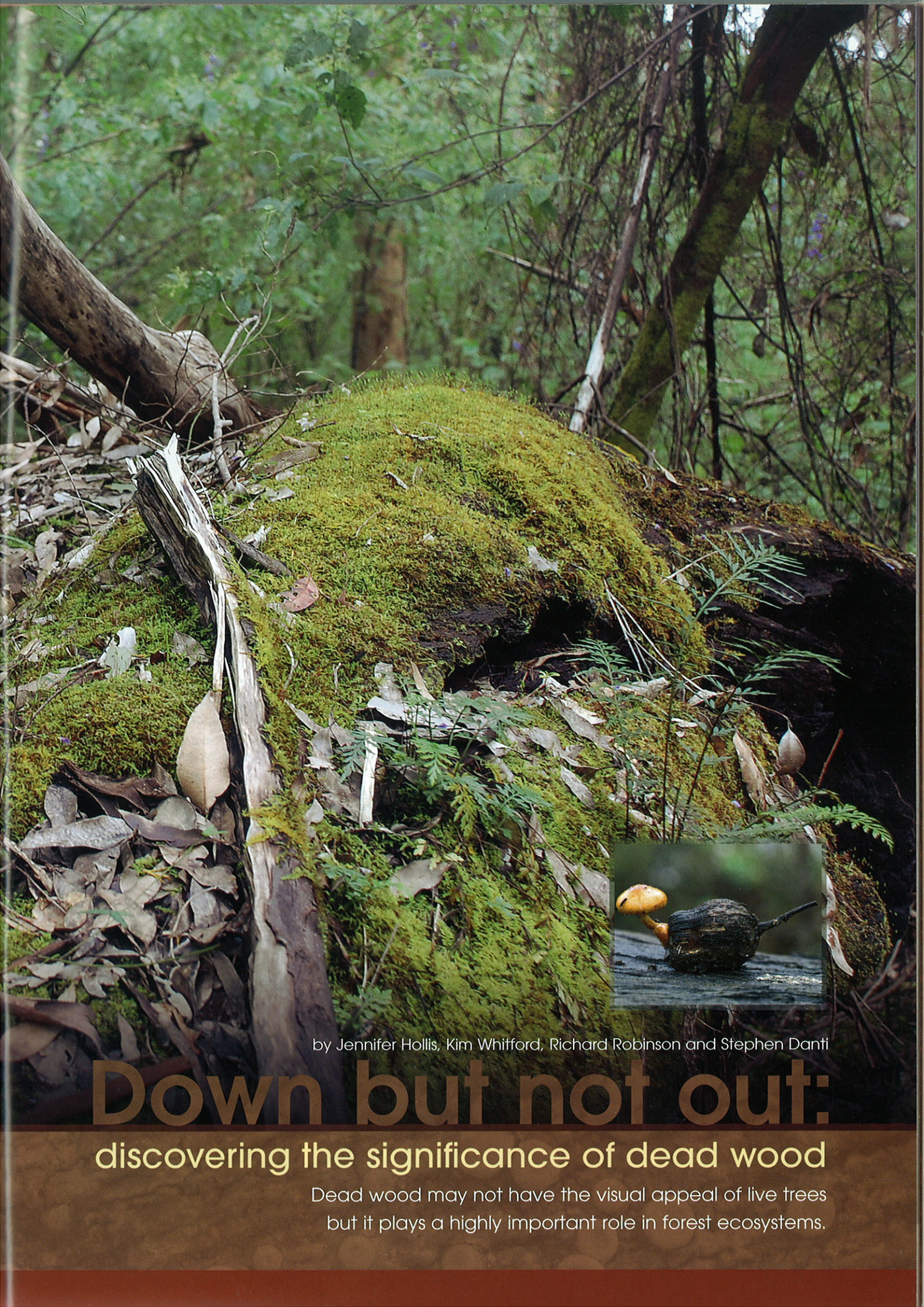

by Jennifer Hollis, Kim Whitford, Richard Robinson and Stephen Danti

Down but not out:

discovering the significance of dead wood

Dead wood may not have the visual appeal of live trees but it plays a highly important role in forest ecosystems.

There is perhaps nothing in the forest more majestic or enchanting than a huge, ancient and gnarly tree. These stately beauties create an atmosphere of awe and wonder, but when they die and fall over, little thought is given to what happens to the dead wood that falls to the forest floor. Dead wood was once thought of as forest waste, of no use but to be gathered up and burnt, but we now realise that dead wood is far from dead—it is teeming with life. The end of the life of a forest veteran marks the beginning of life for a myriad of other organisms—and the initiation of a recycling process that is important for the future health and vitality of forest ecosystems. The shell of these old giants that once provided valuable habitat and structural features within the forest canopy now continues the same roles and more on the forest floor.

Ecologists call these newly fallen and decaying logs and branch wood 'coarse woody debris', and it is an important component of forest ecosystems. It provides habitat on the forest floor, a source for nutrient and carbon cycling, fuel for forest fires, and a substrate for many organisms that depend on dead wood for their survival. The process of decay adds nutrients to soils and the lives of many organisms involved in the decay process, or that simply live within hollows of logs, are intertwined.

Recycling in action

Once on the ground, a fallen log begins to dry, bark is shed and the wood cracks allowing water to enter. Bacteria, invertebrates and wood decay fungi begin to colonise the fallen logs. Decay progresses as cycles of wetting and drying enlarge cracks which funnel water into the heart of the log, furthering the decay process. A moist environment is created encouraging complex interactions between the decay process and the succession of organisms. In this way, dead wood becomes habitat for a wide range of organisms including bacteria, fungi, protozoa, nematodes, lichens, invertebrates and other plants and animals which use or remove the remaining tissue. The process of decay is not swift and for large jarrah logs it may take as long as 100 years or more. Termites can influence this progression at any time as they invade after fungi colonise dead wood and begin to break down the woody tissue.

Disturbances such as fire and timber harvesting can substantially change the volume of coarse woody debris, its pattern of distribution and its decay state, all of which can impact significantly on communities of organisms that use dead wood as habitat.

Vital habitat

Coarse woody debris provides important habitat for many species. Logs and branches of various sizes scattered over the forest floor break up the terrain and moderate the extremes of weather by providing shelter from the sun, wind and rain, as well as valuable protection from radiant heat during fires.

In wet regions of the south-west, large moss-covered logs provide suitable habitat for ferns like the forked spleenwort (*Asplenium aethiopicum*) and seedlings of other plants establish themselves on dead wood or stumps in the final stages of decomposition. Ground-dwelling invertebrates, like cockroaches, beetles and worms, live and breed on, in, under and about the coarse woody debris. They form a major component of the food web and the diet of many forest mammals and birds.

Previous page
Main Forked spleenwort fern on moss-covered log.
Photo – Richard Robinson/DEC
Inset Fungi growing from a decaying gum nut.
Photo – Wanda Finkle/Sallyanne Cousans Photography

Below Napolean skink (*Egernia napoleonis*).
Photo – Jennifer Hollis

Below right Rosenberg's monitor (*Varanus rosenbergi*).
Photo – Duncan Sutherland

Above Juvenile numbats playing at the entrance to their home log.
Photo – Jiri Lochman

Right Onycophoran velvet worms are rare survivors of the ancient super-continent Pangea and rely on well-rotted logs for habitat.
Photo – Janet Farr

Animal life

Logs that sit above the surrounding vegetation provide a sunning platform for larger reptiles such as Rosenberg's monitors (*Varanus rosenbergi*), which emerge from their burrows in winter to bask and revitalise themselves during breaks from their hibernation. Napoleon skinks (*Egernia napoleonis*) hide deep in cracks and crevices that form as dead wood dries with age. Marbled geckos (*Christinus marmoratus*) shelter under the bark and in cracks and various small skinks bask and hunt on the surface of dead wood. Dugites (*Pseudonaja affinis*) sometimes nest in hollow logs and, for large goannas, the hollows provide a den for refuge.

Mammals such as the chuditch (*Dasyurus geoffroii*), numbat (*Myrmecobius fasciatus*), mardo (*Antechinus flavipes*), and western pygmy-possum (*Cercatetus concinnus*) also live and breed in the hollows of decaying logs. Hollows suited to larger mammal fauna are uncommon and occur only in the largest logs. The relative scarcity of these large hollows makes them particularly valuable biological resources.

Invertebrates also make good use of dead wood. There are more species of insects in the world than any other group of organisms. In fact, beetles alone account for 25 per cent of the global species count. Yet, many invertebrate species are still undescribed and very little is known about their life history patterns. What invertebrates lack in size they definitely make up in effort. They are vital in aiding the breakdown of organic matter which returns carbon and other nutrients to the soil. They also assist with the pollination of flowers and are themselves a food source for many birds and mammals. Coarse woody debris is particularly important for many invertebrate species, being used as habitat for many groups including slaters and millipedes, centipedes and spiders. For wood-boring beetles it is also an important food source and for parasitic wasps, a habitat for reproduction. In the southern jarrah forests, Onycophorans, or velvet worms, rely on large well-rotted logs for their survival. Onycophorans are little changed from their ancient ancestors. There are marine Onycophorans fossils more than 540 million years old.

Wood-inhabiting fungi

Like invertebrates, fungi are extremely diverse and numerous and the majority are undescribed. They are important forest organisms (see 'Forest fungi: lifestyles of the little known', *LANDSCOPE*, Spring 2002). Wood and litter-inhabiting fungi are the forest recyclers, decomposing logs and other dead wood that accumulates during the life of a forest. Decomposition of dead wood by fungi releases large amounts of nutrients back into the soil, which is important for maintaining soil fertility and forest health. A single log may support many species of fungi. Some rot the bark, others rot the

sapwood or specialise in rotting heart wood and there are different species of fungi associated with different stages of decay. A number of species, including *Podoscypha petaloides*, are only associated with large logs or wood in an advanced state of decay, so it is important to maintain and conserve old dead wood. Wood-rotting fungi are very diverse in shape and colour. They vary from the common mushroom shape, to being woody or tough brackets, having a jelly-like texture, leathery fan-like structures or simply thin flat or wrinkled sheets on the surface of the wood. Fungi invade and rot wood via thread-like filaments called mycelium and their spore-bearing fruit bodies are generally only seen in the autumn and winter. It is the thread-like filaments that actively release enzymes and other compounds that degrade wood and release compounds for their own nutrition, while also creating suitable environments for invertebrates.

Lichens and mosses

Dead wood also provides an important habitat for lichens and mosses. Lichens represent a symbiotic relationship between algae and fungi. They colonise the surface of logs and other woody debris. There are many species of lichens in the south-west forests. Lichens don't have roots—some attach to the wood by short root-like structures called rhizoids or holdfasts and others sit passively on the surface. They gain nutrition through photosynthesis by the algal partner as well as from their substrate either by releasing weak acids that gradually erode the surface or by absorbing nutrients that become dissolved in water that flows over the surface. Many species are susceptible to pollutants, which makes them important indicators of healthy ecosystems.

Top left Thread-like mycelium can be seen in well-rotted banksia wood if the bark is removed.

Centre left Fan-shaped *Trametes versicolor* are common on stumps and small logs in the early stages of decay.

Left The fairy castle lichen (*Cladonia cervicornis* var. *verticillata*) grows in well-decayed crevices of rotting logs.
Photos – Richard Robinson/DEC

Right A camera (shown in photo opposite) captures a time sequence of images of a decayed marri log consumed by a prescribed fire in the jarrah forest near Hester as part of collaborative research between DEC, Bushfire CRC and CSIRO Sustainable Ecosystems.
Photos – Jennifer Hollis

Lichens are well known 'primary colonisers' so most species are found on dead wood where the surface is still more or less intact. Species more commonly found on the ground may be present on the surface of decaying logs or on decomposed heaps of organic matter produced by large logs in the final stages of decay. The structure of lichens found on wood varies from being branched and plant-like to coral-like, flat and foliose or crust-like structures. Their fruit bodies are generally cup or disc-shaped or line-like structures on their upper surface.

Mosses cover old logs in wet or shaded situations. Like lichens, many mosses are pioneer colonisers on bare surfaces. They act like sponges to absorb nutrients and store water that would otherwise be lost through run-off. This stored moisture benefits other organisms in dry periods. A good cover of moss on large logs also reduces evaporation and maintains humidity within the wood, which is vital for the continuance of decomposition. Many invertebrates use mosses and lichens for shelter and protection and some likely use them as a food source. However, a thick covering of leaves and small twigs will retard the development of lichens and mosses because they need sufficient light to flourish.

Carbon cycling

On 3 December 2007, the Australian Government agreed to ratify the Kyoto Protocol, which came into effect in March 2008. Since then, Australian media has headlined talks of emission cuts, global warming and carbon taxes, offsets and trading. While everyday Australians grapple with reducing their own carbon footprint, the Australian Government is undertaking an ongoing accounting of all relevant ecosystem components that contribute to greenhouse gas sources and sinks in order to achieve its Kyoto obligations. But how does this relate to our forests and the coarse woody debris that lay within them? The coarse woody debris within our forests is a significant source of carbon which can remain in the ecosystem for many years before being released to the atmosphere—either slowly through decay or rapidly through combustion when burnt in a forest fire. Coarse woody debris is an important part of a continuous cycle where carbon stocks move between the living biomass, dead organic matter and the soil and are significantly affected by disturbances such as wildfires, storms and timber harvesting. This makes accounting for its contribution to the carbon stocks of a whole ecosystem a tricky process. For example, in the jarrah forest the coarse woody debris on the ground can contribute up to 32 per cent of the above-ground forest biomass and carbon stock and, when a wildfire sweeps through, coarse woody debris volume can be significantly reduced resulting in changes to carbon stocks and increased greenhouse emissions.

At a regional scale, forest fires have an impact on the dead woody material and the forests' carbon budget for many years. This will vary from forest to forest and due to differences in the fire behaviour and weather conditions

under which they are burnt. The relative emissions from each fire will vary as well, including variations in the amount and type of emissions such as carbon dioxide, carbon monoxide and methane. For example, a prescribed burn with its characteristic low intensity and mosaic of burned and unburned areas will consume less of the dead woody material on the forest floor and produce less in the way of greenhouse gas emissions compared to an intense wildfire.

On a local scale, variations exist between species for each piece of dead wood lying on the forest floor in terms of the length of the decay process and how moist they are. For example, jarrah logs tend to burn hot and relatively quickly compared to marri, which can burn and smoulder for weeks and even months after a fire. These local variations have a significant effect on the heat radiating from the fire ground as well as the fire behaviour characteristics that influence smoke and convection column development, the potential for re-ignition and the strategies that fire managers implement for fire suppression.

Top Ancient mossy stumps, Porongurup National Park.
Photo – Rob Olver

Right Small funnel-shaped *Podoscypha petaloides* fungus on a moss-covered log.
Photo – Richard Robinson/DEC

The projected impacts of climate change will affect Western Australian fire regimes and the biodiversity for which the southern forests are so well known. Climate models suggest that the south-west is expected to become increasingly warmer and drier which will consequently affect wildfire seasons and the period suitable for prescribed burning. For fire and land managers, such as the Department of Environment and Conservation (DEC), understanding the effects that altered fire regimes could have on the amount and quality of coarse woody debris and the resulting implications for carbon stocks and cycles within a forest ecosystem is becoming increasingly important.

Where to from here?

Monitoring of forest biodiversity through DEC's FORESTCHECK monitoring program has greatly increased knowledge of the rich array of forest species that use and depend on coarse woody debris (see 'Keeping our forests in check', *LANDSCOPE*, Autumn 2004). In addition, understanding how fire affects coarse woody debris and the carbon stored within it is growing, as scientists across the world focus their attention on the details of forest carbon cycling. This evolving knowledge has motivated DEC researchers and collaborators to focus their attention on the role of course woody debris in the south-west forest ecosystems.

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