributing factor include:

- *Notomys fuscus* (dusky hopping mouse) (Woinarski et al., 2014)
- *Pseudomys australis* (plains mouse) (Woinarski et al., 2014)

- *Ophidiocephalus taeniatus* (bronzeback snake-lizard) (Cogger et al., 1993).
- *Erythrura gouldiae* (Gouldian finch) (Garnett and Crowley, 2000; Garnett et al., 2011)
- *Geophaps plumifera leucogaster* (spinifex pigeon) (Garnett and Crowley, 2000; Garnett et al., 2011)
- *Dasyuroides burnei* (kowari) (Woinarski et al., 2014)

Link between artificial watering points, grazing and threatened species:

Despite the role that artificial watering points have played in facilitating the spread of grazing across landscapes, and therefore contributing to species declines and extinctions, it is difficult to make the link between these declines and grazing as a sole and direct consequence of the proliferation, placement and management of artificial watering points in a way that meets the thresholds in the criteria for assessment. There are four main reasons for this:

- a) Where decline has been attributed to grazing pressure, the greatest impact is considered to have mostly occurred in the early years of pastoral expansion in the late 1800s and early 1900s, exacerbated during periods of severe drought. There is no reason to believe that the history of biodiversity decline in the rangelands has been arrested given current land uses and time lags in biological responses, and there is evidence that it is accelerating in some areas (Basin and ACRIS, 2008; State of the Environment Committee, 2011). However, for many species where declines are linked or suspected to be a result of grazing pressure, it is often technically difficult to determine if the threat is current or historic. In many cases this may be a consequence of limited recent studies, lack of adequate monitoring and reporting and a lack of current data. In some cases, continuing decline as a result of grazing has been inferred, but there evidence to accurately substantiate a current trend of decline is lacking.
- b) Where grazing is identified as a cause for ongoing biodiversity decline, it is difficult to argue that the grazing is specifically tied to the proliferation, placement and management of artificial watering points. For example, the decline of *Amytornis barbatus barbatus* (grey grasswren (Bulloo)) in south-western Queensland and north-western New South Wales is (at least partly) attributed in several assessments to grazing by livestock and feral herbivores (Garnett and Crowley, 2000; TSSC, 2005; TSSC, 2008). However, the species inhabits dense thickets of lignum with clumps of canegrass and/or *Atriplex nummularia* in swampy floodplains in the drainage basin of the Bulloo River (TSSC, 2008). Given the core habitat is native wetlands, the threat posed by grazing is unlikely to be linked to the presence, locations and management of artificial watering points, as grazers may have been sustained in this location by natural wetlands.
- c) Where declines have been attributed to high levels of grazing as a consequence of the proliferation, placement and (poor) management of artificial watering points, the declines either have ceased, or there is no clear substantiated evidence of continuing current decline, or the taxon is already extinct, e.g.:
 - *Lasiiorhinus krefftii barnardi* (northern hairy-nosed wombat); habitat degradation and resource depletion due to livestock and feral herbivores has been arrested for the remaining population of this species (Woinarski et al., 2014)
 - *Acacia peuce* in the Northern Territory, initially declined from grazing impacts, but fencing and management of available watering points have since addressed this threat (Nano et al., 2007).

- Two subspecies of thick-billed grasswrens (*Amytornis modestus modestus* and *A. m. inexpectatus*) have become extinct as a result of grazing impacts; the other four subspecies declined in the 19th and early 20th centuries, but these declines have either stopped, or the causes are equivocal (Garnett et al., 2011; Pavey and Ward, 2012).
- d) Finally, in most cases, it is difficult to attribute decline to grazing in isolation from other threats such as land clearance, fire and feral predators, and therefore the degree to which decline can be attributed to this cause relative to other causes is uncertain. The Committee notes that the criteria for listing a Key Threatening Process lacks clarity about a requirement (if any) for the threat to be the primary or sole cause of decline, about a requirement that the threat is the major cause of decline rather than a contributing threat among a suit of threats, about whether it is a direct threat or a distant indirect threat, or a requirement for the threat to be independent of other contributing causes, and the degree of evidence required.

Consequently, the Committee is unaware of data to indicate that grazing pressure specifically as a result of the proliferation, placement or management of artificial watering points in the arid and semiarid rangelands is continuing to impact on any listed species and ecological community, or that any listed species are eligible for listing in a category representing a higher degree of endangerment. The Committee is also unaware of data indicating any other native species or ecological community could be listed as threatened because of grazing pressure as a result of the proliferation, placement or management of artificial watering points in the arid and semiarid rangelands.

2. Predators and the role of watering points

Predators are major beneficiaries of artificial water points in arid environments (Brawata and Neeman, 2011). Predators include introduced species as well as native species. These may or may not directly rely on water but provide a focal point for prey items, thereby potentially increasing prey availability and therefore at least locally, increasing predator numbers. Reliable sources of water and food associated with artificial water points may increase survival rates of predators (both native and introduced). An increase in artificial water availability across arid areas may also enable introduced species, including predators, to expand their range into previously water-remote areas (James et al., 1999; Davies et al., 2010). Carcasses of cattle and sheep around watering points during drought help maintain populations of dingos and foxes (James et al., 1999). Predation may not necessarily occur at watering points, but predator search effort is reduced and energy efficiency maximised by targeting prey within a close vicinity of water (Brawata and Neeman, 2011).

Foxes need to drink regularly in hot weather and populations are probably greater and more widely distributed than would be possible without artificial watering points (James et al., 1999). Foxes have been observed to have some extreme dispersal distances, one recorded in a straight line of 300 km (DEWHA, 2008d).

Feral cats may occupy a home range of 10 km², or larger if food is scarce (DEWHA, 2008c). While cats are known to have been brought into Australia by settlers in the 18th century and deliberately released during the 19th century to control rabbits and mice, cats may have arrived with much earlier visitors to the continent (DEWHA, 2008c). The widespread distribution of feral cats through the rangelands is thought to have preceded foxes and rabbits, and had occurred prior to the 1900s (Southgate, 1990). Cats derive most of their water needs from live prey

(James et al., 1999) and the distribution of feral cats does not appear to be limited by artificial watering points. However, cats do occur at higher concentrations around watering points and therefore watering points increase the threat posed by cats. Foxes and feral cats can exist with little surface water, gaining enough water intake through prey intake, however access to artificial water points is likely to reduce physiological stress and enhance survival in arid landscapes (Brawata and Neeman, 2011).

Predation by the red fox *Vulpes vulpes* and the feral cat *Felis catus* has been identified as a primary cause of dramatic declines and extinctions in native fauna in many ecosystems and are well documented (DEWHA, 2008c). Predation by feral cats and predation by the European red fox are listed as key threatening processes under the EPBC Act. However, the extent to which the threat and consequences of predation from introduced species such as foxes, cats, and an increase or concentration of native predators such as dingo, is dependent on the proliferation, placement and management of artificial watering points is unquantified. This makes it difficult to assess this process against the criteria.

The Committee is therefore unaware of data to indicate that predation pressure, specifically attributed to the proliferation, placement or management of artificial watering points in the arid and semiarid rangelands, is impacting on any listed species and ecological community, or that any are eligible for listing in a category representing a higher degree of endangerment. The Committee is unaware of data indicating any other native species or ecological community could be listed as threatened because of predation pressure specifically attributed to the proliferation, placement or management of artificial watering points in the arid and semiarid rangelands.

3. Changes to the distribution of other species

The increase in artificial watering points in arid and semi arid areas has also provided the opportunity for other invasive species to spread more quickly, and/or more evenly through the landscape. These include aquatic and semi aquatic species that may use these artificial watering points as stepping stones, further assisted in dispersal during floods. Examples that have direct negative impacts on other species including population declines include gambusia (mosquito fish) (*Gambusia holbrooki* and *G. affinis*) and cane toads (*Bufo marinus*) (e.g., Fensham et al., 2010; Shine, 2010).

Artificial watering points serve as important breeding sites and dry-season refuges for cane toads and may allow for toads to establish satellite populations that subsequently coalesce during the wet season (Tingley et al., 2013). Letnic et al. (2014) demonstrated that dams provide toads with refuge habitats where they are less at risk from overheating and dehydration, and concluded that dams can facilitate such invasions.

The distribution of cane toads, however, is not solely attributed to artificial watering points with spread possible as a result of natural dispersal after flooding, anthropomorphic routes including as hitchhikers on trucks, pallets, shipping containers and pot plants. It is unlikely that dispersal into new regions could be solely attributed to artificial watering points.

Competition with and predation by eastern gambusia is identified as a potential threat to native species such as Edgbaston goby (*Chlamydogobius squamigenus*) and red-finned blue-eye (*Scaturiginichthys vermeilipinnis*), although the extent to which these native fish are threatened by gambusia relative to other threats is not clear (Fensham et al., 2010). Fensham et al. (2010) note that controlling bores to reduce stream flows in bore drains may greatly reduce the habitat

for aquatic pests including gambusia and may reduce their capacity to disperse into spring wetlands.

Similarly, artificial watering points may assist in the spread of pest plant species that may otherwise be limited to natural waterways, as artificial watering points may also be infested and become stepping stones for further spread, assisted by livestock, feral grazers and humans (planting for shade, or accidental spread by machinery and vehicles between watering points). Examples include athel pine (*Tamarix aphylla*) and parkinsonia (*Parkinsonia aculeata*) (Csurhes, 2008; CRC Weed Management, 2003a, b).

The increased availability of water in arid and semi-arid areas has been identified as supporting the expansion of populations of more water dependent native species into these arid and semi-arid areas. This change has the potential to negatively affect species native to these areas because of competition for resources, or as a result of hybridisation (genetic introgression).

An example where this may have occurred is for *Polytelis alexandrae* (princess parrot) where records in some regions of have become less frequent since the 1950s. The princess parrot is currently listed as vulnerable under the EPBC Act and its numbers may be as low as 1 000 mature individuals in poor years (Garnett et al., 2011). Garnett et al. (2011) note that increased availability of water in areas grazed by domestic stock may have allowed other, more water-dependent parrots to expand into the arid zone and compete with princess parrots. This is one of a number of potential threats suggested as a cause of this species' decline, however, there are no data to provide clarity on the cause.

Manorina melanotis (black-eared miner) is listed as endangered. Past vegetation clearance and consequent mallee fragmentation has contributed to the decline in black-eared miners (Garnett et al., 2011) and clearance is considered to be the fundamental reason for this decline (Garnett and Cowley, 2000). This clearance and modification of vegetation has favoured a range expansion of the yellow-throated miner such that the range of the yellow-throated miner now encompasses that of the black-eared miner. In most areas yellow-throated miners and hybrids are more numerous than black-eared miners, and the black-eared miner now represents an insular population. Under these conditions, uncontrolled genetic introgression will eventually result in the loss of the biological and genetic diversity contributed by the black-eared miner (e.g., Cade, 1983). The threat of hybridisation with the yellow-throated miner is now considered to be the greatest threat to black-eared miners (Garnett and Cowley, 2000; Garnett et al., 2011). Habitat degradation as a result of high total grazing pressure and fire are also identified as major threats to this species (Baker-Gabb, 2003).

The national recovery plan for the black-eared miner (Baker-Gabb, 2003) notes that watering points 'and their associated clearings and degradation' attract yellow-throated miners and thereby threaten black-eared miners which do not need permanent water. A program to decommission artificial water points to reduce total grazing pressure is underway within the habitat of black-ear minors to help address habitat degradation (Baker-Gabb, 2003).

While the black-eared miner is negatively impacted by the expansion of yellow-throated miners, the change in distributional range of the yellow-throated minor is not solely attributed to the proliferation, placement and management of artificial watering points. The expansion is also attributed to other landscape changes associated with land usage, such as land clearance, high total grazing pressure, and fire, and the direct threat of hybridisation with the yellow-throated miner (as a consequence of its expansion in range).

The Committee notes that there is a lack of clarity in the criteria for listing a Key Threatening Process, regarding whether there is a requirement (if any) that the threat is the primary or sole cause of decline, a major cause of decline, a contributing threat among a suit of threats, a direct threat or a distant indirect threat, or a requirement for the threat to be independent of other contributing causes, and the degree of evidence required. In this case, the cause attribution being artificial watering points is no greater than, and less direct, than are the causes of land clearance, high grazing pressure, and fire.

In terms of assessment against criteria for this process, the threat from other species cannot be directly or primarily attributed to an association with the number, placement or management of artificial watering points and not clearly distinguished or separated from other causes associated with land use change (e.g., land clearance, fragmentation of habitat, increased predation or competition, total grazing pressure, changed fire regimes).

The Committee is therefore unaware of data to indicate that threats posed by a change in distribution of species directly or primarily attributed to the proliferation, placement or management of artificial watering points in the arid and semiarid rangelands is negatively impacting on any listed species and ecological community such that they are eligible for listing in a category representing a higher degree of endangerment. The Committee is unaware of data indicating any other native species or ecological community could be listed as threatened because of predation pressure attributed to the proliferation, placement or management of artificial watering points in the arid and semiarid rangelands.

4. Compaction and other changes to the soil crust

Grazing by domestic livestock and feral animals can adversely affect vegetation and soils, particularly when total grazing pressure is high in times of drought (Bastin and ACRIS, 2008). Intensive grazing can damage soil because removal of too much cover leads directly to erosion. Overgrazing can reduce the soil's capacity to retain carbon and absorb water. Bastin and ACRIS (2008) however, note that there are challenges in assessing these grazing impacts from those due to season, fire and other factors. Vehicle traffic also has the potential to damage vegetation and compact soils around watering points. For some species that form burrows in the soil, a concentration and persistence of stock has the potential to cause habitat damage or directly threaten the species.

However, the Committee is unaware of data to indicate that changes in the soil as a result of the proliferation, placement or management of artificial watering points in the arid and semiarid rangelands is continuing to impact on any listed species and ecological community, or that they are eligible for listing in a category representing a higher degree of endangerment. The Committee is unaware of data indicating any other native species or ecological community could be listed as threatened as a result of changes in the soil as a result of the proliferation, placement or management of artificial watering points in the arid and semiarid rangelands.

5. Extraction of artesian water and draw-down of aquifers

Extraction of water for the purposes of proliferation and placement of artificial watering points has resulted in draw down of artesian basins and consequential loss of pressure and flow to artesian springs. The most widely reported is that of the Great Artesian Basin which underlies most of Queensland and parts of New South Wales, South Australia and the Northern Territory (Rolf, 2008). This area includes largely arid and semi-arid regions. The springs of the Great

Artesian Basin provide important biological refuges and are rich in endemic flora and fauna (Rolf, 2008).

There is one ecological community and a number of species that have been listed as threatened with the identified threats including aquifer draw down following drilling of bores (Fensham et al., 2010). These species include *Eriocaulon carsonii* (salt pipewort), *Scaturiginichthys vermeilipinnis* (redfin blue eye), *Chlamydogobius micropterus* (Elizabeth Springs goby), *Chlamydogobius squamigenus* (Edgbaston goby), *Eryngium fontanum* (blue devil) all listed under the EPBC Act in 2000, and the ecological community is 'the community of native species dependent on natural discharge of groundwater from the Great Artesian Basin' listed in 2001. A recovery plan (Fensham et al., 2010) is currently in place for these items.

Rehabilitation work from the 1970s had controlled 630 flowing bores, eliminated 3200 km of bore drains, installed 5500 km of piping and saved 126,000 ML of water per year. The Great Artesian Basin Sustainability Initiative began in 1999 and following from this prior rehabilitation, had by June 2013 rehabilitated 650 additional bores, eliminated more than 19,000 km of additional bore drains and saved approx 327 000 ML of water per year (Great Artesian Basin Coordinating Committee, 2013).

At the time of listing the 'community of native species dependent on natural discharge of groundwater from the Great Artesian Basin' in 2001, it was noted that despite the implementation of the Government Great Artesian Bore Rehabilitation Program, ongoing extraction of artesian water is likely to play a continued role in the decline of these springs.

The Committee is unaware, however, of any information to indicate that aquifer draw down as a result of drilling of bores is continuing to impact on the listed species and ecological community, or that they are eligible for listing in a category representing a higher degree of endangerment. The Committee is unaware of data indicating any other native species or ecological community could be listed as threatened as a result of aquifer draw-down arising from the proliferation, placement or management of artificial watering points.

6. Landscape change – formation of artificial watering points or modification of existing natural water sources

Excavation to form artificial watering points can consist of dredging, conversion to dams, wells, draining, excavation by explosives and the construction of raised concrete structures that limit water flows (Fensham and Fairfax, 2003). The formation of artificial watering points and the ability to extract water from artesian basins has resulted in substantial areas of artificial wetland habitat (Fensham et al., 2010). This has had a direct benefit for many water dependent species and for these species, artificial watering points have the potential to support biodiversity conservation and climate change adaptation (Chester and Robson, 2013) and providing for connectivity.

However, while some species may be able to utilise artificial watering points, not all freshwater dependent species appear to be equally able to inhabit artificial watering points. Most freshwater artificial waterbodies are standing rather than running water. This leads to a bias in any conservation benefit to species that prefer standing water, with those that depend on flowing water for habitat and/or reproduction being disadvantaged (Chester and Robson, 2013).

While artificial wetlands have the potential to benefit aquatic species or species dependent on water, there are very few examples of colonisation of artificial habitats by flora and fauna that is

otherwise endemic to spring wetlands (Fensham et al., 2010). The artificial habitat provided by flowing bores does not seem to be suitable for endemic spring species (Fensham et al., 2010). Artificial water, therefore, is not a direct substitute for loss of natural spring wetlands.

Fensham et al. (2010) found that 11 per cent of active spring complexes, many of which had very significant conservation values, have suffered total or partial damage by excavation. They note that springs are usually excavated because of the perception that this will enhance flows and improve access to water for stock. Spring excavation is identified as a threat to the listed 'community of native species dependent on natural discharge of groundwater from the Great Artesian basin' and associated listed threatened species. The recovery plan for this community notes that unacceptable impacts on Great Artesian Basin discharge springs may occur as a result of

- dams that result in the inundation of springs,
- development of new bores for groundwater extraction or use from existing bores that have the potential to negatively affect natural habitat provided by GAB discharge spring wetlands
- excavation of spring wetlands (Fensham et al., 2010).

Physical modification of the landscape can potentially directly threaten local biodiversity as modification in hydrology can pose threats to biodiversity, particularly on highly endemic species. Ephemeral or terrestrial species would likely be threatened by any hydrological change to permanent inundation.

While any endemic species or community could potentially be threatened by a future impoundment, the Committee is unaware of data indicating a native species or ecological community could become eligible for listing as threatened as a direct result of any imminent inundation for the formation of artificial watering points within the arid or semi-arid rangelands, or if inundation is continuing to impact on any listed species or ecological community such that that it is eligible for listing in a category representing a higher degree of endangerment. Nor is the Committee aware of any instances where the excavation or formation of artificial watering points within the arid or semi-arid rangelands will cause a native species or ecological community could become eligible for listing as threatened or is impacting on any listed species or ecological community such that that it is eligible for listing in a category representing a higher degree of endangerment.

Discussion

Processes considered to be threats to biodiversity discussed above, i.e. aquifer draw down, physical surface modification, changes to hydrology, changes to the soil crust, increase in the number of grazers, spread of pest species, can be associated with artificial watering points. However, the Committee notes these processes can also occur independently of the proliferation, placement and management of artificial watering points. While the proliferation, placement and management of artificial watering points can, or do contribute to these changes, they are not the sole cause. For instance, anthropogenic modification to the physical surface environment from direct modification of the landscape occurs for purposes other than proliferation and placement of artificial watering points. Compaction and other changes to the soil crust occur regardless of watering points through human and mechanical trampling, cropping, building and other development and other land use changes. Total grazing pressure has significantly increased as a result of introduced species, including those with less dependence or no dependence on watering points. Increased predation as a result of introduced predators such

as cats is argued to have occurred prior to and independently of, artificial watering point proliferation. Spread of other introduced pests (e.g., weeds and cane toads) occurs independently of artificial watering points.

Artificial watering points are part of a suite of factors that have changed arid and semi-arid Australia irrevocably. As a process, the proliferation of artificial watering points is a component of a suite of land management practices associated with pastoralism. This suite of processes drives ecological change. Rarely can the proliferation, placement and management of watering points be clearly separated out from these other processes as a direct threat. The Committee notes that occurrences of high grazing pressure as a result of domestic stock and feral herbivores, land clearance, introduced predators, introduced weeds, changed fire regimes, the increase of artificial watering points, and differences in land and water management are factors that occurred in combination in the arid and semi arid rangelands since European settlement (Fig, 1). The effects of these changes are difficult to assess individually and attribute to separate contributing causes, particularly for historical incidences. Nor is it currently possible to assign levels of significance for each of these threats independently.

The proliferation and placement of watering points assists or mediates the increase in threats from pastoralism and introduction of non-native biota. The Committee also notes, however, that the 'management' of artificial watering points can determine whether or not this mediating function is activated. Poor or inappropriate management helps to activate the threats arising from the proliferation and placement of these watering points, while good management can enable this process to have a neutral effect or suppress this risk. In some cases, good management can help to manage the risk interplay (e.g., spelling of land, focus for management of feral grazers) and for some species, the 'proliferation, placement and management of artificial watering points is beneficial (e.g. increaser species).

While Landsberg et al., (1997) identified the provision of artificial watering points as the ultimate cause of trends observed in their study on rangeland biodiversity, the Committee argues that the ultimate causes or factors are instead pastoralism and introduced species. The proliferation of artificial watering points may be a mediating factor, but this is not always the case, and to some extent depends on the management of the watering point and associated factors such as total grazing pressure and fencing, among other management options. Nevertheless, in some circumstances, closing artificial watering points can be an important action in species recovery (e.g. northern hairy-nosed wombats; *Acacia peuce*), and should be considered as an option likely to benefit biodiversity generally, especially in non-agricultural land tenures.

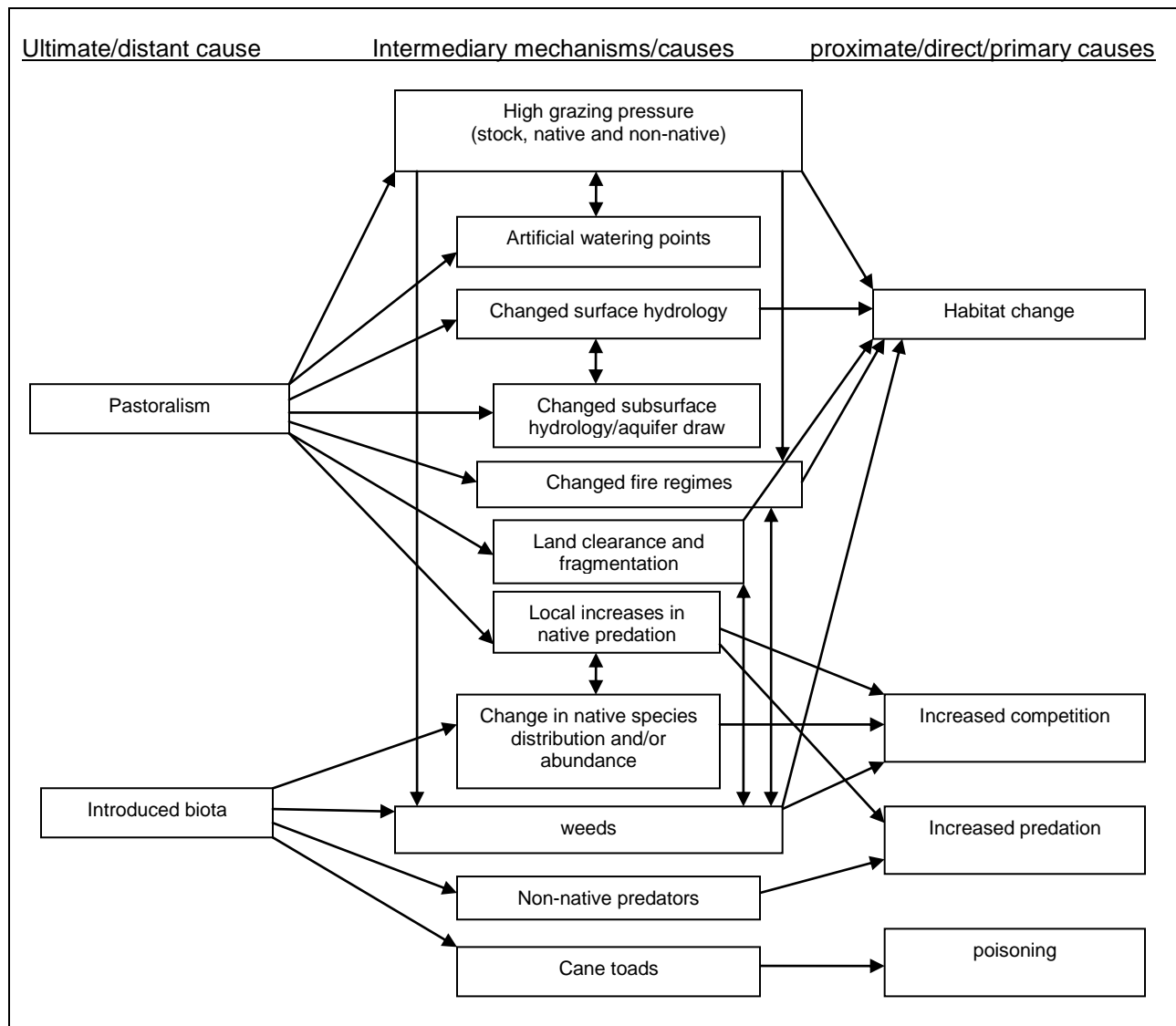


Figure 1. Representation of relationships between ultimate/distant causes, intermediary mechanisms/causes and proximate/direct/primary causes that include artificial watering points.

Conclusion

The Committee has found no evidence that the proliferation, placement or management of artificial watering points in the arid and semi-arid rangelands is solely responsible for currently causing any individual species or ecological community to become either eligible for listing in a category higher than conservation dependent, or, if already listed, being adversely affected. Therefore, the threatening process does not meet s188(4)(a), s188(4)(b) or s188(4)(c) of the EPBC Act. The Committee finds that the threatening process 'Biodiversity decline and habitat degradation in the arid and semi-arid Australian rangelands due to the proliferation, placement and management of artificial watering points' is not eligible for inclusion as a key threatening process in the list referred to in section 183 of the EPBC Act.

Consultation

Notice of the proposed amendment to the list of key threatening processes was made available for public comment for at least 30 business days from 13 December 2013 to 28 February 2014. Comments received that were relevant to the eligibility for inclusion on the list and the effect of listing on the survival of species and ecological communities, have been taken into account by the Committee.

Recommendations

The Committee recommends that the threatening process '***Biodiversity decline and habitat degradation in the arid and semi-arid Australian rangelands due to the proliferation, placement and management of artificial watering points***' is not eligible for inclusion as a key threatening process in the list referred to in section 183 of the EPBC Act.

Threatened Species Scientific Committee

18 September 2014

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