CHAPTER 3

# HOW THE LANDSCAPE WORKS

Most analyses of the conservation values of a region simply document the natural values – catalogues of species, of particular habitats, of beautiful landscapes. We have chosen to look deeper than this simple stock-taking, and seek instead to describe how it is that those assets exist, what keeps them functioning, and what they signify.

This chapter examines the fundamental ecological processes and connections that shape, drive and support the ecosystems and species that make up the environment of Northern Australia.

## ECOLOGICAL FUNCTIONING AND LINKAGES

The defining feature of Northern Australia is its pervasive naturalness. Modified lands – scattered towns and relatively small areas of intensive agricultural development – are the exception, influencing but not yet dominating the ecological functioning of the broader landscape.

But how does this landscape work? How do its elements connect? What sustains them? How much can be changed before the fundamental integrity of the system is lost? If the outstanding values of Northern Australia are to be sustained, these questions need to be answered, and those answers incorporated in land planning, use and management.

These questions are deceptively simple. Ecological science has been far better at understanding the workings of single species in simple fragmented systems than it has in deciphering the complex weave of multiple species operating at varying scales of time and space in large intact systems. Nature is bewilderingly complex, but it is that complexity that gives it its viability, resilience and beauty.

A recent analysis (Soulé *et al*. 2004) identified seven key ecological processes and connections operating at a continental scale in Australia: hydro-ecology; disturbances; long-distance biological movements; strong interspecies interactions; climate change and variability; land-sea connections; and evolutionary processes.

These highly inter-related processes structure the distinctive way the North works as a set of interconnected landscape elements. They connect and drive every aspect of nature.

1 *(Previous page)* Mangrove seedling, Temple Bay, Cape York Peninsula. *Photo by Kerry Trapnell*

2 Dry season deciduousness is a characteristic of many plants, including some eucalypts, as shown here. *Photo by Michelle Watson*

3 Flowering following the Wet season rains. *Photo by Atticus Fleming*

If these processes are altered or degraded, then individual pieces of nature change or disappear. These changes may be predictable and immediate, or they may be unpredictable, subtle and delayed. They may be constrained and localised, or the arcane interconnections may mean that repercussions are enacted remote from the source of change.

For example, a change in flows of spring water to a section of a northern river may immediately affect the feeding habitat of Pig-nosed Turtles at the site of the springs. A month later it may have an impact on the breeding success of barramundi and Magpie Geese tens of kilometres downstream. It may change the success of prawn fisheries off the estuary and influence the fruiting seasonality or success in the coming year of rainforest trees along the river, in turn affecting a colony of Black Fruit-bats currently feeding hundreds of kilometres away at another food source.

Three of the above processes are particularly significant in Northern Australia: *Hydro-ecology (water), Disturbance (fire),* and *Long-distance biological movements*. Highly inter-related, they dominate the distinctive way the North works as a set of interconnected landscapes.

## HYDRO-ECOLOGY: THE INTERDEPENDENCE OF WATER AND LANDSCAPE FUNCTION

Water is a pivotal feature in a landscape dominated by long seasonal droughts interspersed with episodes of torrential rain and flooding. Water availability varies dramatically in the landscape over the course of the year, rendering all northern landscapes highly dynamic. From November onwards, north-westerly winds bring monsoonal troughs and cyclones across Northern Australia. By April or May the winds shift and the monsoon rains retreat. For the next seven or eight months average potential evaporation greatly exceeds rainfall and there is a major water deficit. The duration of the Dry season and the location of water during this time become keys to the survival of most species.

Some general features of the hydro-ecology of the North are that:

- The Dry season is long. For many species, it is a time of increasing resource depletion – a time to endure; to shut down; to hunt the landscape for diminishing patches of shelter, food or sustenance; or to take refuge.
- The Wet season is a time of replenishment and revitalisation. The brown lands become green, and the creeks and waterholes fill.
- But the Wet also brings chaos. Destructive cyclones are common, and frequent floods inundate large areas. The lightning storms that herald the Wet season can be rainless and then ignite fierce fires. But amidst the plenty, there can be lack of food for some species such

as seed-eating birds; or lack of shelter, such as for floodplain-dwelling rats whose burrow systems may suddenly become inundated.

- The timing and location of the first rains are unreliable. The length of the Wet season, its total rainfall and patterning of rain days are highly variable. This poses great risks for species whose survival through the lean times of the Dry season may be on a knife-edge, or those associated with particular environmental conditions. For example, colonies of Magpie Geese nest only once the floodplains have been inundated to a depth of 30–90 cm, but their nests are then susceptible to further flooding if rains persist. (The variability in the onset, duration and rainfall pattern of the Wet season has also led to the collapse of a range of horticultural enterprises, misled by the simplicity of rainfall averages.)

But, of course, some species prefer the Dry season. Compared with the bleak winters of southern Australia, the balmy days of July in Northern Australia are attractive. Many bird species from southern Australia depend upon yearly northern migrations. And the unpredictability of the Wet season is relative: the North has a far more reliable climatic system than that in most other parts of Australia, where drought may be a frequent and unwanted visitor.

The severity of the Dry season is such that, for many months and over large areas, surface water resources are restricted to a few permanent or semi-permanent water holes and streams, which become key foci in the landscape. Mostly, the supply of water at these locations is not maintained by rainwater, but by water discharging from underground aquifers. These aquifers are in turn replenished during the Wet season.

Where the location of particular soils, aquifers or topographic characteristics permit, moisture availability may be maintained at a site for most or all of the year. These conditions favour water-dependent ecosystems such as monsoonal rainforest patches. Even subtle variation in these characteristics may change the relative advantage of different plant or animal species, providing a landscape characterised by a nuanced patchwork of different habitats. This variety leads to the maintenance of higher levels of biodiversity and more options for species trying to live in the landscape.

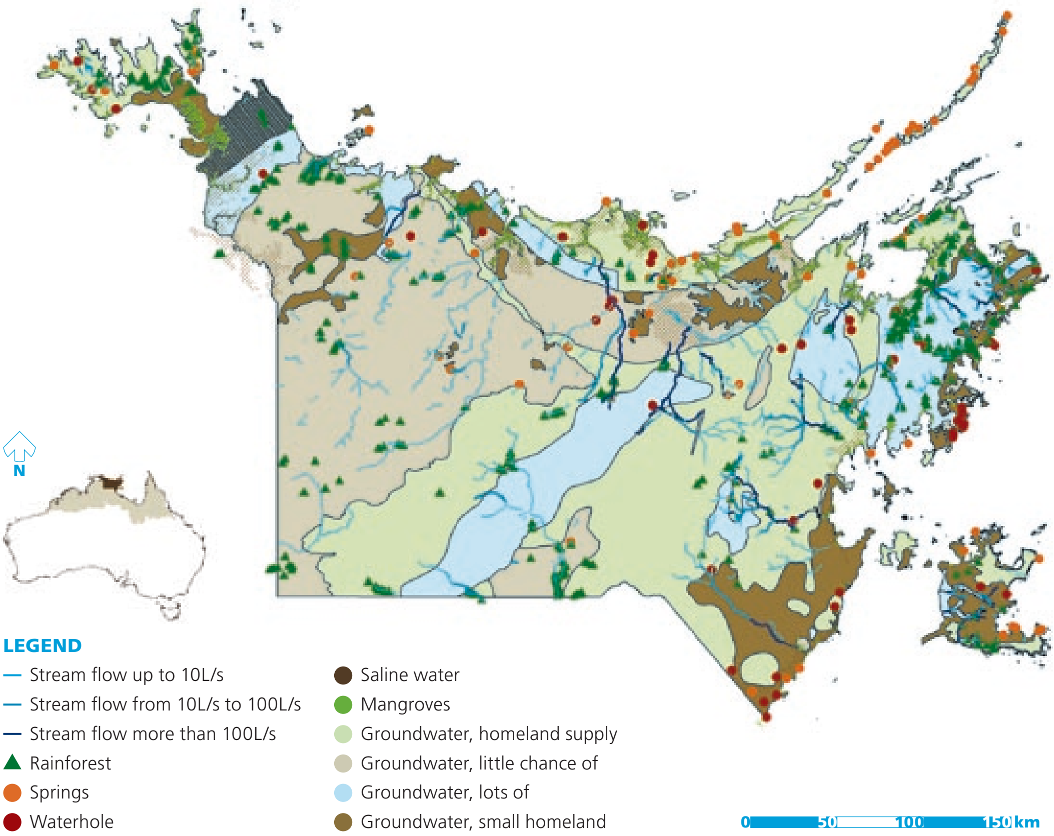
4 Many animals, such as the Red-tailed Black Cockatoo depend on isolated waterholes in the Dry season. *Photo by Lochman Transparencies*

In some regions of Northern Australia, the distribution and interactions of water resources are relatively well-known. Figure 3.1 presents such an example, where the location of springs, water-dependent ecosystems, flow rates of rivers and other hydrological information has been reasonably well-defined. This is a complex system, with broad-scale interconnections between components. Aquifers have a distributional pattern that don't mesh with above-ground landscape divisions; some rivers are far more seasonal than others; and water-dependent ecosystems are highly localised and patchily distributed.

1 Ord River, Kimberley. Most Northern rivers support strips of riparian forest along their banks. *Photo by Barry Traill*


## FIGURE 3.1 **THE DISTRIBUTION OF SURFACE & GROUNDWATER AT THE END OF THE DRY SEASON IN WEST & EAST ARNHEM LAND**

The map shows the minimum volume of water flowing in groundwater fed streams during the Dry season, the location of rainforest patches dependent on groundwater, along with springs and waterholes.




Source: Ursula Zaar, Natural Resources, Environment and the Arts (NRETA).

The characteristics of water availability are important not only for the spatial positioning of different environments and species across the landscape, but also for the timing of resources that those landscape elements produce. Water availability allows plants to grow, and seeds and fruits to be produced. It prompts and allows breeding or emergence of turtles, fish, frogs, crocodiles, aquatic invertebrates, and waterfowl. These responses may be delicately-poised and intricate: seeds of different grass species will germinate in response to different triggering thresholds of rainfall events; seeds of the same grass species will respond more rapidly to the same rain event if they happen to be positioned in even a slight depression; particular levels of river flow will trigger breeding activity in Pig-nosed Turtles but too much river flow may destroy their clutches. In the same year, spatial variation in rainfall characteristics may allow waterfowl breeding in one catchment but not a neighbouring one.

Water interacts with other key ecological processes. For example, relatively high moisture levels – and consequently relatively green vegetation – in the early Dry season means that fires then are generally relatively patchy, cool and small in scale. In contrast, tinder-dry vegetation in the late Dry season provides conditions for fires that are far less manageable, and characteristically hotter and more extensive. This relationship is two-way: extensively burnt landscapes are more likely to further dry out and lose soil moisture. And the fire history around riparian areas will affect stream temperatures, water quality, the chemical and physical properties of the water, and aquatic plants and animals.

To understand, and hence manage, the northern landscapes, the patterning of water availability also needs to be considered at broader spatial and time scales. For example, global climate change will shift environmental relationships across the north.  There has been a marked change in rainfall patterning over the last 30 years, with some regions in Northern Australia experiencing more rain and others less (Figure 3.2). If these changes are indeed the harbinger of climate change then we can expect significant ecological impacts. In response to this change, or perhaps to a combination of factors including increased atmospheric $CO_2$, or changed fire regimes, there have been substantial directional changes in vegetation patterning in Northern Australia. This includes in some areas expansion of rainforest and other denser vegetation, and 'vegetation thickening' (Crowley and Garnett 2000; Lewis 2002; Bowman *et al*. 2001a; Fensham and Fairfax 2003; Banfai and Bowman 2006). In parts of north-eastern Australia, where the

## GROUNDWATER & PLANT COMMUNITIES

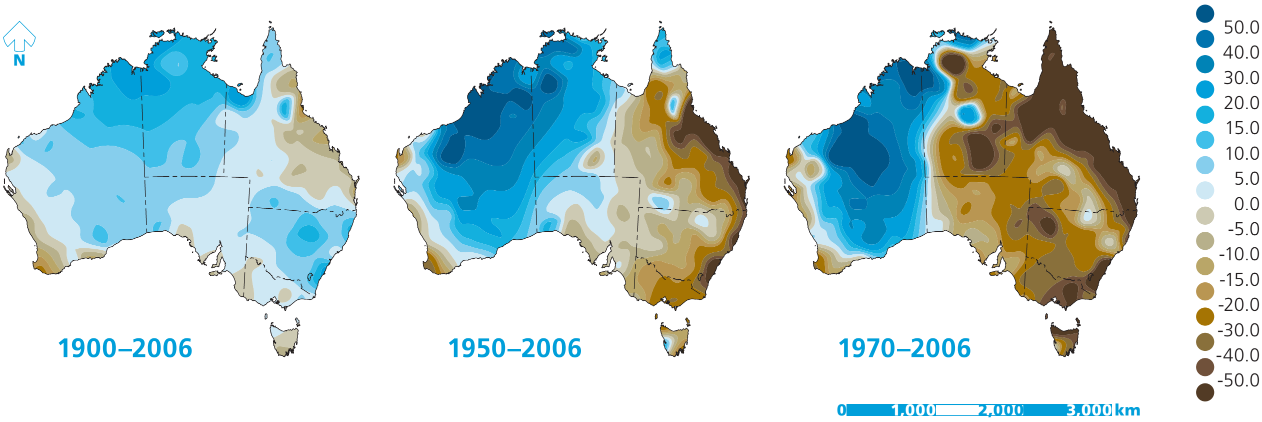
Within a given catchment, variation in local drainage conditions is the most important factor determining the kind and distribution of vegetation communities (CSIRO 1953). At the extremes of topographic position, parts of a landscape are seasonally inundated and support grasslands or grass-reed swamp communities; other locations such as ridges experience excessive run-off and support Deciduous Open Forest. The distribution of most vegetation types can be explained by local drainage conditions: for example, on Cape York Peninsula, *Scleandrium leptocarpus* swamp communities occur on sandy slopes and flats that have restricted drainage and remain wet by seepage; *Pandanus* scrubs often form nearly pure stands at margins of swampy grasslands or along drainage channels in heavy soil areas; and Deciduous Parklands of monsoon forest are associated with some of the larger river systems on alluvial flats (Neldner and Clarkson 1995; Mackey *et al.* 2001).

Of particular interest are the riparian forests that fringe most stream-lines. In tidal waters, riparian forest is dominated by mangroves. Further upstream monsoon rainforest develops, with tall tree species such as kapok, cotton and Leichhardt trees. Monsoon rainforest also occurs sporadically as small patches at the headwaters of spring-fed creeks, on levees or on rocky outcrops. Riparian vegetation ecosystems support unique assemblages of plants and animals, and provide a concentration of natural resources (e.g. water, nutrients) that are otherwise scarce in the broader landscape, at least seasonally (Woinarski *et al.* 2000b). These ecosystems attract not only unique wildlife but also human activity as they represent important recreational, cultural and aesthetic resources.

The depth of the water table in the Dry season may have particular significance for vegetation (Sebastien *et al.* 2005). Plants have evolved differing life history strategies to gain the water they need and persist during the Dry season. For example, Freshwater Mangrove *Barringtonia acutangula* and Silver-leaved Paperbark *Melaleuca argentea* use groundwater almost exclusively and grow along river-banks and lower terraces with shallow water tables, whereas Ghost Gum *Corymbia bella* occurs on levees and mostly uses soil water to survive the Dry season. Other species such as *Cathormium umbellatum* and Darwin Black Wattle *Acacia auriculiformis* draw upon either groundwater or soil water and can occur across the riparian zone.

*Brendan Mackey*

FIGURE 3.2 **TREND IN ANNUAL TOTAL RAINFALL** (mm/10yrs)




Source: Bureau of Meteorology; www.bom.gov.au.

monsoonal rains may be less reliable, tree cover may slowly pulse, increasing in the decades of good seasons and, through extensive tree death, reducing in periods of below-average rainfall (Fensham and Holman 1999).

## ECOLOGICAL DISTURBANCE

Ecological systems are dynamic. Their appearance, species composition, vegetation structure and character change over space and time. Much of this fluidity is a direct response to disturbance, a term used in ecology to describe a range of natural or artificial processes and forces acting on a system. The major disturbances operating in Northern Australia are flood, cyclones and fire. Herbivory, particularly by exotic grazing animals, may also meet some definitions of disturbance. However, we consider this issue elsewhere (in Chapters 4–6), and instead restrict consideration here mostly to the ecological role of fire in Northern Australia.

There is apparent unpredictability and inconstancy in ecological disturbance. We may see disturbances as unmanageable and destructive chaos, but they are also forces that can produce differences and diversity at the landscape scale. Of course, some landscape elements experience far more frequent disturbances than others. Riparian systems experience frequent massive flood events which favour plant species that can withstand these disturbances or recolonise rapidly. Conversely, environments in the rugged sandstone ranges have been largely protected from the more mutable and exposed world of the lowlands over tens of thousands of years. The timeless grandeur people experience when visiting these landscapes reflects the ecological reality that they have sheltered many species that would have little hope in a more frequently disturbed landscape position.

Fire is an inescapable element of the Northern Australian landscape. It is a force of destruction, yet can be the most useful of tools. Ultimately, the prevalence of fire is a consequence of the monsoonal climate. Lands baked dry by the long rainless season invite fire and, even in an unpeopled landscape, would have been regularly and frequently ignited by lightning strike.

For tens of thousands of years Aboriginal people have burnt this landscape. This burning was undertaken in a systematic manner which was deeply considered and embedded within cultural practices. Fires were generally small and patchy, and were lit for ceremony, for hunting, to allow easier travel, and to protect key resources. Poor fire management was deeply censured. Over time, the landscapes and their resources were sculpted by this traditional and consistent use of fire; and we inherited a pattern of species abundance and landscape patchwork that was a product of, and keyed into, this fire regime.

Over the last 100 or so years, that regime has been usurped or broken down. Generally, the current fire regime is far less considered or consistent. Large areas of Northern Australia have become pastoral lands. In smaller and more intensively managed pastoral properties, cattle grazing has greatly reduced grassy fuel loads. Most pastoralists have seen fire as an

## LONG-UNBURNT VS BURNT LANDSCAPES

Most of the eucalypt savannas in Northern Australia are burnt every year or two. People living in or visiting Northern Australia will mostly see, and hence typify, such savannas as structurally simple, little more than a tree layer dominated by one or two eucalypt species above a dense layer of tall grasses: there seems to be not much else to the system. But what would this country look like without fire?

There have been several small-scale experiments in Northern Australia that have successfully kept fire out of research plots for periods of more than a decade, and then compared the resulting vegetation features with those of adjacent frequently-burnt sites (Russell-Smith *et al.* 2003; Williams *et al.* 2003; Woinarski *et al.* 2004a). These studies have consistently shown a gradual development of a woody mid-storey layer (typically dominated by plants that produce fleshy fruits), a corresponding decrease in grass cover, and an increase in leaf litter and woody debris. With reduction in fire frequency, some plant species decrease and others prosper. Plants with rainforest affinity may begin to colonise unburnt sites, especially if the sites are near appropriate recruitment areas.

Because these differences in vegetation between frequently and infrequently burnt sites relate to features affecting habitat suitability for many animal species, there are comparable differences in the abundance of many animals between frequently and infrequently burnt sites. Animals that prefer grass and grass seeds are generally more common in frequently burnt sites, whereas those that prefer leaf litter, shade, logs and fruits become more common when sites are unburnt for longer periods. For example, at the site pictured below, the mean abundance of Northern Brown Bandicoot was 1.8 (animals per 100 trapnights) in frequently burnt locations but only 0.3 in long-unburnt locations; whereas that of the Common Brush-tailed Possum was 2.6 in long-unburnt locations but only 0.4 in frequently-burnt location (Woinarski *et al.* 2004a).

The conservation challenge in Northern Australia is to achieve some balance in fire regimes, such that enough of the landscape is frequently burnt (to provide benefit to species such as the bandicoot) and enough of the landscape is infrequently burnt (to provide benefit to species such as the possum). At present, that balance does not exist: in the eucalypt savanna there are few areas that escape fire for more than five years. The possums and their team-mates are losing out.

*John Woinarski*

Same study site and landscape: the photo on the right is of a frequently-burnt eucalypt savanna, whereas that on the left is of the same eucalypt savanna unburnt for 26 years. *Photos by John Woinarski*

unwelcome thief of fodder, and consequently fires are typically far less frequent. In contrast, more extensively and particularly on Aboriginal lands, fires are still frequent, but generally their patterning and impact has changed substantially; largely as a result of the landscape being depopulated (Bowman *et al.* 2001b). Consequently, few areas are now managed for fire with the same intricate care and intimate knowledge as previously (Yibarbuk *et al.* 2001). Most fires now burn far larger areas, are hotter and less controllable.

The current patterning of fire in Northern Australia is most readily apparent from satellite imagery (Figure 3.3). In an Australian context, fire is far more pervasive in the North than elsewhere. Over large areas of Northern Australia,

fire is an almost annual occurrence, and only a very small proportion of this landscape has escaped more than 3–5 years without fire.

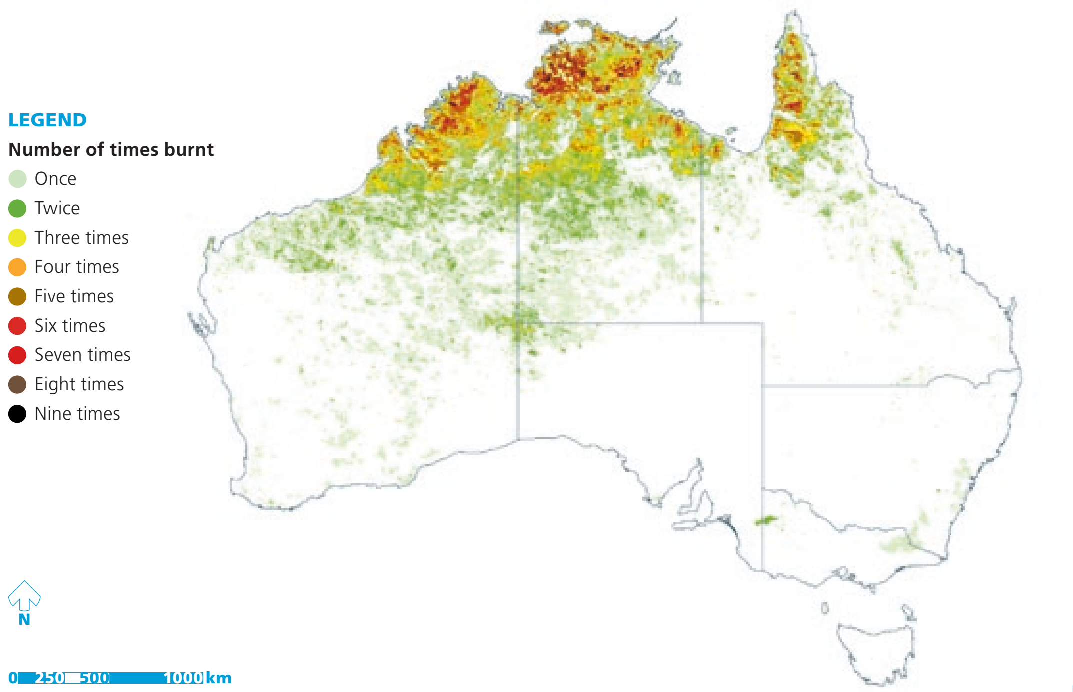
Typically, fires in Northern Australia are of relatively low intensity consuming the grassy understorey but leaving the tree canopy foliage largely unscathed. However, a feature of fires in Northern Australia is that they can also damage or destroy the largest trees, because these typically are hollowed by termite and fungus at ground level. Where fire can enter the base of these trees, the hollowing acts as a chimney and the fire is taken throughout the trunk, often leading to tree fall and loss of nest hollows and shelter.

The intensity and patchiness of fires varies with season and landscape type. In the early months of the Dry season, the grass moisture content is relatively high, fires typically go out at night, and fires burn unevenly, leaving some patches unburnt within their extent. In contrast, the hotter temperatures and far drier fuels of the later Dry season support far more high-intensity and extensive fires; and fires at this time typically are far less patchy, and may be so intense that they damage the canopy. In many places, lands are burnt in the early Dry season as a deliberate attempt to avoid the perceived risk of more destructive late Dry season fires. Given the limited resources available across the Northern Australian landscapes, such preventative burning is one of the few tools available to land managers.

Much of the flora of Northern Australia tolerates frequent fire. Many of the eucalypts reproduce vegetatively, for dependence upon fire-vulnerable seedlings is too risky a strategy. Many of the understorey plants can withstand frequent

1 A typical savanna fire, Cape York Peninsula. *Photo by Kerry Trapnell.*

FIGURE 3.3 **FIRE FREQUENCY (1997–2002)**




Derived from NOAA-AVHRR satellite image by WA DLI.

defoliation by fire. Other plants have seeds that can withstand the characteristically low intensity fires. However, there is a component of the flora that is adapted to fire regimes characterised by extremely long intervals between very low intensity fires. Such plants are commonly referred to as 'fire sensitive' and include a group of shrub and tree species that reproduce only by seed, and that may take five or more years to reach maturity. Where fires occur more frequently than this maturation cycle, these plant species will inevitably decline and be lost. The Northern Cypress-pine is one such species (Bowman and Panton 1993; Price and Bowman 1994). Many other fire sensitive species occur in sandstone heathlands of Arnhem Land – the plant community that supports the highest diversity of Northern Australia's most restricted endemic plant species (Russell-Smith *et al*. 1998, 2000). Many other fire-sensitive plants are restricted to patches of rainforests, and these may be degraded and lost where exposed to frequent fire. Fire sensitive species are largely restricted to sites that offer some protection from frequent and intense fires, either because they are permanently wet (such as springs) or topographically guarded (such as in gorges and escarpments).

Fire regimes affect the ecology of animal species in many ways. Although fires in Northern Australia are typically of relatively low intensity and slow-moving, there may be some direct casualties in any fire. Animals most at risk include ground or grass-nesting birds (such as emus, quails, Partridge Pigeons, Masked Finches, wrens), slow-moving reptiles (such as Blue-tongued Lizards), and species that shelter in fallen hollow logs (such as some snakes and small mammals), leaf litter (such as spiders and geckoes) and/or dense grass (such as bandicoots). Many vertebrates (including tree frogs, goannas, owls, kookaburras, parrots, possums and tree-rats) nest or shelter in tree hollows.

Other animals may survive fire but suffer increased risks of predation in the more open burnt areas. Where fires occur repeatedly over many years, such species will decline. Conversely, single fires may also benefit some species. Many raptors (hawks and eagles) are attracted to burning areas to feast on fleeing prey or the casualties of fires. In unburnt areas, the grass layer may be so dense that many animals may have difficulty moving through it. Fires remove such obstacles, and allow readier access to resources (such as fallen seed) that have survived the fire. The occurrence and timing of fires may

1 Saltwater crocodile, Shelburne Bay, Cape York Peninsula. *Photo by Kerry Trapnell*

affect the productivity and timing of flowers and seeds of many plant species, and hence their availability for consumer animals. While single fires may have any of these impacts, fire regimes may have even more substantial impacts.

Taller shrubby understories develop in areas in which fire is excluded or infrequent. Many of these shrubs comprise species that produce fleshy fruits ('bush tucker'), which provide key resources for animals such as possums and the squirrel-like tree rats. In contrast, frequently burnt areas develop a more simple understorey structure, characterised by the dominance of annual grasses.

Each of these variants may favour particular suites of animal species. However, the current fire regime is such that these variants are far from balanced: there are remarkably few areas in which shrubby understories, and their associated fauna, are sustained.

Some animal species have complex requirements of fire. For example, Partridge Pigeons are most favoured when their territories include some areas that are burnt (where they can forage most efficiently) and some that are unburnt (where they prefer to nest in or under dense grass, and find some refuge from predation) (Fraser 2001). Within any year, the timing of fire will affect the timing of subsequent seed set in grasses. A seed-eating bird (or rodent) will be more advantaged when its home range includes some areas that are unburnt and other areas that are burnt at different times, for this situation will allow a far more extended period of seed availability than if its entire home range was either unburnt or burnt. Likewise, home ranges that include patches with different burning histories over a longer period (say 5–10 years) will also offer a broader menu of food and shelter resources than those exposed to a more homogenous fire regime (Woinarski *et al*. 2005). In most cases, animal species will benefit from fire patterns that are of similar scale to their home range. Current fire regimes are generally occurring at a far coarser scale.

## INTERCONNECTIONS OF ECOLOGICAL MOVEMENTS

The northern landscape is crisscrossed with threads that connect any place with many other places. Water flows through landscapes; nutrients runoff and accumulate; plant seeds are blown or float from place to place; and fleshy fruits are moved by birds and bats.

Some movements, such as most of those listed above, are largely passive. Others are far more directional, forced or selected. For any animal species, the landscape offers a highly uneven and constantly shifting availability of resources. There are several ways of dealing with such inconstancy. Some species may shut down during the lean times. Some freshwater turtles spend much of the Dry season torpid, encased in

and under the hard mud of dried up waterholes (Grigg *et al*. 1986; Kennett and Christian 1993).

Many frogs similarly aestivate under the ground for the Dry season. Many reptiles, including Frill-necked Lizards, remain inactive over much of the Dry season. Many plants shed their foliage and slow their growth rates over the course of the Dry season. Another strategy is to store food during the good times, and eat into that store during the bad, as squirrels store acorns. There are not many such cases in Northern Australia. Some ants harvest and store seeds during the late Wet and early Dry season (Andersen *et al*. 2000). Other species grow fat during the good seasons and this stored fat may tide them through periods of shortage. Rock-rats and dasyurids (small marsupial carnivores) may be the most conspicuous examples of this approach, developing greatly swollen tails at times of high food availability. Yet another approach to food shortage is to change diet to encompass whatever is locally available at any time. The most conspicuous example of this in Northern Australia is the marked increase in nectar-feeding employed by many otherwise typically insect-eating birds during the Dry season, with a special focus on the prolific and conspicuous flowering of the common dominant tree, Darwin Woollybutt, *Eucalyptus miniata* (Franklin 1999).

But by far the most common approach adopted by animals to the ebb and flow of resources is to move around the landscape, searching for habitats or patches where food is more available. This is by no means a strategy restricted to wildlife. Aboriginal people had a long history of undertaking seasonal movements across their clan estates, with these movements associated with shifts to areas where food was relatively more available and abundant (Russell-Smith *et al*. 1997). Pastoralists employ a similar strategy, with foraging cattle moving within and among paddocks to track food availability; and with some pastoralists shifting cattle between properties to overcome local shortage.

In the box on this page and the following page we describe some of the movement patterns that animals in Northern Australia use in order to cope with variation in food and other resources imposed by the strongly seasonal climate. These movement patterns range in scale from hundreds of metres to thousands of kilometres; in numbers from small family groups to hundreds of thousands of individuals; and in regularity from the clockwork to the chaotic. Some are entirely directional and predictable; others are more flexible (or desperate) attempts to respond to a capricious and unreliable patterning of resource availability.

As an example of biological movements, consider the geographic area across all of the North. Connect the threads of animal and plant movements here, and the pattern is remarkably

## WATER PYTHON & DUSKY RAT

The lower reaches of most of the large rivers of Northern Australia lie within extensive fertile plains. In the Dry season, these rivers are slow-moving, restrained within sinuous channels; and their surrounding blacksoil plains are cracked and baked dry. But during the torrential rains of the Wet season, the rivers break out of their channels and flood across vast areas of these low-lying flats. These floodplains are a simple but highly productive environment.

Two of the most characteristic species of these floodplain environments are the Dusky Rat *Rattus colletti* and Water Python *Liasis fuscus*. The Dusky Rat is a medium-large (to 220 g) terrestrial rodent, restricted to the Top End of the Northern Territory. The Water Python is a large (to 2.5 m) partly-aquatic snake. The two species are tightly linked in a simple food web.

There are two main features of interest in this system. The first is its dynamic. The rats don't, indeed can't, remain on the floodplains during inundation: they would drown. So, every year, they migrate (over a scale of hundreds of metres to several kilometres) from the floodplains up the shallow topographic gradient to 'upland' woodlands and forests. This is a relatively regular, predictable dispersal, without close parallel among any other Australian mammal. Keen on a diet of rats, the pythons make a comparable but more diffuse migration, for they can expand their Wet season diet to include more wetland resources, such as the eggs of waterfowl (Madsen and Shine 1996).

The other main feature of this system is its productivity. The density and biomass of rats in this system is extraordinary – rat numbers can exceed 600 individuals per hectare, and biomass approach five tonnes per square kilometre (Madsen *et al*. 2006). The density and biomass of pythons is similarly enormous.

This unique system depends upon the juxtaposition of floodplains and upland woodlands. The rats and pythons need access to both in order to survive. Such species may pose more substantial conservation challenges than species reliant upon only one habitat, for modification of either habitat may compromise their ecology.

*John Woinarski*

## MAGPIE GEESE

The Magpie Goose *Anseranas semipalmata* is another feature species of the floodplains of Northern Australia, an icon more appreciated because it is far more conspicuous than the rats and pythons. It too may reach exceptional densities and biomass, especially during the late Dry season when the geese are concentrated on the relatively few and diminishing wetlands available.

The Magpie Goose is an important wildlife species in Northern Australia. It remains one of the major components of bush tucker in Aboriginal societies, and is the principal focus for recreational shooters. It is a taxonomic oddity, placed in a Family of its own, without close relatives. It is now mostly restricted to Northern Australia and southern New Guinea, though was formerly at least locally abundant in parts of south-eastern Australia. (The pattern of decline from southern Australia but maintenance of status in Northern Australia is noteworthy, and shared with many other species, such as Bush Stone-curlew, Red-tailed Black-cockatoo, and Australian Bustard.)

There are several features of the ecology of Magpie Geese that illustrate the significance of landscape linkages. Magpie Geese nest amongst emergent or floating vegetation of inundated floodplains. Their nesting requirements are fairly specialised: they need sufficient but not too much floodwater. A feature of the Wet season rains is that they show substantial spatial variability. Hence, in some years, the floodplains of the Daly River may be (most) suitable for Magpie Geese; whereas in other years the floodplains of the Mary River may be better. In some years, most floodplains may be entirely unsuitable. Magpie Geese respond to this broad-scale spatial variability by changing the spread of breeding colonies (and colony sizes) between floodplains between years. The maintenance of the Top End population of Magpie Geese is dependent upon the maintenance of options: the more floodplains there are to choose from, the more likely it is that, in any year, at least some floodplains will be suitable (Whitehead *et al.* 1992).

But Magpie Geese also depend upon finer-scale spatial linkage. The best place for Magpie Geese to position their nests is attached to robust emergent grasses and sedges, occurring in deep waters. But such sites may be drowned if the water levels rise too much; and they don't provide much suitable food for newly-hatched young, which must grow rapidly to escape the drying swamps before they become vulnerable to terrestrial predators. The best food sites for the young goslings are dense patches of seeding wild rice, and these typically grow in shallow waters often fringing the river channels. Soon after hatching, the gosling brood must undertake a forced march (of up to 15 km per day) from nest to feeding ground. The juxtaposition and linkage of these different habitats within a single floodplain is critical for the breeding success for this species (Whitehead 1999; Whitehead and Dawson 2000).

Magpie Geese, Cape York Peninsula. *Photo by Kerry Trapnell*

Life for Magpie Geese is one long convoluted series of linkages. During the Dry season, the geese are dependent upon the bulbs ('corms') of a water chestnut *Eleocharis dulcis*. These subterranean corms are accessible to geese only when the water depth is about 30 cm or less, and cannot be accessed when the ground has dried hard. Over the course of the Dry season, swamps dry up rapidly. At any one swamp, this pivotal food resource is available only for a limited time: each swamp offers only a relatively narrow period for optimal feeding, and if all swamps developed and dried in synchrony, then the birds would be offered a brief glut, followed by a prolonged famine. To survive the Dry season, these birds need to move between a network of swamps across a broad landscape. The intricate natural balance on which this species depends is increasingly destabilised by the spread of exotic pasture grasses to its wetland habitat, with these capable of displacing the native plants that provide key food resources at critical times in its life history (Whitehead and Dawson 2000).

*John Woinarski*

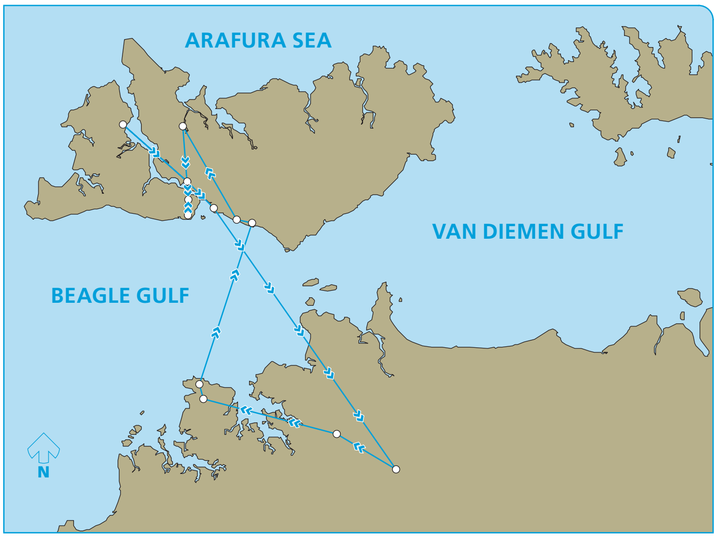
complex: this piece of land (or any other) has biological connections to many other local regions, to distant regions of the continent, and to other continents. For part of every year the shorelines and waterbodies in this area will be home to shorebirds (waders) that spend the rest of the year in northern Asia. For part of the year, the rainforests and savannas here will be home to cuckoos and koels, dollarbirds, swifts and bee-eaters, which spend the rest of the year in New Guinea, Indonesia or Malaysia. For part of the year, the savannas will be home to birds such as Black Kites and Grey Fantails that spend the rest of the year in central or temperate Australia. For part of the year, whales will live in these waters and then disperse to colder seas; barramundi, sawfish and crocodiles will move between the fresh waters and the seas. Flying-foxes and rainforest pigeons will move among the network of isolated rainforest patches, depending on which patch happens to provide the most fruit at any time (Figure 3.4). Driven by the locations of rainfall and waters, Magpie Geese will move throughout this landscape, with different critical sites at different times of year. Black Cockatoos, kites and other birds will move across this entire landscape in different patterns every year, as they track burnt areas. Other species, such as quails, may try to track unburnt areas. At the onset of the rains, termites and flying ants will disperse to found new colonies; butterflies will disperse from Dry season refuges to expand their distributions in the Wet season. The movements are regular, chaotic, predictable, indecipherable, solitary, in massed aggregations, local, regional, international.

All movement patterns are significant. In some cases, the dispersal of animals provides for the dispersal of the plants on which they feed (such as by fruit-eating flying-foxes and pigeons). All demonstrate that the ecological fabric of

1 White Lipped Tree Frog.
*Photo by Kerry Trapnell*

## FIGURE 3.4 **AN EXAMPLE OF LONG DISTANCE MOVEMENTS BY WILDLIFE**

The roosting locations of a single Black Flying-fox over a three-month period near Darwin. Black Flying-foxes pollinate flowers and disperse seeds of many savanna and rainforest trees.




**LEGEND**

Black Flying-fox tracking

0 25 50 100 km

Source: Carol Palmer, NT Natural Resources, Environment and the Arts (NRETA).

Northern Australia is woven from myriad interconnections. Removal or degradation of any site will have repercussions elsewhere in the landscape; the viability of any place is dependent upon the fate of many other places. Most conservation reserves will not alone protect these mobile species, for the scale of their movements is often larger than that of single reserves, and the set of reserves will rarely be positioned to match their regional movement patterns.

## OTHER CRITICAL ECOLOGICAL PROCESSES AND LINKAGES

In the section above, we provided examples of the workings and importance of three main ecological processes in Northern Australia. There are at least four other processes that are important, but are not considered here in such detail.

### Strongly interactive species

Some individual species have a disproportionately major impact on the community of species in which they live, with this influence working across a range of scales. Such species include: (i) major predators (such as dingoes and green tree ants) which may control the relative abundance of prey species (and hence the structure of plant communities) on which they depend; (ii) animal species (such as flying-foxes, pigeons and fruit-doves) critical for the dispersal of the fruits or seeds of plants; (iii) species that change the dynamics or structure of habitats (such as some termites, which are vital for the formation of the tree hollows used by many other animals); and (iv) 'keystone' species that provide resources for many species, particularly at times when few other resources are available (such as some figs, and cockatoo grass). Decline or loss of such species is likely to have impacts that percolate widely across the landscape.

### Climate change and variability

The world is an inconstant place, and this inconstancy may drive evolutionary divergence, and the prosperity or extinction of different species. The climate of Northern Australia, along with other aspects of its geography has changed over time; for example, with the inundation of the former land bridge connecting New Guinea, Cape York Peninsula and Arnhem Land, some 6000–8000 years ago (Mackey *et al*. 2001). Accelerating rates of climate change are likely to ratchet up the ecological and evolutionary pressures on species in Northern Australia (as elsewhere), compromising the viability of some. Temperatures and sea levels will rise, rainfall patterning will change, and there may be an increase in extreme weather events (notably severe cyclones) and in fire severity. Most at risk are those species currently coupled to a narrow climate preference or a fixed juxtaposition of habitats. The conservation challenge is to identify such species, and maintain as many landscape options as possible for them. In general, the more the landscape is fragmented and developed, the fewer the options for such species.

### Land-sea connections

Northern Australia has a long coastline and marine influences reach far upstream in the large tidal rivers. In these blurred boundaries, mangrove forests are extensive, diverse and productive. They have significant linkages with marine and terrestrial systems, perhaps most notably as key breeding areas for many important fish species. Mangrove habitats also provide the primary habitat for a range of – typically highly specialised – plants,

1 Dingoes may control populations of large kangaroos and feral cats in the North. *Photo by Lochman Transparencies*

invertebrates, reptiles (mangrove snakes and mangrove monitors) and birds.

Shorebirds, seabirds, many fish, crocodiles, mangrove snakes, marine turtles and many other species depend upon the coastal frontier and/or need to move between land and sea.

Much marine productivity and functioning depends on inputs from the land, and the health of those terrestrial systems may determine the health of adjacent and more distant marine systems. For example, the productivity of the northern prawn fishery is closely related to rainfall patterning and the consequential amount of nutrients transported in rivers.

Northern Australia has thousands of islands, including (after Tasmania) Australia's second (Melville Island), third (Groote Eylandt) and fifth (Bathurst Island) largest islands. Isolation has sheltered these islands from many destructive processes that have detrimentally affected mainland species and environments. Many now contain plant or animal species no longer found on the mainland (Southgate *et al*. 1996; Woinarski *et al*. 2000a, 2003). Many provide glimpses of what the Northern Australian mainland may have looked like before the influence of European colonisation.

### Maintaining evolutionary processes

Connections and refuges across landscapes allow for long-term changes in the range of species, the genetic flow within species across this range, and the evolution of new species. For example, during the colder drier times of the repeated Ice Ages, refuge areas of tropical rainforest survived on Cape York Peninsula. The rainforest expanded out of these areas during warmer, wetter times, and may contract again in the future. Destruction or fragmentation of refuge areas could prevent such processes happening in the future.

## CONCLUSION

In this chapter we have considered the major natural processes that make the landscapes of Northern Australia work. These processes, especially disturbance (and especially fire), hydro-ecology and long-distance movement of species through the landscape ensure that ecosystems are sustained.

Building upon this knowledge, in Chapter 4 we examine the natural values that flow from and are dependent upon the ongoing healthy functioning of the North's landscapes.

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