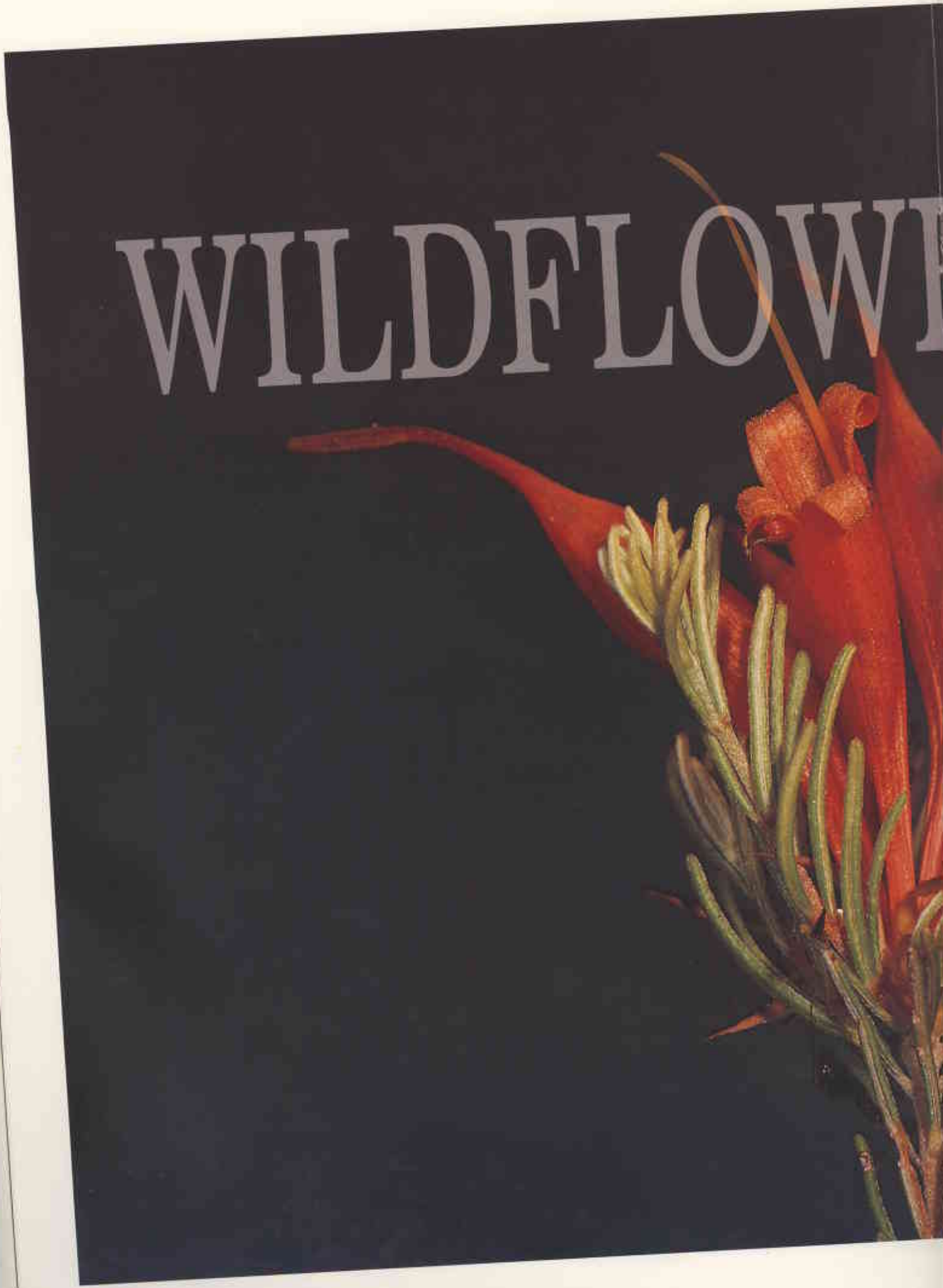
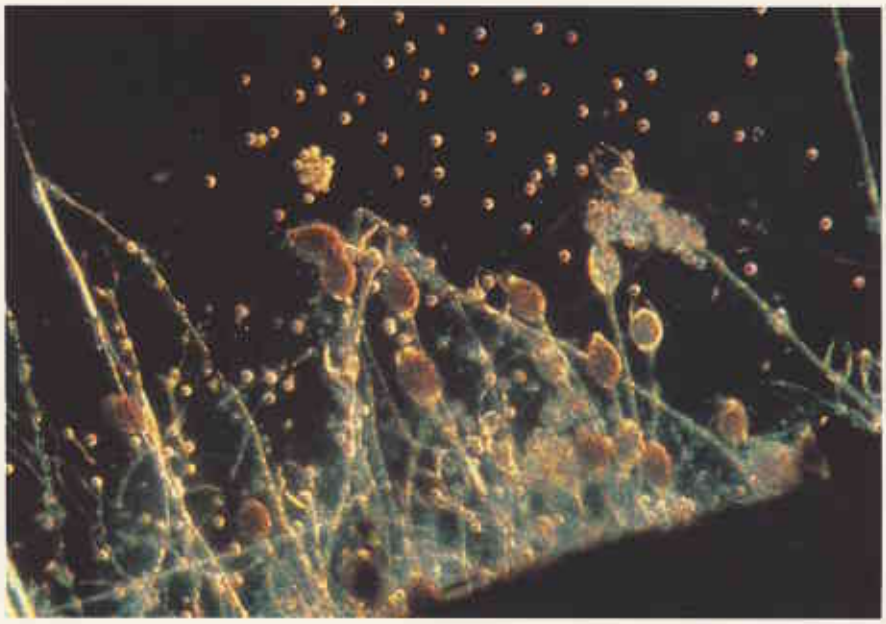

WILDFLOW

ER KILLERS

by Bryan Shearer, Ray Wills and Mike Stukely

Western Australia's unique wildflowers evolved in response to environmental stresses brought about by ice ages, earthquakes, flooding, fire and drought. Now they face one of the greatest threats to their existence, from seemingly insignificant, microscopic fungi belonging to a group called *Phytophthora* - the wildflower killers.



Previous page:
Wild honeysuckle (*Lambertia ericifolia*) and golden dryandra (*Dryandra nobilis*).
Photo - Jiri Lochman

Spore sacs of *P. cinnamomi* release zoospores that swim in free water and infect nearby roots.
Photo - B.L. Shearer

Dieback-stricken banksia woodland in Cape Arid National Park.
Photo - Jiri Lochman▲

For decades after foresters first noticed the deaths of jarrah trees in the early 1920s, the cause of 'jarrah dieback' escaped scientists. Only in the mid 1960s was the destroyer of jarrah finally identified by Dr Frank Podger as the soil-borne fungus, *Phytophthora cinnamomi* (see *LANDSCOPE*, Spring 1989). Dr Podger described the effects of the killer fungus in the jarrah forest, and in banksias and other wildflower communities throughout the South West. However, most of the attention and subsequent research focussed on the jarrah forest. This changed in 1985 when the departments of Forests, National Parks and Wildlife amalgamated to form the Department of Conservation and Land Management (CALM). Since then, a lot more attention has been given to the problem of infections in wildflower communities outside the forest.

We can now identify which wildflower communities are vulnerable to dieback disease, and use hygiene methods developed in the jarrah forest to help protect these communities. We also know that dieback disease is caused by seven species of soil-borne *Phytophthora*. *Phytophthora cinnamomi* is the most common and destructive, but *Phytophthora citricola*, *P. cryptogea*, *P. drechsleri*, *P. megasperma* var. *megasperma*, *P. megasperma* var. *sojae* and *P. nicotianae* also kill wildflowers.

FOREIGN INVADERS

The seven *Phytophthora* species attacking wildflower communities are not native to WA. They were probably introduced to the State with imported plants around 1900, before quarantine procedures were in place. *Phytophthora* species are now spread around the world, but the killer fungi probably originated in the sub-tropics.

During the 40 years before it was recognised that *P. cinnamomi* killed jarrah, the fungus was unwittingly spread throughout the South West by off-road vehicle activity and in infected gravel used in road construction. The fungi are also spread in soil clinging to the boots of bushwalkers, and on the feet of animals. They have also been widely distributed by people moving infected plants.

Within diseased areas, the fungi spread by growing in the root systems of infected plants, and can even spread uphill in this manner. Downhill spread is mainly by infectious spores carried by water; many of our soils contain a hard pan below the surface which causes water to pond and flow across it, carrying spores of the fungi with it. So, as well as being found in water running over the top of the soil, fungi spores may survive and spread up to five metres below the soil surface.

VULNERABLE COMMUNITIES

From the initial small dead patches of forest, dieback disease infected an estimated 280 000 ha of Crown land by 1977. Today, *Phytophthora cinnamomi* threatens diverse wildflower communities from Eneabba in the north, to the eastern edge of the jarrah forest and along the south coast to Cape Arid.

The killer fungus dramatically changes the wildflower-rich jarrah forest understorey. Wildflowers of the banksia, pea and heath families are commonly killed, causing an irreversible decline in the diversity of infected areas. Surviving trees in the forest often mask the full impact of the disease, but its effects can be as severe as those in shrubland and woodland on the coastal plain and south coast.

Dieback disease is destroying banksia communities on coastal sandplains around Perth and on the south coast. North of Perth, it is threatening the geographically restricted rose banksia (*Banksia laricina*) in the Moore River National Park. In banksia woodlands near Perth the dominant candle, holly leaf and firewood banksias (*B. attenuata*, *B. ilicifolia* and *B. menziesii*) are killed. In affected areas, no overstorey remains. Many understorey wildflower species are similarly affected: the number of species in 64-square-metre quadrats decreased from 56 in healthy woodland to 41 in diseased woodland.

On the south coast, the rare and dieback-susceptible feather-leaved banksia (*B. brownii*) is threatened with extinction; all of its few known locations are infected. The rich flora of the Stirling Range National Park is also under threat. The fungus was probably spread throughout the park by off-road vehicles and the construction of firebreaks and roads during the 1940s to 1960s. Walk trails are also infected. Grassy areas of low diversity replace wildflower-rich shrublands and woodlands in the infested areas of the park. Vegetation in Cape

Arid and Cape Le Grand National Parks is also suffering considerable damage.

The Fitzgerald National Park is one of the richest wildflower areas in WA, with 20 per cent of the State's described plant species. *Phytophthora cinnamomi* infects a narrow six-kilometre strip along Bell track, illegally built in 1971 in the northern-central part of the park. Bird's nest banksia (*B. baxteri*) and Lambertia thicket is being destroyed within the infected area. The spectacular royal hakea (*Hakea victoreae*) survives for a time in infected areas, but eventually dies. The protection of the healthy vegetation that still covers most of the park is a high priority.

The other wildflower killers are also causing concern. *Phytophthora citricola* is the most widespread, mainly killing individual plants in the area bordered by Kalbarri in the north, Boyagin Rock to the east and along the south coast to Cape Arid. *Phytophthora megasperma* kills banksia communities in seasonally waterlogged areas on the Northern Sandplains and south coast. *Phytophthora cryptogea* and *P. drechsleri* are associated with water bodies and *P. nicotianae* occasionally kills banksias.

Large areas of wildflower-rich shrublands are still disease-free, but vulnerable to infection. It is essential to prevent further losses by protecting healthy wildflower communities from disease.

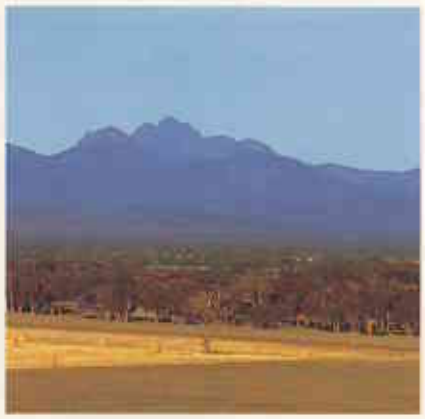
LOSSES TO THE COMMUNITY

In 1989, government and industry spent at least $3.5 million dollars on dieback disease detection, mapping, prevention and research. These costs will probably increase in the future as the fight against the disease intensifies.

The loss of wildflowers directly affects multi-million dollar industries such as tourism and honey production. The wildflower areas north of Perth and on the south coast are vulnerable to infection, while popular tourist areas such as the Stirling Range National Park and Two Peoples Bay Nature Reserve are severely affected.

The death of wildflowers also affects the species that depend on them for food and shelter. Wildflower communities are varied and complex. The firewood banksia and the woollybush (*Adenanthos cygnorum*), for instance, are keystone species in the banksia woodlands around Perth.

Firewood banksia flowers in winter and is an important source of pollen and nectar for many birds and insects, at a time when few other species flower. Insect larvae that use the flower heads are an important food for cockatoos, while in autumn the nutritious seed and seedlings are eaten by many animals. Woollybush flowers from spring to autumn, and complements firewood banksia as a nectar source for birds and insects. It also has special glands that provide nectar for ants, wasps and other insects all year round. Woollybush fruits provide



The rich flora of the Stirling Range National Park is threatened by dieback disease, especially along walktrails.
Photo - Cliff Winfield ▸

Royal hakea survives for a time in infected areas but eventually succumbs to dieback.
Photo - Marie Lochman ▾

food for birds, rodents and ants, while the leaves are eaten by a specialised moth, the larvae of which are preyed upon by a wasp. The death of just these two plants has great consequences for these dependent animals.

Similar interactions occur in many other wildflower communities. About 15 per cent of South West plant species are pollinated by birds and mammals. Banksias and related wildflowers have large flowers pollinated by nectar-eating animals such as the western pygmy possum and honey possum. Seed-eating parrots might also be affected by the loss of favoured seed-producing species such as banksias or hakeas.

Populations of bird or mammal pollinators may dwindle as the plants on which they depend are eliminated. If only a few plants remain, there may not be enough food to sustain the pollinators. If the pollinators disappear, the few remaining plants may never set seed, despite having survived the killer fungi. In this way, death of susceptible species may reduce the numbers of pollinators essential to the survival of more resistant plants such as the endangered rose mallee (*Eucalyptus rhodantha*), and can thus affect neighbouring communities as well. However, we still have to learn a lot more about the interactions within wildflower communities in order to determine the true cost of dieback disease.

WHY SO VULNERABLE?

The *Phytophthora* fungi can attack at least 1 000 plant species throughout the world. Because the killer fungi were only recently introduced to WA, the State's wildflowers have little resistance to infection. Our wildflowers have adapted to poor soils and drought by developing extensive specialised root systems for maximum intake of nutrients and water, but that is precisely what makes them vulnerable to the killer fungi.

Western Australian climate and soils provide many favourable environments for the fungi. *Phytophthora* species thrive in warm, moist conditions during autumn and spring. Rainy winters create wet conditions that allow infectious spores to survive and spread in moist soil picked up by vehicles and in flowing water. Moist conditions are created for most of the year above hard pans deep in the soil. Thus, even though the surface soil may be dry, millions of infectious spores may be produced and distributed deep in the soil. Warm temperatures in summer also favour rapid fungal growth along the root systems of infected plants and result in the infection of new hosts through root-to-root contact.

MANAGING THE DISEASE

Dieback disease is everybody's problem. Effective control depends on the combined efforts of the public, assorted industries, and federal, state and local government. The more people know about the disease, the more they can do to prevent its spread. Rotary International District 9460 and a newly formed Northern Sandplains Dieback Working Party are helping the government increase public awareness and training.

Mapping the extent of the disease is an essential first step in effective prevention. The dieback mapping system developed by CALM staff for the jarrah forest is one of the most effective disease detection techniques in the world. This system is based on the interpretation of colour aerial photographs and is now also used to map dieback distribution in wildflower communities.

Quarantine and hygiene procedures have been developed in areas managed by CALM. Roads and tracks in national parks, reserves and forest have been closed to stop the infection from being introduced into healthy areas with susceptible and endangered wildflowers. Everyone can apply their own quarantine by keeping to all-weather roads, especially during wet weather.

Clean work practices also help to prevent the movement of infected soil, plant material and water into healthy areas. A package of hygienic procedures is used to minimise the consequences

Above:
A CALM officer injects an acorn banksia (*B. prionotes*) with phosphorous acid.
Photo - Bryan Shearer

Far left (above):
Animal species such as honey possums that use susceptible plants for food are also affected by dieback.
Photo - Michael Morcombe

Far left (below):
The rare rose mallee is fairly resistant to the disease.
Photo - Jiri Lochman

Left (above):
Flowering understorey of the jarrah forest - honeybush dies out, leaving only the resistant wattle, prickly moses.
Photo - Marie Lochman

Left (below):
Fox banksia (*Banksia sphaerocarpa*) is susceptible.
Photo - Michael Morcombe

should any one procedure accidentally fail. These include cleaning machinery, vehicles and footwear; controlling the movement of soil and road-making materials; minimising activities when soils are wet and sticky; disinfecting water used from streams and dams; paying attention to drainage; and carrying out essential activities only.

These methods of disease management help protect large areas of healthy bush from dieback disease, but are regarded as a holding action until better methods of controlling the disease have been developed.

FUTURE OPTIONS

At the moment, dieback fungi are usually only detected after plants have died. Remote sensing, using special detectors that sense thermal and infra-red radiation, may give early warning of infection. Trials are under way to see if healthy wildflower communities growing on soils that favour the disease can be mapped and if infected plants can be identified before they die.

Scientists now know much about how *P. cinnamomi* survives and spreads under local conditions. We need to learn more about how the other six *Phytophthora* species reproduce and survive. Determining moisture and temperature conditions that affect the ability of the fungi to produce spores, survive and infect hosts will help scientists to assess the risk of infection, and to develop hygiene maps and effective methods of control.

There may also be great potential in a host's own resistance. While many populations of susceptible species are decimated by the killer fungi, a few individuals occasionally survive. Though they often escape by chance (perhaps some subtle barrier in the soil prevented infection), some plants may have developed a genetic variation that helps them resist the fungus. If resistant individuals can be found, there is hope of replacing susceptible populations with resistant varieties. Research on resistant jarrah has shown great promise. This work will be expanded to include other key groups of plants.

Where conserving plants in the wild is not possible, tissue culture can be used to propagate and store plants at risk. This may allow us to re-establish these plants after means of controlling the killer fungi have been fully developed. Longer-term research may allow genetic engineering of the plants to include genes for resistance found in other species.

Chemotherapy is another important measure. Phosphorous acid, a cheap, biodegradable fungicide not toxic to people or animals, may be a practical way to control infection in wildflower communities. The fungicide controls all the *Phytophthora* species except *P. megasperma*. It penetrates all parts of the plant, even roots metres below the soil surface. The fungicide has a double action; it directly attacks the fungi and also boosts the plants' natural defences. Phosphorous acid protects banksias from

Photo - Jiri Lochman

WHAT YOU CAN DO

The fight against wildflower dieback must involve the whole community. You can help if you:

- Find out about the biology of the killer fungi.
- Become aware of where wildflower dieback already occurs and the effects the disease is having on plant communities.
- Take an interest in protecting your local piece of bush.
- Support the efforts aimed at containing the spread of the fungi and at finding a cure.
- Stop the spread by keeping to well-formed, well-drained roads and observe "road closed" signs.
- Make sure you are not a fungus carrier if you have to go off road.

Thick-walled oospores of *P. citricola*.
Photo - Bryan Shearer

infection for at least four years after being applied, and banksias already infected by the fungi can heal themselves after treatment. The fungicide can be applied to plants by injecting it in their trunks, and by spraying onto the foliage for large areas. It is currently being used to protect the feather-leaved banksia from infection.

Biological research offers hope of turning the fungi on themselves. Genetic engineering may be able to exploit weaknesses in the make-up of the fungi in order to help control them. However, such options are expensive and will take time to develop.

In the meantime, the whole community must combine to fight the killer fungi. The cost of protecting healthy plant communities is small compared to the loss of conservation, plant resource and aesthetic values caused by the disease.

Although there is as yet no cure for dieback disease, human ingenuity always provides hope for the future. Meanwhile, considerable advances in research and hygiene procedures provide a holding action. Until the wildflower-killing fungi are beaten, the preservation of some of WA's unique plants and animals will hang in the balance. ⊡

Bryan Shearer, Ray Wills, & Mike Stukely are all research scientists within CALM's plants disease program.

THE KILLING FUNGI

The seven soil-borne *Phytophthora* species that kill our wildflowers extract their food from plant tissues by a mass of microscopic threads, or **mycelium**, which forms the body of the fungi.

Given warm, moist conditions and interaction with soil microbes, the mycelium can bud off microscopic spore sacs which release millions of tiny infectious **zoospores**. This is the main way the *Phytophthora* species infect plants and reproduce. Once released, the zoospores swim over short distances or are passively moved in moist soil through human activity and in running water.

Active zoospore production occurs mainly in spring and autumn. In winter zoospores survive in moist soil but their production is limited by low temperatures. If the soil dries out in summer the fungi usually die, but can survive in infected roots or as more resistant spore types.

The mycelium may also bud-off **chlamydospores** which are larger than zoospores and can survive in soil and plant tissue for long periods, provided conditions do not become too dry. They cannot move on their own, but can be transferred in infected roots and soil particles. When conditions are favourable the chlamydospores germinate and produce mycelium and zoospores.

Thick-walled spores called **oospores** are also produced by the mycelium under certain conditions. Oospore production by *P. cinnamomi* is infrequent because two types of mycelium must grow together before they are formed. In comparison, *P. citricola* and *P. megasperma* readily produce oospores, as the fungi form the spores from the one type of mycelium. The thick-walled oospores can survive dry conditions and probably account for the wide distribution of *P. citricola* in south-western Australia.

After infection, the fungi invade root bark and form lesions of dead tissue. The fungi kill their hosts by destroying fine roots and girdling major roots or the base of the stem, depriving the plant of access to nutrients and water.

More than 80 per cent of species in the banksia family (banksias, grevilleas, dryandras, hakeas, and so on) may be killed by the fungi. The banksia family is often the most abundant group in many areas of the South West and so provides the fundamental elements of many plant communities.

LANDSCOPE

VOLUME SEVEN NO. 1 SPRING EDITION 1991

A wave of colour is spreading from Shark Bay to Jurien and inland to Meekatharra. Our story on page 10 takes you into Wildflower Country.

The WA Museum is 100 years old. It houses a staggering four million specimens of insects, marine animals, fish, birds, reptiles and frogs. Page 22.

Seven species of microscopic dieback-disease fungi are attacking WA's unique wildflowers. See page 28.

The rugged Pilbara landscape has some hidden delights. On page 16, go up hill to Hamersley Range, then down Dales and other spectacular gorges.

How does WA's conservation heritage look to the people who look after it? Turn to page 26 for some great photographs from a recent competition run for CALM staff.

COVER

Out now! Wildflowers are blooming in the vast tracts of country north of Perth, especially in the northern sandplains and Murchison, which is experiencing a bumper wildflower season following heavy winter rains. Philippa Nikulinsky's illustration shows some of the wildflowers for which WA is justly famous: the splendid everlasting, buttercup, red leschenaultia, Sturt's desert pea, catspaw, wattle, native wisteria, black kangaroo paw, flame pea, and scaevola - all covered in the newly released book Wildflower Country. *See page 10.*

FEATURES

REGULARS

SPECIALS

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