

THREATENED SPECIES SCIENTIFIC COMMITTEE

Established under the *Environment Protection and Biodiversity Conservation Act 1999*

The Minister's delegate approved this Conservation Advice on 16/12/2016.

Conservation Advice

Eulamprus leuraensis

Blue Mountains water skink

Conservation Status

Eulamprus leuraensis (Blue Mountains water skink) is listed as Endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act) effective from the 16 July 2000. The species was eligible for listing under the EPBC Act as on 16 July 2000 it was listed as Endangered under Schedule 1 of the preceding Act, the *Endangered Species Protection Act 1992* (Cwlth).

The species can also be listed as threatened under state and territory legislation. For information on the current listing status of this species under relevant state or territory legislation, see <http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl>.

The main factors that are the cause of the species being eligible for listing in the Endangered category are the species' limited extent of occurrence and area of occupancy, its small population size and the fragmented nature of its distribution.

Description

The Blue Mountains water skink is a medium sized lizard that grows to a maximum length (including tail) of approximately 20 cm with the snout-to-vent length up to approximately 8 cm. It reaches a maximum weight of approximately 10 g (LeBreton 1996). The limbs are well developed, each ending in five toes (NSW NPWS 2001; NSW OEH 2012). The species' body is much darker in colour than that of other species of *Eulamprus* found in the Blue Mountains. The back is dark brown to black with narrow yellow-bronze to white stripes along its length to the beginning of the tail, and continuing along the tail as a series of spots. This gives the appearance of a distinctive dark dorsal stripe bordered by yellow lines. The legs and sides are dark brown to black with yellow to bronze streaks and small blotches. The head is brown to bronze-coloured with black flecks and the underside is cream to golden yellow with small dark blotches. The chin and underbelly is cream to golden yellow with small dark blotches. There is occasionally a green or bluish sheen, especially in juveniles and on the necks of some adults (LeBreton pers. comm. 1999 cited in NSW NPWS 2001).

Distribution

The Blue Mountains water skink occurs in the mid to upper Blue Mountains (from 560 m above sea level upwards) of New South Wales between Hazelbrook in the east and Newnes in the west (Keith & Benson 1988, and Benson & Keith 1990 cited in NSW NPWS 2001; NSW OEH 2012).

The species inhabits permanently wet sandy-peat swamps found on the slopes of narrow valleys, or in low-lying areas of flat or undulating plateaux that are primarily restricted to the high, dissected Narrabeen group sandstone plateau. Such swamps occur where groundwater perches in permeable sandstone and derived sandy soils above basins of impermeable rock (Holland 1972 cited in NSW NPWS 2001).

A number of vegetation types occurring in the Blue Mountains represent suitable habitat for the Blue Mountains water skink and are indicative of the species potential distribution. Blue Mountains Sedge Swamps and Newnes Plateau Shrub Swamps are likely to comprise the majority of the species potential habitat, although Boyd Plateau Bogs and Cox's River Swamps also represent potential habitat for the species (NSW NPWS 2001). Blue Mountains Sedge

Swamps extend from the lower Blue Mountains on the eastern side through to the upper Blue Mountains where they are most numerous. The abundance of Blue Mountains Sedge Swamps increase significantly at around 500 - 600 m (Keith & Benson 1988 cited in NSW NPWS 2001). Newnes Plateau Shrub Swamps are largely restricted to the Newnes area. The Blue Mountains Sedge Swamps and Newnes Plateau Shrub Swamps ecological communities are synonymous with the *Temperate Highland Peat Swamps on Sandstone* ecological community which is listed as Endangered under the EPBC Act. Boyd Plateau Bogs are generally restricted to the Boyd Plateau, while Cox's River Swamps are present in small numbers on the western side of the Blue Mountains and are usually found on flats in the deeper valleys (NSW NPWS 2001).

The Blue Mountains water skink may also occur in swamps in the lower Blue Mountains south and east of Hazelbrook (Benson 1992 cited in NSW NPWS 2001), the region just south of Jenolan Caves, the Lithgow Valley and the region south of the Greater Sydney Metropolitan Area (LeBreton 1996 and LeBreton pers. comm. 1999 cited in NSW NPWS 2001).

In 2012, fewer than 40 subpopulations of the Blue Mountains water skink were known (NSW OEH 2012). All known subpopulations of the species have been recorded in areas managed by the NSW National Parks and Wildlife Service (NSW NPWS), the Sydney Catchment Authority, Forestry Corporation (NSW) and Blue Mountains City Council (BMCC) (NSW NPWS 2001). In 2001, seven of these subpopulations partially extended into privately owned land (NSW NPWS 2001). Subpopulations at Blackheath, Leura Park, Wentworth Falls Lake and Jamison Creek are adjacent to or surrounded by urban development (NSW NPWS 2001).

Relevant Ecology

The swamps inhabited by Blue Mountains water skink are most commonly sedgeland that are usually 1.2 - 1.5 m deep (Holland et al., 1992), and are interspersed with shrubs and, in some cases, dense shrub thickets (Keith & Benson 1988; LeBreton 1996). Flora species that commonly occur in the species' habitat are *Gymnoschoenus sphaerocephalus* (button grass), *Baeckea linifolia* (weeping baeckea), *Hakea teretifolia* (dagger hakea), *Grevillea acanthifolia* subsp. *acanthifolia* (Blue Mountains bog grevillea) and *Lepidosperma limicola* (blade grass) (Keith & Benson 1988, and LeBreton 1996). Although, not all swamps inhabited by the Blue Mountains water skink contain all of these plant species (NSW NPWS 2001).

The Blue Mountains water skink is semi-aquatic (Wells & Wellington 1985). Research conducted by LeBreton (1996) (cited in NSW NPWS 2001) showed that the species was more likely to occur in larger (greater than 0.7 ha) wetter swamps. The species' abundance is greater in swamps with higher soil moisture and deeper leaf litter (LeBreton 1996), which could be due to a greater abundance of invertebrates in the deeper leaf litter enhancing availability of food resources. Moist soil and deeper leaf litter may also provide a more suitable microclimate or allow individuals to escape predators more easily (LeBreton 1996).

LeBreton (1992) (cited in NSW NPWS 2001) collected Blue Mountains water skink scats at Wentworth Falls Lake and identified the remains of grasshoppers (Suborder Caelifera), flies (Order Diptera), moths (Order Lepidoptera), weevils (Superfamily Curculionoidea) and wasps (Suborder Apocrita). The presence of non-ground-dwelling insects in these scats indicated that the subpopulation may have been feeding mainly while active on the vegetation above the ground. A small unidentified fruit with a seed was found in a scat at Leura (LeBreton 1992 cited in NSW NPWS 2001).

Females are ovoviviparous – embryos develop and hatch from eggs inside the female in late December (LeBreton 1996). No specific information is available about the species' breeding habitat, however basking sites are likely to be important for the species' reproduction (NSW NPWS 2001) because higher temperature for the developing young can be achieved by females while basking in sunlight (Greer 1989 cited in NSW NPWS 2001).

The Blue Mountains water skink is active on warm sunny days from September to late April (LeBreton 1996). Like most reptiles from low-temperature climates, the species is likely to hibernate during winter (NSW NPWS 2001). Shea and Peterson (1985) (cited in NSW NPWS

2001) collected two inactive Blue Mountains water skinks on the edge of the swamp at Wentworth Falls Lake following winter rains. This suggested that some individuals may move out of the waterlogged areas of swamps into surrounding vegetation in the winter to take advantage of extra vegetative cover where available (NSW NPWS 2001). In addition, specimens captured by LeBreton (1994b) (cited in NSW NPWS 2001) on the swamp/forest margin indicated that skinks may occasionally inhabit parts of the surrounding forest. When disturbed, the Blue Mountains water skink rapidly takes shelter in dense grass tussocks or down holes. The species also uses burrows constructed by *Euastacus* species (spiny freshwater crayfish) or *Cherax* species (common yabby) (Shea & Peterson 1985 cited in NSW NPWS 2001), and possibly *Heleioporus australiacus* (giant burrowing frog) (LeBreton pers. comm. 1999 cited in NSW NPWS 2001), which is listed as Vulnerable under the EPBC Act.

The Blue Mountains water skink has been observed in burnt habitats immediately after a wildfire and, hence, is capable of surviving such events (LeBreton pers. comm. 1999 cited in NSW NPWS 2001). The species may use burrows to survive the immediate effects of fire (NSW NPWS 2001). LeBreton (1996) (cited in NSW NPWS 2001) noted that burrows in swamps are usually filled with water and suggested that individuals of the species may gain further protection from fire by submerging themselves during fire events.

Holland and colleagues (1992) observed over a period of eight years post-fire changes in vegetation in a swamp known to be inhabited by the Blue Mountains water skink. After the fire, which burned the vegetation in the swamp to ground level, many plant species re-sprouted and the ecological community appeared to quickly re-establish. LeBreton (1996) (cited in NSW NPWS 2001) found no direct relationship between the species' presence or abundance at swamps and the time since fire.

Threats

The Blue Mountains water skink is threatened by habitat loss, fragmentation and degradation resulting from indirect or downstream effects of land clearing and development, pollution, nutrient enrichment, sedimentation and weed invasion of inhabited swamps, recreational activity and livestock grazing (NSW NPWS 2001; NSW OEH 2012). Other threats to the species are and predation by European red foxes (*Vulpes vulpes*), and cats (*Felis catus*) and dogs (*Canis familiaris*), both feral and domestic (NSW NPWS 2001; NSW OEH 2012). The alteration of the hydrology of inhabited swamps and the removal of coarse woody debris from areas of habitat are potential threats to the Blue Mountains water skink (NSW NPWS 2001; NSW OEH 2012; Wells & Washington 1984).

Table 1 – Threats affecting the Blue Mountains water skink in approximate order of severity of risk, based on available evidence.

Threat factor	Threat type and status	Evidence base
Habitat loss, fragmentation or degradation		
Pollution of habitat	known current	Pollution of Blue Mountains water skink habitat primarily occurs when those environments receive quantities of waste products, contaminants or nutrients transported in overland water run-off or groundwater flowing from higher in the local catchment (NSW NPWS 2001; NSW OEH 2012). Inflows of nutrient-rich or contaminated water can lead to nitrification, toxification and/or high levels of pathogens in areas of habitat, thereby significantly degrading those ecosystems (NSW NPWS 2001). Surface run-off and groundwater flows are retained by the peaty soils in most swamps due to the presence of shale or clay aquicludes underneath the soil (Holland et al., 1992 cited in NSW NPWS 2001).

Threat factor	Threat type and status	Evidence base
		Sources of polluted water flowing into areas of habitat include: stormwater run-off from roads and industrial sites transporting substances such as petroleum compounds, oils and detergents; inappropriate disposal of industrial and domestic waste; pesticides, herbicides and fertilisers used on forestry and agricultural lands; herbicides applied along powerline easements; animal waste produced on agricultural lands; long-wall coal mines; and sewerage infrastructure maintenance works or leakages of sewer pipes, septic tanks or absorption trenches (NSW NPWS 2001; NSW OEH 2012; NSW OEH 2016).
Sedimentation of habitat	known current	<p>Sedimentation of habitat primarily occurs when the run-off of water transports sediments that have been exposed by vegetation clearing or earthworks in the catchment (NSW NPWS 2001; NSW OEH 2012; NSW OEH 2016). Where adequate measures to control sediment erosion and transport are not implemented, timber harvesting operations and the creation, maintenance and use of unsealed roads, tracks and firebreaks in close proximity to many of the species' habitats continue to be sources of sediment potentially flowing into habitats (NSW NPWS 2001; NSW OEH 2012). Exposure of burnt soils in swamps to heavy post-fire rainfall may result in significant erosion (Keith 1996).</p> <p>Vegetation clearing can also reduce the water infiltration capacity of soils resulting in increased concentration of overland flows into channels that erode soils faster and increase sediment deposition in habitats (NSW NPWS 2001). In urban areas located upstream or adjacent to swamp habitats, this effect is exacerbated by the prevalence of hard surfaces that prevent water infiltration (NSW NPWS 2001).</p>
Altered catchment hydrology	known current	<p>The Blue Mountains water skink is threatened by actions that cause reductions in groundwater recharge (infiltration of water to underground), depletion of aquifers that discharge into inhabited swamps and the resultant dehydration of swamp habitat (NSW NPWS 2001; NSW OEH 2012; NSW OEH 2016).</p> <p>In urban areas located upstream or adjacent to swamp inhabited by the Blue Mountains water skink, hard, impermeable ground surfaces significantly limit the infiltration of rainwater in soils and, therefore, groundwater recharge in the local catchment (NSW NPWS 2001). Similarly, in areas where vegetation has been cleared, rainwater accumulates more rapidly aboveground, tends to flow overland into creeks and rivers, and much less water directly infiltrates the soil. Where this occurs in a catchment above or adjacent to swamps that are inhabited by the species, significantly reduced groundwater recharge is likely to lower surface water levels in those swamps and may cause them to dry out (NSW NPWS 2001).</p> <p>Other land-uses that may result in a reduction of groundwater in perched aquifers leading to the drying out of inhabited swamps include, but are not limited to: the extraction of groundwater via domestic, agricultural, commercial or public water supply bores;</p>

Threat factor	Threat type and status	Evidence base
		<p>the establishment or extension of pine plantations that are likely to draw down water tables, especially during early growth stages (NSW OEH 2012); roads that cut across and interrupt areas of groundwater flow (Porter 1984 cited in NSW NPWS 2001); subsidence and cracking of bedrock potentially caused by underground coal mining (NSW NPWS 2001; NSW OEH 2012); and the predicted effects of climate change in south-eastern Australia, such as increased frequency of extreme weather conditions and severity of drought (NSW OEH 2012; Williams et al., 2009).</p>
<p>Small-scale damage or removal of habitat</p>	<p>known current</p>	<p>Recreational activities, such as bushwalking, horse riding and the unauthorised use of off-road vehicles are known to damage areas of the species' habitat, particularly where purpose-built and unofficial tracks verge on or cut across these areas (NSW NPWS 2001; NSW OEH 2012; Wells & Washington 1984). People on trail-bikes were observed riding across the site at Lawson in the Blue Mountains National Park after the site was burnt in 1994 (LeBreton pers. comm. 1999 cited in NSW NPWS 2001) suggesting that track use may increase after fire, when vegetation is sparse and allows easier access (NSW NPWS 2001).</p> <p>Many other areas of the species' habitat, including areas in the Blue Mountains National Park, are easily accessible via roads, tracks, and fire trails and are vulnerable to being damaged by recreational users (NSW NPWS 2001). The illegal felling of trees and shrubs to create trail-bike tracks, including earthworks to create jumps, is a problem in areas of bushland on the edge of urban areas within the Blue Mountains local government area and is, therefore, a potential threat to Blue Mountains water skink subpopulations in those areas (NSW NPWS 2001).</p> <p>Wildfire hazard reduction fire management activities, such as the construction of fuel breaks and access tracks, slashing and mechanical hazard reduction also potentially threaten subpopulations of the species (NSW OEH 2012).</p>
<p>Degradation of habitat by livestock and feral pigs (<i>Sus scrofa</i>)</p>	<p>known current</p>	<p>Cattle trample swamp vegetation and can lead to soil compaction and erosion. Livestock also disperse weeds by transporting them externally, and internally in their manure (NSW NPWS 2001; NSW OEH 2012). Grazing may be a threat in areas of potential habitat (Boyd Plateau, Ben Bullen State Forest, Lithgow Valley) (NSW NPWS 2001).</p>
<p>Broad-scale vegetation clearing in habitat</p>	<p>known past and potential</p>	<p>The broad-scale removal of vegetation for urban development has resulted in the reduction of the area of known and potential habitat as well as the apparent extinction of subpopulations from areas where the species had been recorded (Wells & Wellington 1984).</p> <p>Fragmentation of habitat is likely to restrict the movement of individuals and gene flow between subpopulations of the species resulting in isolated subpopulations, genetic clustering and</p>

Threat factor	Threat type and status	Evidence base
		bottlenecks due to inbreeding (NSW OEH 2012). While residential development is constrained by land-use zoning for environmental protection, and further vegetation clearing for development within swamp habitats is unlikely (NSW NPWS 2001), it is possible that vegetation corridors that may allow for the movement of individual skinks between swamp habitats could be cleared for future development.
Removal of coarse woody debris from habitat	potential current	It is likely that fallen timber forms an important source of shelter, basking sites and invertebrates for the species (NSW NPWS 2001). All areas of habitat that are reasonably accessible by the public are vulnerable to firewood collection (NSW NPWS 2001).
Invasive weeds		
Weed invasion of habitat	known current	<p>Stormwater run-off from developed areas carries and deposits seeds of numerous weed species into areas of habitat and surrounding vegetation (NSW NPWS 2001). Run-off from urban and agricultural areas also tends to carry nutrients which promote the growth of weeds (NSW NPWS 2001).</p> <p>Invasive shrubs and climbers tend to overgrow and out-compete native flora in inhabited swamps, thereby degrading those ecological communities that sustain the species (NSW OEH 2012; NSW OEH 2016). Numerous areas of habitat are experiencing encroachment by radiata pine (<i>Pinus radiata</i>) wildlings from adjacent pine plantations and private properties (NSW NPWS 2001).</p> <p>Weed infestation is also a problem where access tracks are used to dump garden waste (NSW NPWS 2001). Slashing along powerline easements is likely to physically disperse weed seeds and vegetative propagules. Controlled burning of vegetation without implementing post-fire weed suppression measures is likely to create ideal conditions for weeds to establish and outcompete native flora species and disperse into adjacent habitats of the species (NSW NPWS 2001).</p>
Invasive predators		
Predation of the species by domestic and feral animals	potential current	Cats (<i>Felis catus</i>) and dogs (<i>Canis familiaris</i>), both feral and domestic, European red foxes (<i>Vulpes vulpes</i>) and feral pigs are known to kill lizards (NSW NPWS 2001; NSW OEH 2012; NSW OEH 2016). All occur in regions where the Blue Mountains water skink occurs, however their impact as predators of these species is unknown.

Threat factor	Threat type and status	Evidence base
Fire		
Too frequent or infrequent fires	potential current	<p>Much urban development in the region is encroaching on fire-prone dry sclerophyll forests and woodlands (bushland) and hazard reduction burning is used for the protection of life and property (NSW NPWS 2001). Hazard reduction burning and potential arson attacks have the potential to increase the frequency of fire in Blue Mountains water skink habitat (NSW NPWS 2001; NSW OEH 2012).</p> <p>Fire may play an important role in the maintenance of the swamp ecological communities in which the species occurs. Regular burning may favour sedge, rush and grass species, which are able to re-sprout quickly after fire, at the expense of obligate seeding shrub species, which regenerate through seed germination (Stricker & Wall 1994). Long-term exclusion of fire from the ecological communities in which the species occurs is likely to lead to the loss of obligate seeding shrubs. This will radically alter the floristic composition and structure of these communities which may be detrimental to the species, especially in the absence of other disturbance regimes that encourage the regeneration of swamp vegetation (NSW NPWS 2001; NSW OEH 2016).</p>
Increased risk of intense fires due to climate change	potential	<p>The frequency and severity of wildfires is also predicted to increase as a result of climate change (NSW OEH 2012; Williams et al., 2009). More intense fires may directly threaten the species and result in incremental, long-term loss of peat resulting in reduced water-holding capacity and contraction and degradation of inhabited swamps (Keith 1996; NSW OEH 2012; Stricker & Wall 1994). Keith (1996) noted that where the peat substrate is burnt, seed banks and subsoil rhizomes of living plants may also be destroyed.</p> <p>All evidence on the response of the Blue Mountains water skink to fire is observational or anecdotal (NSW NPWS 2001). The reduction in shelter resources in the post-fire environment may result in increased rates of predation (NSW NPWS 2001). If a fire of sufficient intensity was to totally burn a swamp and to remove all individuals, then it may be some time, if ever, before the area is recolonised (NSW NPWS 2001).</p>

Conservation Actions

Conservation and Management priorities

Habitat loss, fragmentation or degradation

- In accordance with Commonwealth and state environmental legislation, assess all actions that may result in the loss, fragmentation or degradation of Blue Mountains water skink subpopulations or their habitats.
- Continue to devise, implement and maintain site-specific management plans for developed sites, or sites that are proposed to be developed, to avoid direct and

potential indirect impacts on subpopulations of the species and their habitats. Develop and adapt plans in consultation with relevant experts and when new information about the ecological requirements of the species or threatening processes is made available through the ongoing monitoring programme.

- Where there is a potential for pollutants or sediments to be transported in surface water run-off from sites (including unsealed roads or firebreaks) into the surrounding environment, land owners/managers/developers of those sites should devise, implement and maintain an effective sediment erosion control and stormwater retention plan to minimise potential impacts on Blue Mountains water skink habitat.
- Install and maintain appropriate control mechanisms to prevent or minimise urban runoff, sewerage overflows, and illegal stormwater connections and groundwater extraction.
- Where necessary, prevent access for off-road recreational vehicle users, horse riders, bushwalkers, livestock and people harvesting firewood in swamp habitat and adjacent ecological communities through appropriate signage, fencing or by re-routing tracks.
- Using information gathered during the monitoring of known habitats, determine which sites on NSW Government or Council owned and managed land may require restricted public access through the use of barriers and gates and negotiate the provision of such mechanisms with the organisation responsible for management of the site.
- Encourage land owners/managers to devise and implement plans for the redesign or rehabilitation of sites that are contributing to the alteration of landscape hydrology and affecting swamp habitat for the species lower in the catchment. Sites containing structures such as water diversion or drainage channels, or disused roads, mines or pine plantations, should be appropriately restored in accordance with the *National Standards for the Practice of Ecological Restoration in Australia* (McDonald et al. 2016).

Invasive weeds

- Continue to develop and/or maintain a coordinated weed management/habitat restoration strategy for all properties and tenures on which swamps and their local catchments in which subpopulations of Blue Mountains water skink are known to occur. Modify these plan, where necessary, to adapt to changing environmental circumstances.
- Continue to encourage all private land owners, whose properties contain or adjoin swamps inhabited by the species, to develop and maintain weed management/habitat restoration plans to avoid potential weed infestations, including radiata pine wildings.
- Weed management plans should describe the most appropriate weed suppression methods for eliminating/suppressing relevant weed species at sites while minimising the risk of incidental impacts on subpopulations of the species and their habitats.

Avoid broad-scale spraying of herbicide in local catchments in which swamps inhabited by the species occur. Use appropriate bush regeneration techniques to manage dispersal and growth of relevant weed species in catchments that drain into inhabited swamps.

Invasive predators

- Pending further knowledge on the impact of cat predation on the Blue Mountains water skink, consider zoning residential areas in proximity to Blue Mountains water skink habitat as Wildlife Protection Areas under the *Companion Animals Act 1998* (NSW).
- Continue to enforce the registration of domestic cats and dogs under the relevant provisions of the *Companion Animals Act 1998* (NSW).
- Continue to encourage responsible pet ownership in the Blue Mountains: that pet owners should de-sex their cats and dogs, secure these animals on their properties, and not allow them to enter areas of habitat for the Blue Mountain water skink.
- Where domestic dogs are permitted, they should be restrained on a leash when being taken on walks in the vicinity of swamps supporting habitat for the Blue Mountains water skink.
- If necessary (i.e. if foxes and/or feral cats are shown to be consuming Blue Mountains water skinks), install and maintain predator-proof exclusion fencing around swamps inhabited by the species.
- Maintain control programmes for the European red fox, and feral cats and dogs.

Fire

- Avoid the degradation of known and potential Blue Mountains water skink habitat as a result of fires burning through inhabited peat swamp ecological communities too frequently or infrequently.
- Develop, implement and maintain a fire management plan for the prescribed ecological burning of inhabited and potentially inhabited ecological communities in accordance with the latest scientific information about the fire ecology of those communities and in consultation with relevant land owners/managers, NSW Government agencies/authorities and the BMCC (NSW NPWS 2001).
- Conduct patchy, low-intensity burns to ensure that shelter and other resources are always available and reduce the risk of loss of entire subpopulations (NSW NPWS 2001). In order to control the size of a prescribed burn, fires should be avoided during summer and after prolonged dry periods when the intensity of any fire event is likely to be higher and more destructive (NSW NPWS 2001).
- Ensure that a high proportion of the habitat is maintained with a post-fire age sufficient to provide adequate cover (or habitat) to the Blue Mountains water skink.
- Avoid using chemical fire retardants in areas where the species is known to occur.
- Ensure immediate and ongoing post-fire predator control within the habitat when fires do occur.
- Ensure grazing by introduced herbivores is minimised or excluded post-fire until adequate vegetation recovery has occurred.
- Ensure that areas of dense ground cover/ leaf litter are retained within the habitat when prescribed fires are implemented. Reduce the frequency of high-intensity fires sufficiently to retain hollow logs and large woody debris on the ground.
- To ensure appropriate fire management of known and potential habitats for the species, all relevant land owners/managers, including NSW Government agencies/ authorities

and BMCC, will liaise and cooperate with the Rural Fire Service in association with the relevant Bush Fire Management Committees.

Ex situ recovery actions

- Consider implementing a captive breeding and/or translocation programme for the Blue Mountains water skink when a subpopulation is determined to be at risk of extinction. In considering whether a translocation program is feasible, it is necessary to firstly understand the reasons for the decline in the numbers of mature individuals in the subpopulation(s) and determine whether the causes of the decline can be eliminated or adequately managed. Consideration also needs to be given as to whether translocation is technically possible and whether the resources are available to undertake a translocation program.
- Translocate mature individuals of the species to areas of suitable habitat, including areas connected by suitable dispersal habitat, to increase the potential for the movement of individuals and exchange of genetic material between subpopulations. Identify areas of habitat suitable for translocation through habitat modelling.

Stakeholder Engagement

- Continue to update a species profile of the Blue Mountains water skink and distribute it to relevant landholders, NSW Government agencies and authorities, and community groups. Make the profile publically available at the Blue Mountains National Park Visitors Centre, the NSW NPWS office at Blackheath, BMCC chambers and on the Internet. The species' profile should outline the species' conservation status, and describing its ecological requirements, how known and potential threats adversely affect the species, specific environmental impact assessment guidelines, conservation actions that are being implemented to promote the species' recovery and related advice about how to assist in the species' conservation.
- Continue to provide information based on the abovementioned species profile to the Blue Mountains community. Address a leaflet specifically tailored to residents of Blackheath, Leura Falls Park, Wentworth Falls and Wentworth Falls Lake and Jamison Creek; give presentations to community conservation groups; and produce news articles/posters for inclusion in the NSW *Saving our Species e-news* and local media.
- Continue to install and maintain appropriate, strategically located signage at each site where subpopulations of the species are known to occur in Blue Mountains National Park, other NSW Government forests and reserves, and reserves owned and managed by the BMCC. Signage should advise NSW Government and the BMCC employees and contractors, and the public of the occurrence of the species and the importance of avoiding damage and minimising disturbance to the species' habitats. Ensure that signs are placed in areas that are obvious to the public (e.g. parking areas adjacent to bushland), but not immediately amongst key habitat.
- Continue to assess, prioritise and coordinate conservation actions between the BMCC and relevant NSW Government agencies/authorities, where they are responsible for lands on, or adjacent to, which subpopulations of the species occur, and community conservation groups.
- Continue to liaise with relevant landowners/managers to: emphasise the conservation significance of subpopulations of the species occurring on or adjacent to their properties; provide advice about species ecology, threatening processes and relevant conservation actions; and discuss management options, such as property management

plans and voluntary conservation agreements, and sources of management incentives for landowners to protect areas of habitat.

- Continue to encourage and coordinate the involvement of scientific researchers, regional conservation groups and volunteers in the implementation of conservation actions, including surveys, monitoring and other conservation activities for the species.

Survey and monitoring priorities

- Using a habitat suitability model for the Blue Mountains water skink, identify and prioritise areas of potential habitat to survey in the species' potential distribution. Coordinate survey efforts between NSW NPWS, the BMCC and interested conservation groups.
- Continue to implement and maintain a programme for the monitoring of all known subpopulations and areas of habitat on a two-yearly basis.
- Conduct surveys of potential habitat and monitoring of known subpopulations when the species is most likely to be active on warm sunny days between October and March.
- During monitoring of known subpopulations, record detailed information on each subpopulation, including: the extent, size, and age and sex structure of the subpopulation; floristic and environmental information relevant to the condition of the ecological communities in which the species occurs, particularly the presence/extent of weed species, evidence of fire, and damage to habitat and the potential causes of the damage.
- Continue to maintain a database of all monitoring activities and findings, and store all new point location records of the species in the *Atlas of NSW Wildlife* (available on the Internet at: <http://www.environment.nsw.gov.au/wildlifeatlas/about.htm>).

Information and research priorities

- Research key biology and ecological functions of the species. Record life-history stages and their timeframes; fecundity; normal fluctuations in population size and composition; the habitat components that constitute key resources for foraging, breeding, basking, shelter (especially wintering sites) and use of adjacent ecological communities. Record individual home ranges and movement within the home range; dispersal between populations; and genetic variation between subpopulations. Use this information to estimate dispersal rates and connectivity of populations and the potential for recolonisation of swamps where subpopulations have become locally extinct.
- Identify populations that may be genetically distinct and important for maintenance of genetic variability within the species.
- Research the fire ecology of ecological communities that support the species. Conduct scientific trials to investigate the optimal fire regime (frequency and intensity) for the regeneration of these ecological communities.
- Research the impacts of the above-listed threats to the species and habitat.
- Develop a habitat suitability model for the Blue Mountains water skink to determine the ecological/ environmental indices responsible for the species' distribution of the species, and how it may change due to the impending threats. This requires a high number of presence records and the environmental variables recorded at those corresponding sites chosen at random (Guisan & Zimmermann, 2000). With the assistance of species experts, use aerial photographs, existing GIS layers, and vegetation maps in the development of the model and test predictive equations developed by LeBreton (1996).

- Undertake a habitat connectivity analysis to identify critical habitat linkages and potential barriers to the movement of individuals of the species and prioritise important areas for linking, enhancing or establishing additional subpopulations (e.g. McRae et al., 2008).
- Analyse demographic data to infer or estimate population trends and responses against abovementioned conservation actions. Collate and analyse census data, compare with management histories and conduct population viability analyses.
- Measure the effectiveness of management actions and assess the need to adapt them if necessary.

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