Best practice guidelines

Hygrocybeae Community of Lane Cove Bushland Park

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Department of Environment and Climate Change NSW
59–61 Goulburn Street, Sydney
PO Box A290, Sydney South 1232
Phone: (02) 9995 5000 (switchboard)
Phone: 131 555 (information and publications requests)
TTY: (02) 9211 4723
Fax: (02) 9995 5999
Email: info@environment.nsw.gov.au
Website: www.environment.nsw.gov.au

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Front cover photo: *Hygrocybe collucera*
Back cover: Lane Cove Bushland Park map

All photographs are by Ray and Elma Kearney unless otherwise attributed.

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1 Introduction

The Hygrocybeae Community of Lane Cove Bushland Park is an assemblage of more than 20 documented fungal species in the Hygrophoraceae family which are found only in this park. The assemblage was listed as an endangered ecological community in 2000 under the *Threatened Species Conservation Act 1995* (NSW) (TSC Act). This community represents the first of its kind to be listed as threatened in Australia, and pushed the boundaries of the legislation beyond the realm of plants, animals and invertebrates into the kingdom of fungi.

The Sydney Metropolitan Catchment Management Authority, Department of Environment and Climate Change NSW (DECC), Lane Cove Municipal Council and the Sydney Fungal Studies Group Inc. identified the need to produce best practice guidelines. Lane Cove Bushland Park is a demonstration site as part of the Threatened Species Demonstration Sites Project where current best practice management ensures the long-term viability of this endangered community.

These guidelines outline the innovative management of the site by Lane Cove Municipal Council and local community groups to provide a technical guide applicable to the management of fungal communities. They provide theoretical and practical guidance to bush regenerators, volunteers and the general community wishing to conserve fungi while undertaking bushland regeneration. Resource managers can apply these practices to manage fungal communities in other locations more effectively.

1.1 Lane Cove Bushland Park

Lane Cove Bushland Park is located approximately 10.5 km north-west of Sydney's CBD and measures ~800 m in length and ~300 m at its widest point, covering approximately nine hectares (back cover). The park is mostly covered by warm-temperate wet sclerophyll forest (Figure 1). In some sections as little as 10% of the sunlight reaches the understorey. Over the past century the vegetation structure of the park has changed considerably from sandstone sclerophyll forest, to open grazing pastures, to a mixture of Coastal Sandstone Gully Forest and Coastal Sandstone Ridgetop Woodland.

Gore Creek runs through this bushland and is surrounded by many steep-sided ridges and gullies which carry run-off from surrounding urban areas. Gore Creek flows into Sydney Harbour at Gore Cove, less than 1 km from the park (Figure 2).

Figure 1: Warm–temperate sclerophyll forest in the northern section

Figure 2: A tributary of Gore Creek in the northern section

Figure 3: Open forest in the southern section

Figure 4: Native ground orchids *Cryptostylis erecta* and *Dipodium variegatum*
Photos: Cheyne Ramsay

In the southern, more open section of Lane Cove Bushland Park the ground is covered by grasses which grow amid the various species of eucalypt, angophora and coachwood (Figure 3). Several different species of ground orchids abound in the more sheltered sections of the park which mostly have southerly aspects (Figure 4). Epiphytes are relatively common on tree trunks, especially in the upper tributary areas.

The area records an annual rainfall of more than 1200 mm, making it one of the wettest parts of Sydney. Most of the rain falls from January to July. The average maximum summer temperature is around 24°C and the average minimum is 18°C; average winter temperatures are a maximum of 16°C and a minimum of 7°C. Extremes of temperature are infrequent.

The majority of species in the Hygrophoraceae family are found in the wet sclerophyll forest; its north–south aspect between sloping hillsides governs shade and heat in autumn and winter. Dry sclerophyll forests, which surround the gullies in the park, harbour Hygrocybeae species, and this bushland acts as a buffer between the fungal habitat and the residential area around the park.

The two major rock types in this bushland are Wianamatta shale and Hawkesbury sandstone, which give rise to two distinct types of soil. The shale produces deep, fertile clay soils, while the sandstone produces sandy, stony soils which dry out readily and tend to be associated with steep slopes and rock outcrops. Water dripping from the outcrops onto leaf litter provides ideal conditions for certain species in the Hygrocybeae tribe. The unusual combination of soil types, coupled with the topography of the site with a north–south aspect, has created a range of unique habitats and ecosystems which support a variety of species in the Hygrophoraceae family.

1.2 History

Local community action resulted in the protection of Lane Cove Bushland Park from development in 1972, and it was proclaimed a Wildlife Refuge in September 1979. In 2000 the Hygrocebeae Community of Lane Cove Bushland Park was listed under the TSC Act as an endangered ecological community. This was due to two nominations submitted to the NSW Scientific Committee (Kearney and Kearney 2000), assisted by a taxonomic mycologist (Young 1999). Lane Cove Bushland Park is zoned as Bushland (6B) in the Local Environmental Plan and is managed by Lane Cove Municipal Council.

2 Types of fungi

The fungi are a large group of organisms which includes moulds, yeasts, mushrooms and toadstools. None of these contain the green pigment chlorophyll, so they cannot make their own food by the process of photosynthesis. Being neither plants nor animals, fungi belong to a separate kingdom.

Toadstools
Fungi are sometimes referred to as toadstools, a term commonly applied to the above-ground spore-bearing bodies of those fungi that are poisonous, such as the luminescent *Omphalotus nidiformis* (Figures 5 and 6).

Figure 5: The poisonous *Omphalotus nidiformis* resembling the related edible oyster mushroom in daylight

Figure 6: *Omphalotus nidiformis* revealing its distinguishing luminescent qualities in the dark

Mushrooms
The term mushroom also refers to the above-ground spore-bearing bodies of fungi. The edible varieties of common mushrooms which are grown commercially are 'fruiting' structures whose purpose is to produce spores and disperse them into the air. Fungi spores function in a similar way to seeds in flowering plants (Figure 7). Once the fungal spores disperse and are subject to favourable environmental conditions they are capable of producing new individuals.

The mushroom structure enables the fungus to preserve its own species. Species of fungi in the family Hygrophoraceae cannot be cultivated in artificial media. As they are part of a threatened community they must not be picked or disturbed in any way. Unlicensed collection or harm of endangered fungi can result in criminal penalties under the TSC Act, *Environmental Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act) and the *National Parks and Wildlife Act 1974* (NSW).

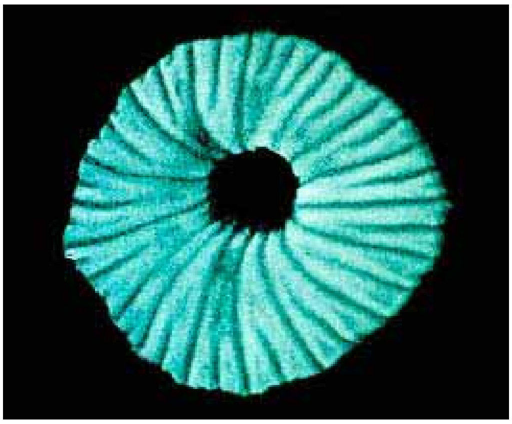

Figure 7: Spore print of *Hygrocybe collucera*

Mycelium
What is seen above the ground is only part of the fungal structure. At the base of the stem is the commonly seen ‘cotton wool-like’ material, the mycelium, which is composed of living threads called hypha that grow by lengthening and branching. The mycelium is vital in gathering nutrients and can extend a large distance from the mushroom.

When the mycelium inhabits grass, it grows outwards from a central point. After rain, the mycelium of some fungi is activated to produce a ring of mushrooms that is commonly called a ‘fairy ring’. The grass is greener within the ‘fairy ring’ of mushrooms because the mycelium provides nutrients to the roots of the grass.

2.1 The categories of fungi

Fungi are divided into three categories:
1 mycorrhizal – symbiotic fungi
2 saprotrophic – fungi subsisting on dead or decaying matter
3 parasitic – fungi feeding on living organisms.

Mycorrhizal fungi
Most vascular plants, including trees, bushes and grasses, depend upon a symbiotic invasion or association where a special relationship develops between the plant and a mycorrhizal fungus. Mycorrhizal fungi inhabit the root systems of their host plant and each helps the other to obtain essential nutrients and increase their resilience to environmental stresses such as drought. This symbiotic relationship is called a mycorrhizal association (Figure 8).

Some fungi have a close relationship with only one species of plant while others grow in association with a variety of species. If, however, the fungus disappears due to unsuitable environmental conditions, the growth of the plant is also affected. Most native species of orchids depend on fungi for germination, flowering and adult growth.

Saprotrophic fungi
Saprotrophic fungi release digestive proteins (enzymes) to break down non-living organic matter (fallen leaves, logs, faecal material), and then absorb the soluble, simple nutrients that they cannot make for themselves (Figures 9–12). In doing so, saprotrophic fungi carry out a vital process of decomposition and, along with bacteria, are the primary decomposers in an ecosystem. This conversion of organic matter eventually leads to the release of raw nutrients that can be used by plants and algae, thereby resupplying the ecosystem.

Parasitic fungi
Some parasitic fungi can invade living tissue of both plants and animals to produce infection. This form of invasion can threaten the life and wellbeing of the host. An example of this is *Gymnopilus junonius*, which is a parasitic fungus that grows in clusters at the base of living trees, absorbing nutrients from its host (Figure 13). *Gymnopilus junonius* also grows in clusters at the base of dead stumps. It can kill a tree and live on as a saprotroph on the dead wood.

Figure 8: The large mycorrhizal fungus, *Cortinarius radicatus*, fruiting beside a species of eucalyptus

Figure 9: Shelves of the leathery bracket fungus *Stereum ostrea* attached to the dead wood of a living tree

Figure 10: The rare scalloped fungus, *Pleurotus djamor*, living on the wood of a dead mangrove tree

Figure 11: The *saprotrophic* fungus, *Pleurotus djamor*

Figure 12: The 'jelly' *fungus Auricularia auricula-judae* which grows on a variety of dead wood

Figure 13: The parasitic fungus *Gymnopilus junonius*

2.2 Endangered fungi: the Hygrophoraceae

Mycological life in Australia has evolved in relative isolation for at least 50 million years. As a result, Australia possesses a rich diversity of unique and unusual fungi. The family Hygrophoraceae includes some of the most unique examples of gilled fungi (Figures 14–21). Many species are brightly coloured and their shapes are unusually symmetrical. Most bushland areas support one or more species of Hygrophoraceae, and their abundance and diversity increase with the availability of moisture.

Figure 14: A green *Hygrocybe graminicolor* – the colour can range from cream to brown to shades of green

Figure 15: *Hygrocybe collucera*

Figure 16: *Hygrocybe cheelii*, mauve to lilac in colour

Figure 17: *Hygrocybe lanecovensis*

Figure 18: *Hygrocybe irrigata*

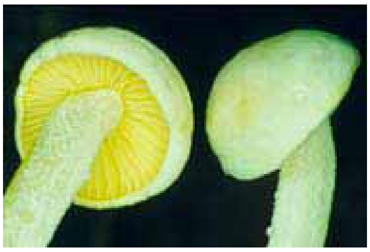

Figure 19: *Hygrophorus involutus*

Figure 20: *Hygrocybe anomala* var. *ianthinomarginata*

Figure 21: *Hygrocybe anomala* var. ianthinomarginata

3 Guidelines for bushland managers and regenerators

Many fungal species are affected by a combination of threats including clearing and modifying of vegetation, weeds, altered fire and hydrological regimes, competition or predation from introduced pests, disease, climate change, polluted stormwater and sewage overflows.

Successful best practice methods implemented in the Hygrocybeae Community of Lane Cove Bushland Park are:

- fire management
- weed management
- fauna management
- stormwater control
- access management and community awareness
- monitoring.

3.1 Fire management

The Hygrocybeae habitat at Lane Cove Bushland Park is characterised by a moist riparian zone with little available sunlight. Although fire can benefit native plant regeneration and ash can activate certain species of fungi, a dense canopy of foliage is crucial for retaining the humidity required for the Hygrocybeae community.

It is recommended that fire should not be used as a regeneration technique in areas containing dense concentrations of fungi unless it is a crucial factor in the species' life cycle (RFS 2008). Fires can be both an advantage and a disadvantage to fungal species. Inappropriate fire regimes can alter the floristic and structural diversity of plant communities and increase the amount of sunlight reaching the soil which can be detrimental to fungal communities. The use of fire in fungal communities can also lead to the destruction of decaying wood and plant species, thereby changing the interdependency of some rare species of fungi. The regeneration of fungal communities after bushfires is extremely complex and slow. Fires following shortly after previous fires can pose serious threats to a stable ecosystem. In areas where a dense canopy may restrict seed germination and regeneration of vegetation, controlled thinning is recommended rather than burning if fungal communities are present.

Managing edge effects

Lane Cove Bushland Park is a long narrow reserve surrounded by private property. Edge effects (such as weed encroachment) largely impact the park and threaten a range of fungal life-support factors such as humidity, temperature and wind draughts, as well as the ecological dynamics of the bushland canopy and understorey. This is a major threat to the stability of the ecosystem and to the fungal biodiversity. Lane Cove Municipal Council has adopted *Development Control Plan 1 – Control of Development Adjacent to Bushland* which seeks to preserve bushland on private properties adjacent to reserves to act as a buffer to the reserves' ecosystems. Council has adopted a designated building line for properties adjacent to Lane Cove Bushland Park to help protect the vegetation surrounding the park and extend the ecological boundary of the reserve (LCMC 2007).

Fire management in Lane Cove Bushland Park
Lane Cove Municipal Council does not conduct controlled burns in areas where fungi are known in Lane Cove Bushland Park. The vegetation structure is maintained in a constant state so as not to disturb the fungal community. Past burns carried out in Lane Cove Bushland Park have been out of the known fungal areas (Figure 22). The Threatened Species Hazard Reduction List recommends that fire not be used as a regeneration technique in the Hygrocybeae Community of Lane Cove Bushland Park (RFS 2008).

3.2 Weed management

Fungal communities are threatened by introduced plant species. Weed infestations change the surrounding environmental factors such as light intensity and moisture availability, and reduce the diversity of native plant species. Ground cover weeds such as trad or wandering jew (*Tradescantia fluminensis*) carpet the ground, inhibiting the life cycles of the existing fungi.

Figure 22: A controlled burn in the park with no threatened fungi impacted

Keeping records of fungi
When working in the bush it is advisable to keep a record of fungal species encountered. If possible, take a photograph of unfamiliar species. Record the top view of the specimen, the under-surface of the cap and size of the fungus (Fuhrer 2005) (Figure 23). Also include the date and recent climatic conditions, as well as a description of the substrate, for example soil, moss, root, decaying wood or leaf litter, on which the specimen is growing. A mycologist can assist in identification.

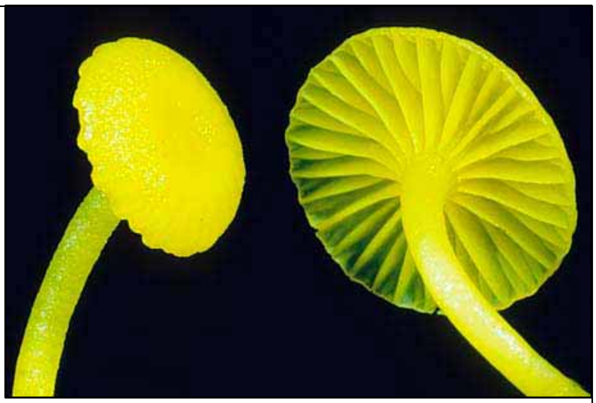

Figure 23: *Hygrocybe chromolimonea*

General ecological principles
While prescribed burns tend to promote canopy and mid-storey regeneration, bush regeneration by manually removing weeds tends to promote the recovery of ferns, herbs, grasses and orchids. Bush regeneration strategies focus on areas that are relatively free of weeds, and then work towards areas of high weed infestations. Bush regeneration works at a pace that allows native vegetation time to establish. There are three phases of the weed control program: primary, consolidation and maintenance.

1. **Primary**: The bulk of the weeds are removed section by section.
2. **Consolidation**: Weed removal causes an increase in available sunlight and resources which promotes both native and weed seed germination. Follow-up weeding must be undertaken to prevent weeds out-competing native seedlings (Buchanan 1989).
3. **Maintenance**: Generally, as regenerating natives become established, the need for maintenance lessens. However, many areas of bushland are surrounded by established subdivisions and invasion of weeds from neighbouring areas is ongoing. In particular, birds spread weeds through their faecal material after feeding on local weeds such as privet and lantana. Consequently, ongoing maintenance will be required for most bushland areas.

Weeding techniques implemented in Lane Cove Bushland Park
Since the 1970s Lane Cove Municipal Council staff and volunteers have been undertaking bush regeneration in Lane Cove Bushland Park. Since the 1990s the regeneration program has focused on maintaining native ground covers to preserve fungal habitat.

Prioritising which weeds to focus on is based on the potential of the weeds to spread and impact on native vegetation and fungal communities. Low priority weeds include broad-leaved privet (*Ligustrum lucidum*) which takes considerable time to mature and fruit; therefore juvenile plants do not have to be removed immediately. In contrast, high priority weeds are quick to establish and reproduce and thus have a devastating effect on native bushland. These weeds are constantly searched for and destroyed.

Specific techniques that minimise soil disturbance and herbicide use have been implemented in Lane Cove Bushland Park. Fungal species are sensitive to soil disturbance and herbicides all year round as they exist as delicate mycelium underground even while they are not fruiting. Where possible hand weeding, or cut and paint is recommended to control weeds. The use of pesticides should also be avoided as fungi may be dependent on insect species to complete their life cycle.

Leaving weeds as barriers to protect sensitive areas
Weeds such as privet have been left temporarily in dense stands along the edges of the park for the following reasons:

- **as a physical barrier** to prevent competitive weeds from entering the reserve via the adjacent urbanised area
- **to protect areas** by preventing both unnecessary human traffic into the reserve and the formation of new tracks through sensitive regeneration areas
- **to maintain fungal microclimate** by minimising change in humidity, temperature and wind in the park.

Weed exclusion through sediment fencing
Sediment fences act as physical barriers preventing exotic weeds such as trad from entering the park (Figure 24). They may also contain infestations within the park enabling easier management. This practice significantly reduces maintenance hours dedicated to the interface between bushland and the urban fringe (BARRC 2007).

When and where not to weed

Care must be taken when bushland is being regenerated between April and August as this is when mushrooms emerge, especially after rain. In Lane Cove Bushland Park bushland regeneration is not undertaken when Hygrocybeae species are fruiting or in areas known to contain Hygrocybeae. Soil disturbance should be minimised in known fungal areas all year round to prevent disturbance to the underground mycelium. Sandstone outcrops over which rainwater flows onto leaf litter provide ideal habitat for many fungal species including Hygrocybeae. Sheltered moss-covered creek banks also provide habitat where many fungal species can flourish. Special care should be taken when undergoing rehabilitation work in these habitats.

Figure 24: A sediment fence
Photo: Nicholas Coleman

Removing trad

Remove trad using the following procedures:

- **Remove the thinnest infestations first.** Give priority to weeding areas where trad has been removed previously. Tackle new trad infestations only when weeded areas are well maintained.
- **Weed by hand wherever possible.** This is to ensure minimal soil and therefore minimal mycelium disturbance. Only rake trad to bare soil where the infestation is dense.
- **Remove trad only in dry conditions.** Weeding in wet, muddy conditions increases soil disturbance and allows stem and root fragments to be buried in the soil.

Follow these steps to remove dense trad infestations (Figure 25):

- Install sediment fences to contain the spread of trad.
- Rake or roll up the trad like a carpet, with all native ferns and vines cut back prior to raking to avoid uprooting them.
- Carefully collect every piece of trad as it is able to regrow from root and stem fragments. If the trad is not completely removed and natives regenerate, it is difficult and time consuming to remove it from between regenerating plants.
- To dispose of the trad, move it to a sunny position and cover with black plastic; the heat trapped under the plastic kills the trad which then decomposes.
- Inspect the area regularly and weed by hand to prevent any trad regrowth from establishing.

Figure 25:Trad infestation
Photo: Nicholas Coleman

Managing plant communities
To preserve fungal communities during bush regeneration, existing vegetation structures should be maintained. In Lane Cove Bushland Park the structure and composition of canopy species are preserved, thick understorey species are encouraged, and sparse ground covers are maintained. Along with the topography of the park this assists in maintaining good climatic conditions for fungi. Gradual removal of weed species, allowing for the natural succession of native plants, is recommended. In sensitive fungal habitats beneath dense canopy vegetation, care should be taken to minimise opening of the canopy when canopy weeds and trees are removed and when branches are lopped.

Fallen timber
If there is no pressing need, do *not* remove fallen timber, or even turn over logs, in or around fungal communities. Decomposing fungal (saprotrophic) species colonise the wood and use fallen timber as a substrate. Moving logs, even slightly, may change the microclimate of fungal habitat and threaten saprotrophic fungi.

Hygiene
The introduction of exotic parasitic fungal species into an area can be detrimental to existing fungal communities. Exotic parasitic fungal infections are commonly spread with the introduction of wood chips or by being carried on regenerator's tools.

The introduction of wood chips into a fungal community for weed suppression is not recommended. Wood chips derived from trees killed by parasitic fungi are likely to be carrying *Gymnophilus junonius* or *Armillaria luteobubalina*. *Gymnopilus junonius* is a parasitic fungus that grows in clusters at the base of living trees, absorbing nutrients from its host plant (Figure 13). It kills mature trees, and lives on as a saprotroph consuming the dead wood. *Never* convert a tree that is infected by *Gymnopilus junonius* into mulch as the mycelium inside the tree will live on in the mulch and be transported with it.

If plant species infected by parasitic fungi are handled, precautions should be taken to avoid spreading the fungi to new areas. When handling infected material always wear disposable gloves. Decontaminate tools, boots and hands in a solution of disinfectant and ensure all traces of soil are washed off. As the mycelium lives inside the wood caution must be exercised in disposing of infected trees and shrubs. Care must be taken not to introduce parasitic fungal species into areas of bushland where they are not native.

Soil pathogens
Phytophthora cinnamomi is a microscopic soil-borne organism that can survive in very small quantities of soil for long periods of time. It kills a wide variety of native and non-native plant species by rotting the roots of its host. It is listed as a Key Threatening Process under the TSC Act and the EPBC Act (DECC 2008). The risk of spreading *Phytophthora* can be minimised by appropriate hygiene procedures.

Tools, machinery, boots and tyres are to be regularly drenched in a solution of disinfectant with all traces of soil washed off. When planting a number of plants, disinfect tools before and after each individual planting. *Phytophthora* can persist in dead organic tissue of the trees it has infected for many years. Infected vegetation is to be disposed of carefully. *Never* woodchip vegetation suspected of being infected by *Phytophthora*. DEH (2006) describes in detail the management of communities infected with *Phytophthora*.

Tip: When working in the bush it is advisable to carry some disinfectant in a spray bottle and a scrubbing brush to decontaminate boots and equipment when moving between sites or if unexpected pathogens are encountered.

Revegetation

Restoration ecologists have only recently begun to understand the role of fungi in ensuring the success of revegetation and in maintaining biodiversity in degraded bushland. It is possible to reintroduce fungi back into revegetated areas to enhance biodiversity. Fungal spores must be correctly inoculated into soil; incorrectly doing so can cause irreversible damage to the existing vegetation and risks transfer of soil pathogens such as *Phytophthora cinnamomi*. The artificial introduction of fungi into ecosystems is recommended only with the advice of an experienced mycologist.

A diverse array of fungi inhabits all bushland remnants, but fungi take a long time to re-establish in revegetation sites. The fungi need to be naturally assisted to promote sustained soil functioning for greater long-term sustainability of bushland. Many species of macrofungi (fungi visible to the naked eye) increase in numbers after weed removal through the dispersal of animal scats. Fungal fruiting can display natural seasonal variation. In dry weather the topsoil where the mycelium is found can dry out and impede fruiting, and it can take several wet seasons for fruiting to recommence. Therefore, during dry periods fungal fruiting can be very sparse.

The establishment of native vegetation in Lane Cove Bushland Park has occurred through regeneration and not revegetation. Revegetation can, however, be carried out in areas of low resilience if care is taken not to introduce exotic fungi. Plants used in revegetation should be sourced locally to retain the genetic integrity of the area. The use of local stock in revegetation programs will encourage the founding of endemic mycorrhizal associations with local native fungal species. A diverse range of plant species will increase the diversity of mycorrhizal species and the associations formed.

The introduction of exotic soils, potting mix and fertilisers in fungal communities is not recommended. Introducing foreign soils into fungal communities can introduce exotic parasitic fungal spores and alter the existing fungal community's composition. Fungal species can be sensitive to changes in soil nutrient levels caused by fertilisers. In fungal communities with low resilience the planting of seeds rather than tubestock is recommended. Endemic ground covers should be encouraged as much as possible to regenerate during weed removal in fungal communities. Where inoculated tubestock and the skills of an experienced mycologist are available the following general procedure is recommended (DEC 2005).

- Give all seedlings a thorough watering the day before planting.
- Plant each seedling at the same depth in the soil as it was in the container.
- Give seedlings a good soaking after planting to remove any air pockets in the soil.
- Install tree guards around the seedlings to protect them from predation and extreme weather.

3.3 Fauna management

Every organism within a community is part of a food web. In Lane Cove Bushland Park a web involving species of Hygrocybeae is very complex, perhaps comprising scores of different types of organisms assisting in the establishment and germination of fungal species.

The relationship of any species to others in its food web is an important dimension of its ecological niche. Numerous organisms, such as rats, mice, lizards, slugs, insects and larva, feed off fungal fruit.

While predation is a major cause of fungal death, the predation of fungi in Lane Cove Bushland Park does not necessarily reduce the numbers of an equilibrium population below carrying capacity. Predation of fungi may actually be a means of assisting in the dispersal (and perhaps even germination) of spores ingested by various predators (Figure 26).

A reduction in natural predators may have serious consequences for the long term survival of fungal communities. Exotic plants such as lantana, privet and blackberry provide habitat and foraging resources for birds and other fauna. Careful consideration must be taken during the removal of these weeds, in regards to retaining functioning habitat for native fauna. This can be achieved by the following approaches.

Figure 26: Predation by larvae of fungal gnats in *Hygrocybe griseoramosa*

Work to an appropriate time frame that allows native trees and shrubs to replace the weeds that have been removed. Always search exotic plants for bird and possum nests before their removal.

Maintain habitat by only working small manageable areas at a time, leaving stands of 'caretaker' weeds behind to maintain habitat. Observe which weeds the birds favour; this ensures that the correct caretaker weeds are left. As many bird species feed on and among logs and leaf litter, branches and dead trees should be left on the ground. Nesting hollows for birds (Figures 27 and 28) and possums in many cases need to be provided as old natural hollows often do not exist. Also, debris needs to be present on the ground as refuge for many insects, invertebrates, small mammals and reptiles as well as a substrate for fungi.

Consider the habitat potential of rubbish as old pipes, tiles, car bodies and pieces of tin can be temporary habitat, especially when the rubbish is well established and away from public view. It may be advantageous to leave the rubbish *in situ* and work towards its replacement by natural components, allowing time for fauna to adapt to the new sites before rubbish removal.

Figure 27: An emerald dove

Figure 28: A powerful owl *Ninox strenua*

Build fauna habitat by constructing a raft – arrange branches and logs in a circular pile and then place removed weeds, such as lantana, on the raft to decompose off the ground.

Maintain and improve fauna habitat by planting native vines and shrubs next to clumps of lantana, so that the vines grow over the framework of the lantana. Before planting the vines the main trunk of the lantana should be cut and painted with herbicide.

The fungus, the orchid and the gnat

As with most ecosystems, the ground layer of vegetation in Lane Cove Bushland Park contains strong inter-dependencies between species. Several different species of ground orchids greatly depend on fungi for survival through mycorrhizal associations and for pollination. Some ground orchids, such as *Pterostylis* species, emit pheromones that mimic the odour of mushrooms to attract fungal gnats (Figure 29). Normally the fungal gnats lay eggs in the fungal flesh to breed (Figure 30). The gnats locate the fungi by the pheromones they excrete. However, the gnats can be deceived by pheromones emitted by species of *Pterostylis*, and act as pollinators for the orchid. The strong inter-dependence of different species with fungal communities highlights the importance of maintaining fungi and endemic ground layer vegetation throughout the regeneration process.

Figure 29: Native ground orchids in the genus *Pterostylis* (greenhoods)

Figure 30: The eggs of fungi gnats laid between the gills of *Humidicutis helicoides*

3.4 Stormwater control

Many species of the Hygrocybeae tribe present in Lane Cove Bushland Park inhabit moist areas on creek banks and in flood zones. Large flows of water and high nutrient levels associated with stormwater can have negative impacts on fungal communities.

Long-term successful stormwater management requires that all water that flows onto the site be managed. High velocity stormwater can erode creek banks and introduce refuse such as silt, nutrients and weeds. Solely focusing on weed removal from stormwater-affected areas would not be an effective use of time as more weeds and nutrients would be continually deposited after rain (BARRC 2007).

The creeks and streams that flow through Lane Cove Bushland Park contain many sandstone boulders (Figure 31). These rocks dissipate water pressure, permitting natural litter traps to form in the creek below. Natural litter traps consist of sand, silt, rocks and woody debris that slow and filter the water. Sandstone boulders can be placed to minimise creek bank erosion in fungal communities if the geology and hydrology of the area are compatible.

Lane Cove Municipal Council has a stormwater control plan that requires all new development adjacent to bushland to implement a detention system and dispersal trench. This reduces the amount of erosion and nutrient loading in the park due to stormwater running off surrounding private lands. Public education for residents adjacent and upstream is important to limit damaging substances entering stormwater. Fungal communities can be particularly susceptible to common stormwater pollutants such as fertilisers and chlorinated water from swimming pools.

Lane Cove Municipal Council, with community vigilance, maintains surveillance of Gore Creek and has successfully prosecuted offenders polluting the creek. It is important to liaise with and educate adjacent and upstream landholders about water quality control within catchments containing fungal communities.

Figure 31: A stream through the central section

3.5 Access management and community awareness

Lane Cove Bushland Park is well served by trails and walking tracks (Figure 32). The encroachment of bushwalkers into unstable and sensitive areas must be prevented to allow fragile ecosystems to retain biodiversity.

Walking off trails adds pressure to fungal species by:

- compaction of soil which prevents fungal growth
- damage to fruiting structures
- local fragmentation of vegetation.

All non-essential tracks in Lane Cove Bushland Park have been closed to allow natural regeneration of the fungal community. This included installing warning signs and blocking the tracks with boulders or logs. The potential detrimental effects created by community access to reserves can be minimised by limiting the extent of walking tracks. The use of mulch and brush matting to restrict access and prevent erosion should be avoided in fungal communities, as these materials can alter the microclimate favoured by fungi and have detrimental effects on the community.

Figure 32: A constructed path
Photo: Nicholas Coleman

The following community education messages should be encouraged in fungal communities and have been promoted at Lane Cove Bushland Park:

- Stick to the tracks.
- Keep dogs on leads and out of waterholes and creeks.
- Pick up your dog's faeces.
- Keep cats out of the reserve at all times.
- Do not remove plants or soils from the reserve.
- Do not plant trees or introduce soil into bushland.
- Use green waste services provided by Lane Cove Municipal Council.
- Do not dump waste in bushland.

3.6 Monitoring

Monitoring involves observing the changes that take place before, during and after the restoration work. Keeping comprehensive records provides information on the effectiveness of management practices, allowing land managers to determine if the natural vegetation is improving or declining (DEC 2005). General monitoring techniques include:

- **Before and after photographs.** Photographs taken at permanent monitoring posts (star pickets) installed at the corner of 5 m x 5 m monitoring quadrats provide visual documentation of the vegetation regrowth if taken at regular time intervals.
- **Native plant and weed counts.** Periodically recording the diversity and abundance of weed and native plant species within each 5 m x 5 m quadrat, during pre- and post-treatment of weeds, provides a quantitative account of site conditions. The bush regeneration management practice employed should also be noted; this enables different techniques to be compared (McDonald *et al.* 2002).
- **Vegetation maps.** Mapping the area can provide a visual representation of where the weed infestations occur, and also documents the type of regeneration works in a particular area which provides a visual mapped history.
- **Documenting and reporting.** Clearly specifying the desired ecological objectives and documenting the actions implemented provides a better position to evaluate progress, correct any mistakes and ensure ongoing success. Good data management also provides useful information for other groups about successful restoration activities and guides future restoration works.

4 Summary of threatening processes and their management

Threatening processes	Management of threatening processes
Inappropriate fire regimes	• Fire is not recommended as a management tool in Hygrocybeae communities.
Weed invasion	• Minimise or avoid weeding from April to August. • Maintain vegetation structure and fallen timbers. • Follow hygiene procedures. • Minimise soil disturbance and herbicide and pesticide use. • Install sediment fences to prevent further weed encroachment. • Monitor pre- and post-bush regeneration. • Use local provenance seed to revegetate low resilience sites. • Encourage native ground covers. • Undertake neighbourhood education.
Absence of fauna	• Work to an appropriate time frame. • Maintain fauna habitat when weeding.
Urban run-off	• Install detention systems and dispersal trenches. • Use sandstone boulders. • Implement public education programs for residents to limit damaging substances going into stormwater. • Encourage community surveillance of creeks.
Inappropriate access	• Close non-essential tracks using signage, boulders or logs. • Promote the appropriate use of bushland.

5 Further reading

Websites

Fun facts about fungi, at http://herbarium.usu.edu/fungi/FunFacts/factindx.htm

FungiBank, at http://www.fungibank.csiro.au/

Introduction to the Fungi, at http://www.ucmp.berkeley.edu/fungi/fungi.html

MycoKey, at http://www.mycokey.com/uk.html

Sydney Fungal Studies Group Inc., at http://www.sydneyfungalstudies.org.au

Tom Volk's Fungi, at http://botit.botany.wisc.edu/toms_fungi/

The WWW Virtual Library: Mycology, at http://mycology.cornell.edu/

Books

Kendrick, B. (2001) *The Fifth Kingdom* (3rd edn), Mycologue Publications, Sidney, British Columbia, Canada.

Young, A.M. (2005) *Fungi of Australia: Hygrophoraceae*, CSIRO Publishing, Melbourne.

Journal articles

Bougher, N.L. and Tommerup, I.C. (2000) Nature's ground force, *Biologist* 47: 19–23.

Claridge, A.W. (2007) Linking the above-ground to the below-ground: why we should be restoring processes as well as species in our revegetation efforts, *Australasian Plant Conservation* 15(4): 11–13.

May, T.W. and Simpson, J.A. (1997) Fungal diversity and ecology in eucalypt ecosystems, in J. Williams and J. Woinarski (eds), *Eucalypt Ecology: individuals to ecosystems*. pp 246–277, Cambridge University Press: Cambridge.

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Buchanan, R. (1989) *Bush Regeneration: Recovering Australian Landscapes*, TAFE NSW.

DEC (2005) *Recovering Bushland on the Cumberland Plain: Best practice guidelines for the management and restoration of bushland*, Department of Environment and Conservation (NSW), Sydney.
http://www.environment.nsw.gov.au/resources/nature/RecoveringCumberlandPlain.pdf.

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http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/threat_profile.aspx?id=20026 .

DEH (2006) Management of *Phytophthora cinnamomi* for Biodiversity Conservation in Australia, Department of the Environment, Heritage, Water and the Arts. Accessed 11 March 2008 at http://www.environment.gov.au/biodiversity/invasive/publications/p-cinnamomi/index.html .

Fuhrer, B. (2005) *A Field Guide to Australian Fungi*, Bloomings Books, Melbourne.

Kearney, R. and Kearney, E. (2000) Significance of the Hygroghoraceae Community of Lane Cove Bushland Park in listings under the NSW *Threatened Species Conservation Act 1995* and under the *Australian Heritage Commission Act 1975*, *Australasian Mycolologist* 19: 64–70.

LCMC (2007) *Plan of Management for Bushland in Lane Cove*, Lane Cove Municipal Council, Sydney.

McDonald, T., Wale, K. and Bear, V. (2002) Restoring Blue Gum High Forest: Lessons from Sheldon Forest, *Ecological Management & Restoration* 3: 15–26.

RFS (2004) Threatened Species Hazard Reduction List Part 3 – Endangered Ecological Communities, NSW Rural Fire Service Accessed 4 March 2008 at
http://www.rfs.nsw.gov.au/file_system/attachments/State/Attachment_20050304_61C9CAC7.pdf .

Young, A.M. (1999) The Hygrocybeae (Fungi, Basidiomycota, Agaricales, Hygrophoraceae) of the Lane Cove Bushland Park, New South Wales. *Austrobaileya* 5: 535–564.

Lane Cove Bushland Park map