



FUNGI

INTRODUCTION TO FUNGI AND FIELD RECORDING

Did you know that,

- Fungi have no chlorophyll, are non-photosynthetic and are not plants or animals - they are in their own Fungi Kingdom. ^[1]
- Fungi make up about 25% of the total biomass on Earth, yet only about 1 in 15 species have been described. ^{[2],[3]}
- It is estimated there may be over 1.5 million species of fungi worldwide, and greater than 10,000 macrofungi in Australia, making them more than six times as diverse as flowering plants. ^[4]
- 80% terrestrial plants require mycorrhizal fungi for their health and ALL orchids require mycorrhizal fungi for their growth ^[5]

Ecological roles of Fungi

- Fungal diversity is important for ecosystem health and resilience.
- Fungi are too often ignored in biodiversity actions and policies. We need to embed fungi in biodiversity conservation & find cures for "mycomyopia". ^[6]
- Decomposer fungi do not make their own food and must feed on pre-existing organic matter, hence are important for nutrient recycling.
- Fungal hyphae (fungi cells formed into thin filaments) are important for good soil structure, water retention and nutrient availability.
- Fungi are food for some animals, particularly truffles (subterranean fruiting bodies) for macropods; hyphae and mushrooms (fruiting bodies) for vertebrates & invertebrates.
- Endophytes (bacterium or fungus present in most plant tissues) have a role in disease and herbivory avoidance.
- Fungal diseases including rusts, smuts, galls etc have a role in natural selection.
- Terrestrial orchids form mycorrhizal associations and need fungal partners in order for seedlings to survive beyond the germination stage.



Invertebrate / vertebrate food – fungus showing bite / nibble marks

Note:

- **Slime Moulds** are not Fungi but are in the Kingdom Protocista. Hence, these notes do not include information regarding Slime Moulds.

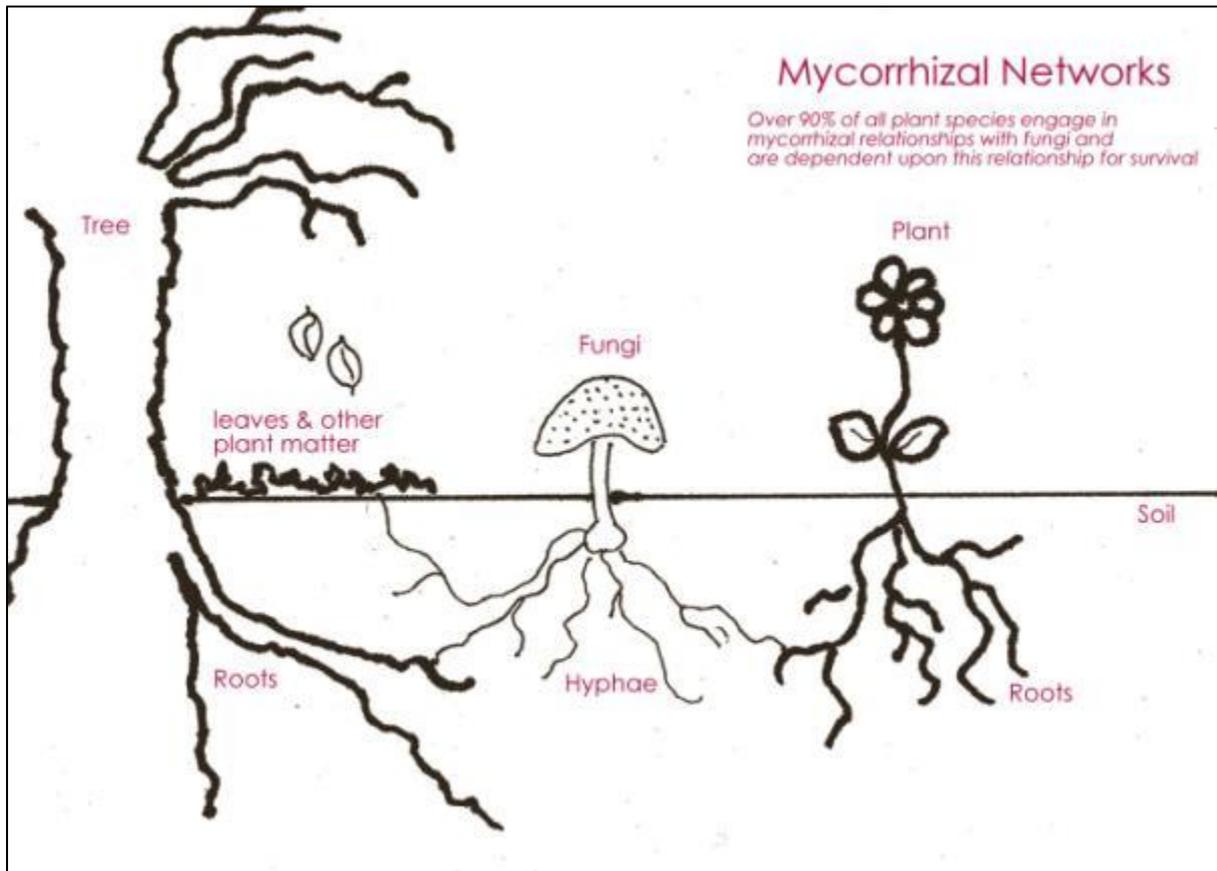
Fungi Relationships

Saprophytic - Fungi as Decomposers

- These are organisms that obtain food from decaying organic matter
- Fungi play an essential role in maintaining equilibrium in nearly every ecosystem. They recycle nutrients by breaking down the bodies and wastes of other organisms by releasing digestive enzymes.

Symbiotic - both partners benefit

- Mycorrhizae: Symbiotic relationship between plant roots and fungi. Fungi allow plants to absorb more water and minerals; Fungi also release enzymes that free nutrients into the soil; Plants provide fungi with the products of photosynthesis.
- Lichens: Symbiotic association between a fungus and a photosynthetic organism. The algae or cyanobacteria carry out photosynthesis providing the fungus with food; the fungus provides the algae or bacteria with water and minerals that it collects and also protects the delicate algae cell.



Mycorrhizal Network. (Diagram by Jenny Talbot)

Diagram shows a mycorrhizal network. Tree supplies fungus with carbohydrates in return for water and nutrients the mycorrhizal fungal mycelia gather from the soil, from decaying matter or from other plants.

Parasitic

- Some fungi can infect animals and plants and cause diseases, eg Athlete's Foot, Bread Mould.
- Other parasitic fungi may take over the host, eg Cordyceps species are parasitic mainly on insects and arthropods, living inside and ultimately killing host.
- A few are parasitic on other fungi.



Parasitic or Symbiotic Fungi - Substrate is another Fungus.

Reproduction

- The mushrooms you see above ground are the fruiting body, not the organism itself. The mushroom is only a **small part** of the organism. The above ground part is used for reproduction and carries the spores (like seeds).
- Most fungi grow as hyphae which are cylindrical, thread-like structures 2–10 μm in diameter and up to several centimetres in length (a human hair is about 90 μm wide).
- Many hyphae tangled together into a thick mass or network is called a mycelium. This spreads through soil and is present even when mushrooms are not visible.
- Spore dispersal can be by various means, including
 - Gravity and wind (eg Agarics)
 - Water (eg Birdnest Fungi relies on rain drops to push spore mass from cap)
 - Explosion (eg Puffballs)
 - Insects (eg Phalloides)
 - Animals (eg Truffles form about 90% of some Macropods eg Potoroos diet)



Puff Ball: Spores ejected explosively are then dispersed by wind.
(Photograph by Oliver Ford)



Phallus rubicundus: Insects attracted to foul smelling spore mass which is then dispersed



Crucibulum laeve (Birdnest Fungi): Rain drops disperse spore mass which splash onto nearby vegetation.



Crucibulum laeve (Birdnest Fungi): Spore mass are eaten by animals, and dispersed in animal dropping substrate.



Cortinarius rotundisporus:

Rusty coloured spores fall and carried by wind, water etc

Fungi Morphology / Identification

- Mushrooms are the reproductive structure (fruiting body) of the fungi.
- Fungi have walled cells made of chitin (the same material that insect exoskeletons & prawn shells are made of) unlike the cell walls of plants which contain cellulose, and unlike the cell walls of bacteria.
- Fungi cells form into thin filaments called hyphae. When many hyphae tangle together into a thicker mass or network this forms a mycelium.
- Thousands of tiny thread like mycelium spread throughout the area on which the mushroom is growing and can be likened to plant roots. The mycelium makes up the biggest part of the fungus.
- The reproductive structure (a mushroom) grows from the mycelium in the substrate.

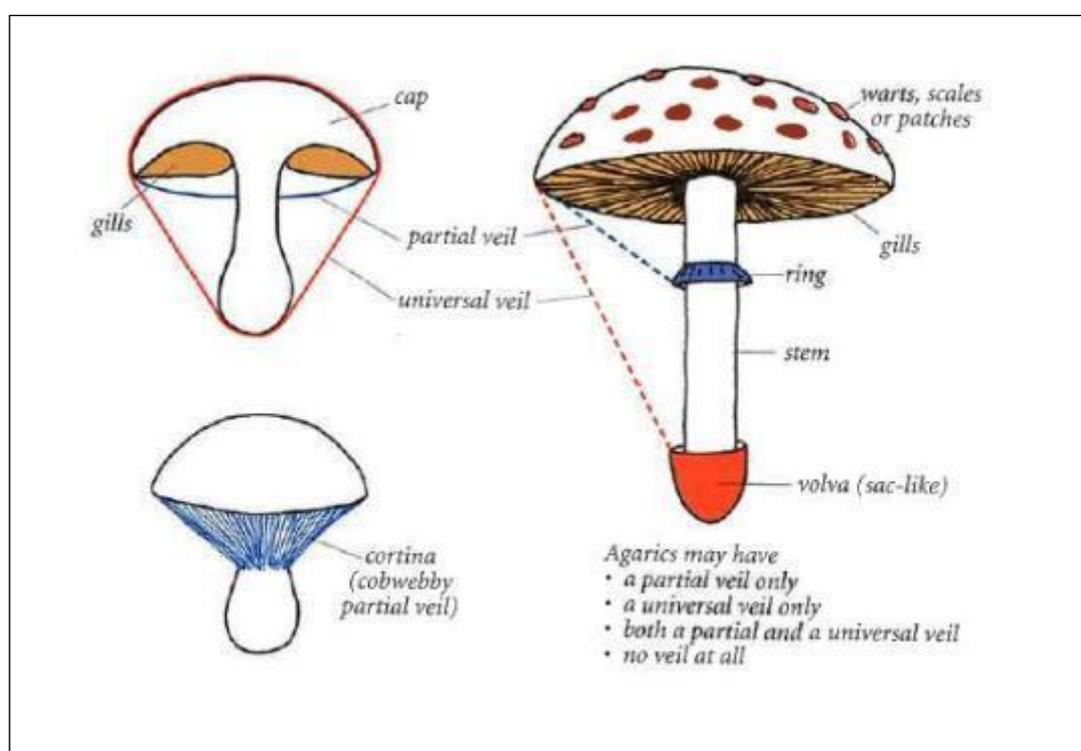
Describing a Fungus

The aim here is to familiarise you with the nature of many macro-ID features, not with the jargon.

Amateur mycologists are usually interested in the fungi big enough to see and describe with the naked eye. These are known as macro-fungi.

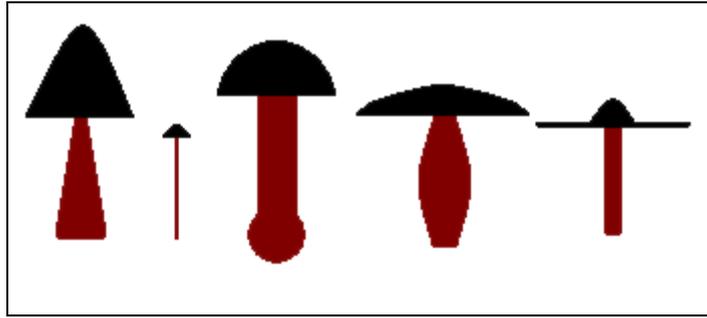
A hand lens is very useful for examining features, and a small mirror is handy for looking at the undersides of mushroom caps, so they won't need to be picked.

- **Cap** - What shape is the cap? What colour is it?
- **Gills** - Does it have gills or are there pores or spines under the cap? What colour are the gills, and how are they attached?
- **Stem** - What is the colour of the stem? Does the stem attach centrally to the cap, or off to one side? Does it have a volva or ring? Does the stem discolour when broken? Does it exude latex?
- **Spores** - What is the colour of the spore print? Making a spore print is a way to find out the colour of spores. Put a cap on a piece of paper with gills downward, and cover for 2-3 hours. Spores will drop and make a coloured pattern.
Hint: you may not be able to see white spores on white paper, but using a sheet of clear strong plastic allows the background colour to be changed for better contrast.

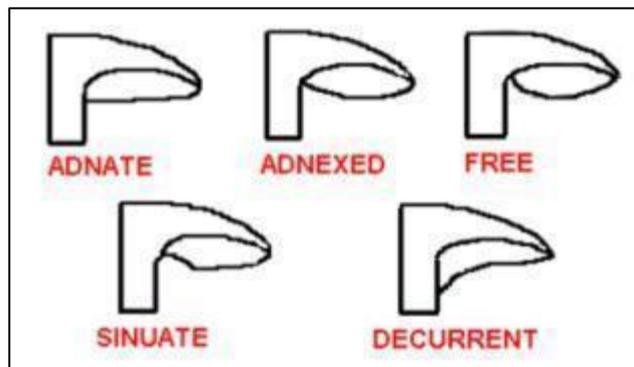


Macro features

(Ref: <http://fungimap.org.au/index.php/learn-about-fungi/beginners/describe>)



Caps may be just a few millimetres in diameter or many centimetres in diameter and the stems may be solid or hollow inside.
 (Ref: <http://www.anbg.gov.au/fungi/macrosopic.html>)



Gills may attach to the stem in a variety of ways.
 (Ref: http://www.geocities.ws/keithdnorman_2002/structure/st3.gif)

Morphological Groups

- The form and structure of fungi are convenient categories in which to place fungi based on shape and other shared visible characteristics.
- Species that are in the same morphogroup are not necessarily related and genetically they could be quite dissimilar, but placing species that look alike together into a morphogroup can make it easier to navigate through a field guide to find the species that you are after.
- Different field guides may use different terminology for morphogroups, and they may have more or less categories than other guides, depending on the characteristics which they deem important.

Summary of the Fungimap Morphogroups

Agarics	Gills, like radiating blades, underneath a cap. Fleshy texture.
Beech Orange	Round, orange fruit-bodies with large pits.
Boletes	Have tubes opening by pores under their caps. Soft or fleshy texture.
Brackets	Shelf or shell-shaped. Spores formed on underside of the shelf.
Chanterelles	Shallow gill folds extend down the stem underneath the cap. Fleshy texture.
Clubs	Club-shaped. Fleshy or tough texture. Spores formed on outside of head. (See also Corals.)
Corals	Coral-like or club-shaped (See also Clubs). Fleshy texture.
Crusts	Thick or thin crust. Spores formed on outer surface.
Cups	Cup-shaped. Spores formed on inner surface of cup.
Discs	Small, disc-shaped. Spores formed on upper surface.
Earthstars	Powdery spores enclosed in a sac, surrounded by star-shaped rays.
Jellies	Brain-like mass or individual clubs. Jelly-like or rubbery texture.
Leathers	Smooth or wrinkled lower surface. Tough texture.
Lichens	Green (because of the algal layer), usually flat or bushy.
Morels	Honeycomb-like head on a stem. Spores formed on surface which lines pits.
Pins	Pin-shaped. Spores formed on head.
Polypores	Pores (tubes) underneath their caps. Tough texture.
Puffballs	Powdery spores enclosed in a sac but which does not have any stem.
Rusts	Tiny, disc-shaped or cylindrical, in cluster-cup stage. Always on living plants.
Stinkhorns	Cage-shaped, phallic-shaped, egg-shaped or with arms. Foul smelling slimy spore mass.
Stalked Puffballs	Powdery spores enclosed in a sac which is supported on a tough stem.
Tooth Fungi	Spines or teeth pointing down. Fleshy or leathery texture.

From *Fungi Down Under Online (FDU Online)*

Ku-ring-gai Wildflower Garden's Fungi

Fungi one may expect to find at KWG

These are some of the macrofungi previously found or expected to be found in Ku-ring-gai Wildflower Garden. Photos were taken by Wendy Grimm and Jenny Talbot.

1. **Agaric** (gills present, usually with a stipe (stem / stalk) attached to the cap)



2. **Bolete** (no gills but have pores or tubes)



3. **Stinkhorn** (Foul smelling slimy spore mass, cage-shaped, phallic-shaped, egg-shaped or with arms.)



Phallus indusiatus
(Bridal veil stinkhorn)



Aseroe rubra
(Anemone of Sea-star Fungus)



Mutinus sp

4. **Puff Ball** (no stem, powdery spores formed in a sac)



5. **Corals** (Coral-like or club-shaped, fleshy texture)



6. **Leathers, Bracket Fungi, Conks** (Smooth or wrinkled lower surface. Tough texture with pores or tubes on the underside)



7. **Jellies** (Brain-like mass or some like individual clubs. Jelly-like or rubbery texture)



Fungi Field Recording

Fungi can be ephemeral and sporadic – some occur every few years and last for just a few hours. Mushrooms may be produced over much of the mycelium, or just in some parts. Thus it not possible to find and identify every fungus in a given area during just one survey, so return visits will be needed.

To conduct a systematic survey of macrofungi requires three basic skills:

1. Able to recognise the great variety of fungi
2. The ability to distinguish micro-habitats
3. Knowledge of important features

Surveys can be either

- Species-Specific: Survey an area looking for the presence of a single species / genus or for more than one.
- Site-Specific: aiming to find all the species at a given site and obtain a complete list of every fungi species.

Equipment or Supplies

- Field guides (eg *Fungi Down Under*)
- Survey forms and pencil(s) and ruler for measuring
- A good hand lens can be helpful
- A colour card (such as in *Fungi Down Under*) for checking and describing colours accurately
- Permanent tags to mark sites, specimen field tags & marking pens
- Appropriate anti-Phytophthora equipment (70% methylated spirits and brushes/spray bottles to wipe boots, hats, equipment, and car wheels.)

Safety in the field

- Plan for your safety and the safety of your group
- Take a first aid kit and know how to use it
- Wash your hands after handling fungi and avoid breathing in spores.
- Some fungi are poisonous or may cause allergies. Always exercise caution.
- In an emergency dial 000

Photos & GPS location

Decide what fungus you have and which characters need to be documented for ID or future ID confirmation. Photos need to be clear, in-focus, particularly the gills, pores or teeth.

Useful photography equipment may include

- Digital GPS capable camera or GPS unit, compass, and maps
- A small mirror to check & photo underside gill shape and attachment

Finally, you can lodge copies of your survey results with your local fungal studies group, Fungimap, and herbaria. Using a standard form, such the one from Fungimap below, simplifies your field notes.

You can send your records and images (digital preferred but hand written/printed is also acceptable) to Fungimap, who will

- add your records to the National Australian Fungimap Database
- upload your observations to the Atlas of Living Australia

References

- [1] Fungimap, www.fungimap.org.au
- [2] McCormick, M. K., Lee Taylor, D., Juhaszova, K., Burnett, R. K., Whigham, D. F., O'Neill, J. P. (2012). "Limitations on orchid recruitment: not a simple picture". *Molecular Ecology* **21**: 1511–1523
- [3] Miller, JD (1992). "Fungi as contaminants in indoor air". *Atmospheric Environment* **26** (12): 2163–2172.
- [4] Hawksworth DL. The magnitude of fungal diversity: the 1.5 million species estimate revisited. *Mycol Res* 2001;105:1422-32.
- [5] Sorenson, WG (1999). "Fungal spores: Hazardous to health?" (PDF). *Environ Health Perspect* **107** (Suppl 3): 469–472.
- [6] Finding cures for mycomyopia: Embedding fungi in Australian biodiversity conservation. Alison Pouliot - discusses challenges to fungal conservation in Australia at the Fungimap VII Conference in Rawson, Victoria on May 24th 2013
<https://www.youtube.com/watch?v=ZiQgKcjPMXo#t=20>
- Grey, P. and Grey, E. Fungi Down Under – the Fungimap Guide to Australian Fungi, Fungimap Inc. 2009
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<http://fungimap.org.au/index.php/fduonline-home/294/fdu-online-home>
- Guide_to_Surveying_Fungi_in_Australia_v1.1
https://www.fungimap.org.au/Guide_to_Surveying_Fungi_in_Australia_v1.1.pdf

Websites

Heino Lepp, 2012, Australian National Botanic Gardens, Canberra,
<http://www.anbg.gov.au/fungi>

International Society for Fungal Conservation, www.fungal-conservation.org

Periodicals

Fungimap Newsletter published three times per year, sent to Fungimap members.
Australasian Mycologist, Published by Australasian Mycological Society,
<http://www.australasianmycology.com/>

Organisations and Groups

Fungimap, c/o Royal Botanic Gardens Melbourne, Private Bag 2000, Birdwood Avenue, South Yarra, VIC 3141. <http://www.fungimap.org.au>
Australasian Mycological Society <http://www.australasianmycology.com/>
Sydney Fungal Studies Group www.sydneyfungalstudies.org.au

APPENDIX No: 1

Fungimap – Background Summary

Fungimap Inc is a national non-profit citizen-science organisation dedicated to raising the profile of Australia's incredible fungal diversity.

Fungimap maintains the National Australian Fungimap Database (NAFD) containing over 100,000 records and 6,500 images of fungi from over 700 contributors nationwide.

This valuable resource is used for research, conservation, and policy purposes and has been provided to the Australian National Heritage Assessment Tool (ANHAT), state and Commonwealth environment agencies, and the Atlas of Living Australia.

Fungimap publishes *Fungi Down Under* a field guide which helps with the identification of Fungimap's 100 'target' species, which can be easily identified in the field by distinctive characteristics.

Fungimap delivers national and local educational events training people in all aspects of macro fungi identification, recording, collecting and surveying, as well as advancing the status of fungal conservation and management.

Fungimap - Aims and Activities

- To stimulate and support the study and appreciation of Australian macrofungi
- To promote the conservation of Australian indigenous macrofungi and their relevant ecosystems
- Educational conference, which provide a forum for conservation issues
- Contribute to enhancing the conservation of fungi by making submissions to reviews of biodiversity policy
- Contribute to federal, state and local council biodiversity policies by submitting comments and reviews
- Newsletter for members

Appendix No: 2

Fungi Field Guide Glossary

Glossary by Rus Shulla, Fungimap Newsletter No. 2, June 1996, updated in 2012 by Alena Moison.

Agaric

This is the word often used synonymously with 'mushroom' - it means to be a member of the Agaricaceae

Annulus

This is a remnant of the partial veil left as the mushroom matures. It often leaves a ring of membranous tissue around the stem (stipe)

Bolete

The common name for soft textured fungi which generally have pores instead of gills

Bulbous

Refers to a bulbous like swelling at the base of the stem (stipe), often underground

Button

Immature specimen

Cap

The pileus which is the umbrella or bell like 'hat' of the mushroom. The pileus holds the spores in either gills or pores

Carpophore

The complete fruit body of the fungus (i.e. cap, stem, gills, etc). Sporophore and sporocarp are other names also used

Check characters:

When ID Ease states to "check characters" this means that there are one or several identifying characteristics of this fungi which differentiate it from other look-alikes that cannot necessarily be determined in the field. This may require microscopic examination, spore print identification, or other more advanced identification techniques.

Cup

The description given to the saucer shape of the Ascomycetes group

Face

The side of a gill

Genus

Taxonomic term meaning a group of similar species. Genera which are closely related are placed into families

Gill

The spore-bearing structure of mushrooms

Fungi Field Guide Glossary

Glossary by Rus Shulla, Fungimap Newsletter No. 2, June 1996, updated in 2012 by Alena Moison.

ID Ease:

There are two categories under ID Ease. Fungi are either "Identifiable in the field" or Fungimap recommends that you "Check characters". Basically, some more advanced identification technique (spore print, microscopy, etc) than merely observation of the fungi in its natural habitat is required to determine with certainty any species where "Check characters" has been noted.

Identifiable in the field:

A category of ID Ease signifying that the fungi can be determined with certainty by an educated observer viewing the fungi in its natural habitat and without the use of more sophisticated techniques.

Ink cap

Common name of the *Coprinus* genus-- the caps turn to an inky mess when picked and before you can dry them!

Margin

The outermost edge of the gill (i.e. the edge facing downwards)

Milk

A liquid exuded from certain species such as *Lactarius deliciosus*

Mycelium

The vegetative part of the fungus which grows in the host or soil and produces the fruit body. The mycelium is like a mass of often microscopic fibres

Mycorrhiza

This refers to the association between the mycelium of a fungus and the rootlets of plants.

Mycorrhizal:

The fungi forms a symbiotic relationship with the roots of another plant in order to obtain its food source.

Partial veil

The covering of the gills while very young that breaks open, often leaving remnants on the stem (stipe)

Phenolic:

Sometimes described as smelling like paste, mothballs or burnt circuit boards, and often associated with species of *Agaricus*.

Polypores

Common name of tough-textured fungi with pores

Pileus

The cap

Spore

A microscopic part of the fungus which can germinate to reproduce the fungus

Fungi Field Guide Glossary

Glossary by Rus Shulla, Fungimap Newsletter No. 2, June 1996, updated in 2012 by Alena Moison.

Saprotrophic:

The fungi obtains its food source from processing dead or decaying organic matter.

Spore print:

One of the more advanced techniques to identify fungi. The spore material left on paper when the cap is left for a period of time -- the colour can be an important identifying characteristic

Stipe

The stalk or stem of the fruiting body of the fungus

Universal veil

Material which completely covers the young immature mushroom

Volva

This refers to the remnant of the universal veil sometimes left at the base of the stipe (stem)

Source: Fungimap Inc, c/o Royal Botanic Gardens Melbourne, Private Bag 2000, South Yarra Victoria 3141; Tel: (03) 9252 2374; ABN 28290974280. Vic Cert A0047228L

Appendix No: 3

Recording Fungi sightings / Citizen Science

- How can we deal with so many fungi, with so few mycologists, so many pressures and so few resources?
- How can we get message across to government, conservationists, biodiversity officials and the public that we need to work with these fungi?
- How to promote sustainable projects and stimulate mycological research?
- Finding cures for '*mycomyopia*', thus ensuring fungi is a better recognised aspect of conservation and management practices, in Australian biodiversity conservation.

Volunteer citizen scientists are a part of a scientific collaboration that feeds knowledge into the scientific community. Using digitized natural history collections, volunteer citizen scientists help to fill gaps in understanding

- Help to confirm the distributions and habits of species
- Locate and document species which are new to science
- Contribute to our understanding of how fungi are likely to respond under threat

Collect and contribute information which is important to researchers and policy makers. Scientists and researchers can use the data to conduct new research and make better conservation decisions.

Fungi perform vital ecological roles in decomposing wood, cycling nutrients, providing shelter and sustenance to animals, invertebrates, and microbes, in promoting disease resilience, and in symbiotic relationships with plants and algae.

Despite their importance, little is known about what Australian fungi exist or about their distribution, conservation status, or the complex interactions they may have with the flora and fauna on this continent.

Participate in Fungi Citizen Science using Fungimap or Atlas of Living Australia.

To find a list of fungi that have been previously recorded in an area, you can use the Atlas of Living Australia at www.ala.org.au or the Fungimap Survey Resources at www.fungimap.org.au/index.php/surveyingfungi

ATLAS of LIVING AUSTRALIA
Sharing Community Knowledge

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Species Locations Collections Mapping & analysis Data sets Blogs Get Help! About the Atlas

Home → Locations → Your Area

Explore Your Area

Enter your location or address:

st ives new E.g. a street address, place name, postcode or GPS coordinates (as lat, long)

Showing records for: 414-420 Mona Vale Road, Saint Ives NSW 2075, Australia

Display records in a

Group	Species	Species - Common Name	Records
All Species	2059		
Animals	791	1. <i>Asperula albiverrucosa</i>	1
Mammals	53	2. <i>Asperula janthocapitata</i>	1
Birds	240	3. <i>Asperula australis</i>	40
Reptiles	44	4. <i>Asperula rubra</i> - Anemone Fungus	2
Amphibians	16	5. <i>Asperula schrenkii</i>	1
Fish	8	6. <i>Asperula circumlocum</i>	1
Mollusca	20	7. <i>Asperula strasseri</i>	1
Arthropods	395	8. <i>Asperula stricklandii</i> - Squirr Lichen	1
Crustaceans	7	9. <i>Asperula elegans</i>	2
Insects	312	10. <i>Asperula rufiformis</i>	1
Plants	1229	11. <i>Asperula leucostigma</i>	1
Bryophytes	2	12. <i>Asperula niveo-hollandiae</i>	1
Gymnosperms	13	13. <i>Asperula stricklandii</i>	1
FernsAndAlgae	57	14. <i>Asperula stricklandii</i>	1
Angiosperms	1140	15. <i>Asperula velata</i> - Pure Lichen	2
Mosses	338	16. <i>Phellinus indusciatus</i>	1
Diets	804	17. <i>Leptomytilus complanatus</i> - Common Porecupin	2
Fungi	19	18. <i>Remora scutiformis</i>	1
Cnidaria	0	19. <i>Lithocarpus laevis</i>	1
Protists	0		
Bacteria	0		
Algae	0		

Tip: you can fine-tune the location of the area by dragging the red marker icon

Atlas of Living Australia at www.ala.org.au lists fungal species seen at specific locations.