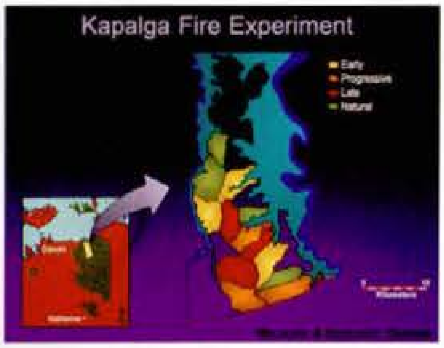
Fire and life at the Top

Photos courtesy CSIRO Division of Wildlife and Ecology, Darwin.



Fire is a burning issue in the Top End. Every dry season, between May and October, the countryside is ablaze, sparking public debate about the effects of fire on the environment.

Much of the information fuelling this debate is anecdotal, and based on the visual appearance of burnt country. Fire is a natural part of the Top End environment, but little reliable information exists on the long-term ecological effects of different types of fires in the region. The challenge is to understanding of it better, and to manage it wisely.

In view of this need, a five-year fire experiment was conducted by CSIRO between 1990 and 1994 at Kapalga Research Station in the Northern Territory's Kakadu National Park. The experiment involved students and researchers from Australian and overseas universities and government departments, and was supported by the Australian Nature Conservation Agency (the manager of Kakadu).

Four different types of fires were tested during the experiment which covered more than 200 square kilometres, requiring nearly 500 km of fire breaks. The fire types represented a range of fires normally occurring in the Top End, including fires lit early and late in the dry season, fires lit progressively through the dry season, and no fires at all. Through these fire treatments, scientists sought to address issues relating to the conservation management of Kakadu and other areas in the Top End. These included the effects of fire on animal populations, plant regeneration, soil erosion, nutrient cycling and the atmosphere.

Much of data gathered on these topics are still being analysed, but preliminary results of the study have been released. These pages summarise the major findings to date.

Why burn?

Burning in the Top End is carried out by traditional Aboriginal landowners and managers of conservation areas, by pastoralists to improve pasture for cattle production, and by government agencies to protect property and fire-sensitive vegetation such as monsoon rainforest.

What goes up in smoke?

GASES released during savanna fires in the Top End are estimated to comprise 2% of Australia's contribution to the greenhouse effect. Changed burning practices may reduce greenhouse-gas emissions, but this reduction would be small because of the high frequency of natural fires in northern Australia.

In a typical year, savanna fires in northern Australia release about 80 million tonnes of carbon as carbon dioxide (CO_2) to the atmosphere. These fires occur during the dry season, but plant growth each subsequent wet season takes up a roughly equivalent amount. Therefore, grass fires are not contributing to increased levels of CO_2 in the long term. In contrast, about 70 million tonnes of CO_2 are released from Australian vehicles and industry each year, and virtually all of this will remain in the atmosphere.

Fires release a range of other gases too. Some of these are important for the greenhouse effect, but the amounts released are small compared with other sources. Methane, carbon monoxide and nitrogen oxides can form photochemical smog late in the dry season, leading to hazy skies and reduced visibility.

The major visible component of smoke from savanna fires is water vapour. Even dry grass and twigs contain some water that is released as vapour, and more water is created during the burning of plant tissues. Clouds can sometimes be seen at the top of smoke plumes, formed from condensation of water vapour produced by the fires. Various gases containing carbon and nitrogen make up most of the other components of smoke which stings people's eyes because of the ammonia (NH3) produced during burning.

Solid particles, including fine ash and pieces of charred vegetation, are also carried up with the rising air above a fire. These particles are usually deposited within several kilometres of a fire. In southern Australia, fires can spread from burning pieces of eucalypt bark being carried by winds in front of the fire. This rarely occurs in the Top End because the tree species are different, and the fuel is mainly dead grass. Nevertheless, the deposition of ash can cause a nuisance in residential areas.

Where smoke is likely to be a problem near habitation, one approach would be to burn early in the dry season. Fires tend to be of lower intensity at this time and more manageable. As well, the fires tend to be more patchy, and leave some of the fuel unburnt, to rot in the subsequent 'wet'.

Most fires are lit early in the dry season, when the ground vegetation is still moist. Fires at this time of year tend to be low in intensity, patchy, and limited in extent. Such fires remove fuel from the country that is burnt, restricting the higher intensity fires which may occur later in the year.

Nutrients on the move

Plants in the Top End have a tough time finding enough nutrients to survive and grow. Australia's soils are among the most infertile in the world, and those in the Top End are no exception. High temperatures all year ensure rapid decomposition of soil organic matter, and high rainfall during the wet season leaches soil nutrients.

A typical fire in the Kakadu region transfers about 4000 to 6000 kilograms of material to the atmosphere for every hectare burnt. Of this, about 50 to 150 kg are particles, including fine ash and charred leaves. These particles can be carried in air currents more than 1000 metres above the ground, but settle to earth relatively quickly.

The rest of the material transferred to the atmosphere is water vapour and a range of gases. Nutrients removed as gases will be lost to savanna ecosystems, whereas particles are redistributed across the landscape. The main gaseous losses are composed of sulfur and nitrogen, both important components of protein molecules, which are the building blocks of life in plants and animals.

Nitrogen is lost to the atmosphere during savanna fires at a rate of 15 to 20 kg per hectare, with only 2 kg per hectare returning to the Earth's surface in wet season rainfall. The most commonly recognised source of nitrogen in soils is from special plants, such as acacias, that have bacteria capable of fixing atmospheric nitrogen in their roots. However, the maximum amount of nitrogen measured in the Top End (under an acacia plantation) was only 12 kg per hectare. Other potential sources of nitrogen replenishment include nitrogen-fixing perennial grasses and termites.

More information about the Kapalga Fire Experiment is available from the communication officer, CSIRO Division of Wildlife and Ecology Tropical Ecosystems Research Centre, (08) 8944 8400, fax (08) 8944 8444.

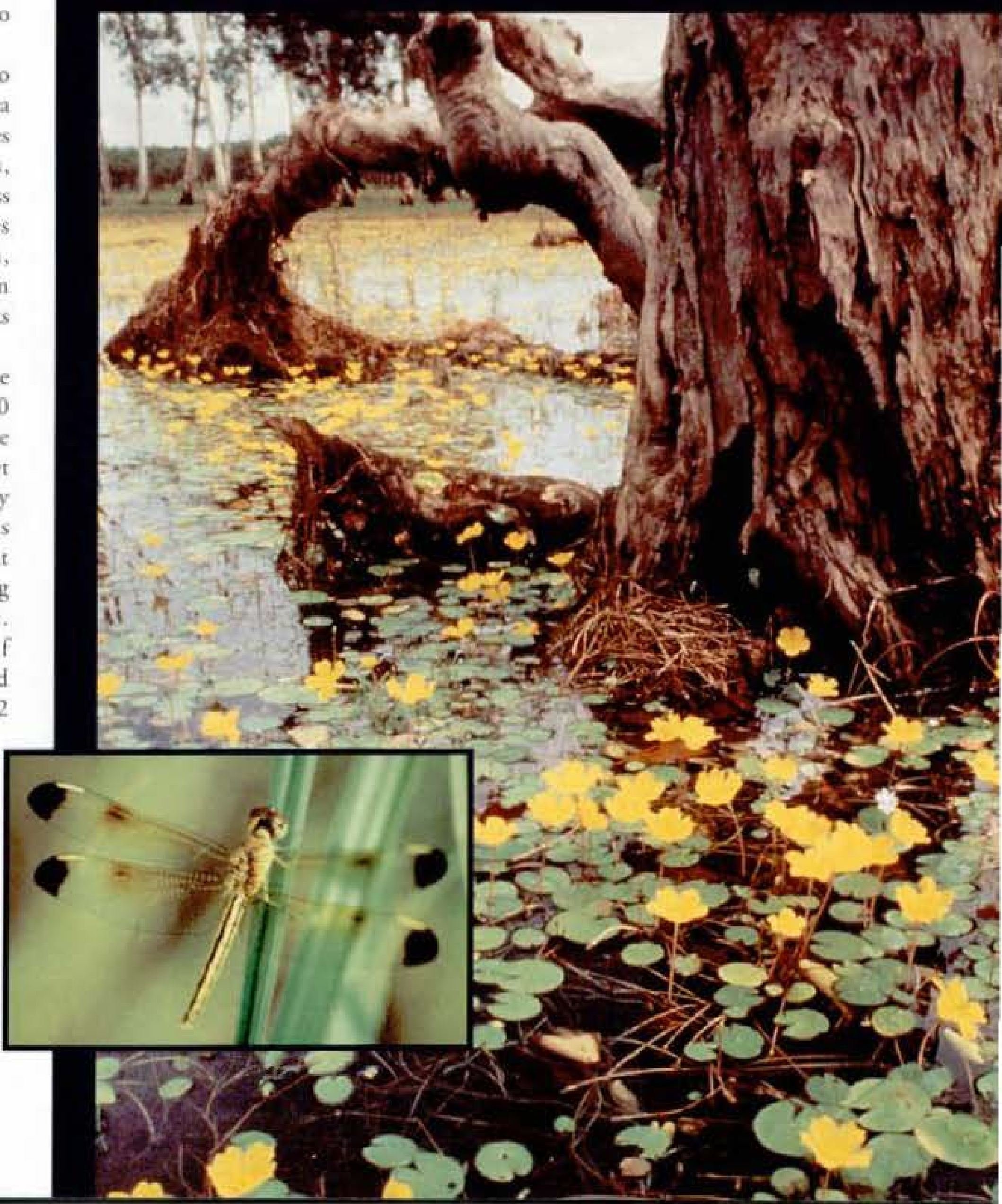
Benefits for stream dwellers

TOP END streams are temporary, flowing for a few months during the wet season, and remaining dry for much of the year. At the end of the wet season, pools from streams in burnt catchments contain more than 10 times the amount and six times as many aquatic plant species as those in unburnt catchments. The plants may respond to nutrients washed off the catchment during early wet season storms. They may also receive more sunlight once fire has damaged the riparian vegetation.

The vast numbers of aquatic invertebrates that live in streams – tiny animals such as bugs, beetles, worms and midges – also seem to benefit from burning. Although there is no difference total animal numbers, streams in burnt catchments have about 50% more species. Many aquatic invertebrates rely on aquatic plants for food and cover, so it could be that there are more types of invertebrates in burnt streams because they contain more aquatic plants.

For the plants that grow beside the streams, however, fire is a more damaging prospect. Most streamside or 'riparian' species are fire-sensitive, and burns late in the dry season seem either to kill the adult plants, or prevent them from reproducing. In contrast, streams in unburnt catchments develop a dense fringe of riparian vegetation with about three times as many trees, and a much greater species diversity than burnt streamside habitats.

Stream catchments that are burnt late in the dry season are vulnerable to erosion from wet season storms. This is due to significant reductions in the vegetation cover. Streams in these catchments carry more plant nutrients and sediment than streams draining catchments that are not burnt, or burnt early in the dry season.



Frill-neck lizards forage in recently-burnt areas.

David Curl

Above: Northern brushtail possums are vulnerable to high-intensity fire.

Below: Blue-winged kookaburras clean up after the burn.

Above: Green tree ants: common in unburnt habitats.

Below: Northern meat ants are favoured by frequent fire.

Opportunities for predators and scavengers

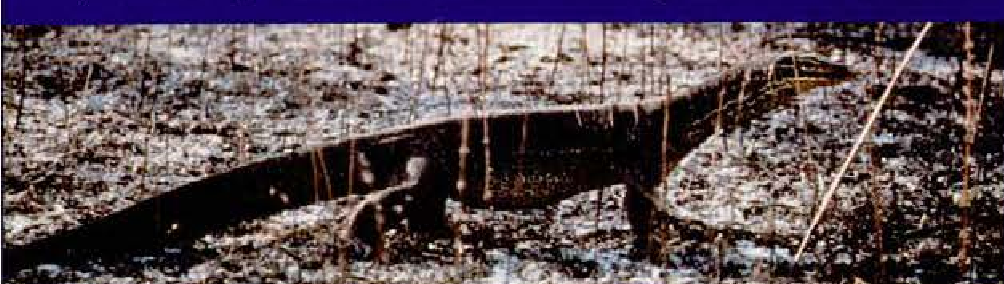
FIRE affects animal populations indirectly through changes in habitat, food supplies, and the risk of predation (due to loss of vegetation cover). Whatever the type of fire, some species will benefit, and others will be disadvantaged. The greatest number of different species, however, occurs in unburnt habitats.

Small mammals, such as bandicoots, are vulnerable to fire, and tree-dwelling species, such as possums and tree-rats, are particularly sensitive to high-intensity fires late in the dry season. Larger species, such as dingoes and wallabies, easily outrun the flames, and can move between patches of country with different burning histories.

Factors such as rainfall and food supplies can interact with fire so that similar fires can have different effects in different years. For example, numbers of northern brushtail possums (*Trichosurus vulpecula*) were highest at Kapalga in areas that were burnt early in one year, but highest in unburnt areas in another.

Many birds take direct advantage of fire. Flocks of black kites are a common sight at fire fronts, feeding on insects and other small animals flushed out by the flames. Immediately after fire, predatory and scavenging birds such as hawks, butcherbirds and blue-winged kookaburras picnic on dead and injured animals. Red-tailed black cockatoos feed on exposed seeds and nuts.

Less in known of the longer term effects of fire on birds. Partridge pigeons nest on the ground during the early dry season, and are sensitive to fires at this time of year. This also applies to masked finches and brown honeyeaters, which often nest close to ground. In contrast, quail species often prefer dry season fires because of the patchy nature of the burn. They forage in the burnt patches, with unburnt patches providing cover from predators. Species such as red-backed kingfisher appear to be favoured by high-intensity fires which provide open habitat for hunting.



Predatory and scavenging reptiles, such as snakes and goannas, also 'clean up' after fire. Frill-necked lizards (*Chlamydosaurus kingii*) forage in recently burnt areas, presumably because prey are conspicuous there. These lizards spend most of the dry season in the tops of trees, out of the way of low intensity fires. But on the approach of high-intensity fires, they make spectacular leaps to the ground, to shelter in old hollowed termite mounds.

Open habitats produced by frequent fires support the highest densities of ant specie s in the world. Many of these belong to the 'sun-loving' groups centred in the Australian arid zone. The northern meat ants (*Iromyrmex sanguines* and *I. reburrus*) are good examples. Ant diversity is far lower in unburnt habitats where green tree ants (*Oecophylla smaragdina*) are particularly common. The diversity and composition of other insect groups are also likely to be influenced by fire.

The cocky apple (*Planchonia careya*).

Plant and fire diversity interlinked

SPEAR GRASS, the tall, sorghum species that blankets the Top End's sun-drenched savannas, has a clever strategy for surviving the region's inevitable dry-season fires. It produces a special kind of seed that buries itself in the ground during the danger period, ready to sprout when nurturing rains begin. If fires come early in the wet season, however, the grass may be killed before producing seed. This knowledge can assist land managers in areas where early burns could reduce fuel load.

About 50% of the savanna vegetation is burnt during the Top End's dry season each year. Fire intensity is much lower than in southern Australia, so the short-term effects are less severe. Many tropical eucalypts have thick, non-combustible bark, which protects buds in the trunk and branches, and the leaves have only small amounts of volatile eucalyptus oil, compared with their southern cousins. Two to four weeks after a fire, perennial grasses and underground stems and roots have usually resprouted, and new leaves have appeared on trees.

As fire intensity increases, so does the number of trees killed. Smaller trees are more vulnerable to intense fires than larger ones. Late dry season fires are typically the most intense as there is more dry fuel and winds are often stronger than at other times of the year.

The timing of fire is important, regardless of intensity. For example, herbs which flower early in the dry season may be damaged by fires at this time of year. Fires late in the dry season are more likely to kill fleshy-fruited, deciduous plants, such as the billygoat plum (*Terminalia fernandianna*) and cocky apple (*Planchonia careya*).

Fire frequency also has a major impact on vegetation structure. Young trees may require several fire-free years in order to grow out of the 'fire zone' and enter the forest canopy. Frequent burning often produces a forest consisting of only two layers: canopy trees and a ground layer of suppressed woody sprouts. Forests that are infrequently burnt have many layers, with a dense mid-storey.

The longer-term effects of various fire regimes over a large area usually are more significant than the effects of any particular fire at any particular time. A range of patches of vegetation representing a variety of fire intensities, timing and frequencies is likely to be the best way of maintaining overall plant diversity. Burning of fire breaks can be used to protect especially sensitive vegetation types, such as monsoon rainforests. It is important that the impacts of fire management practices are monitored.

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