2. Savanna landscapes

by Dick Williams and Garry Cook

What are savannas?

Savannas are grassy landscapes—woodlands with a grassy ground layer, or grasslands—that occur in tropical areas where the climate is seasonally dry.

Savannas are important nationally and internationally. They cover about 20% of the world's land surface and about 20% of the Australian continent. The many different types of savanna we see in Australia reflect broad differences in rainfall and soil patterns, but the basic climate of the savannas makes them all prone to fire and frequent fire in particular. Hence, to understand and manage savannas we need to understand not only how climate and soil influence them, but how fire has shaped, and will continue to shape, the savanna landscapes.

In Australian savannas, the trees are mostly eucalypts, but several species of tall shrub may occur in association with the eucalypts. The grasses and other herbs may be annual or perennial, and the grass layer is usually dense. Tree and shrub 'canopy cover' (the proportion of ground covered or shaded by the tree's canopy) may vary between <1% and 60–70%, and tree density may be up to 100 per hectare. But even in the denser woodlands, the canopies of eucalypts do not generally overlap, and light intensities beneath the canopies are relatively high. Thus, competition between trees, shrubs and grasses is generally for water and nutrients rather than sunlight.

Kathryn Thorburn

Fire has played an important role in the evolution of savanna landscapes.

The landscapes

Evolution

Australian savannas have been evolving for many millions of years. During the early Tertiary period (about 60 million years ago), the continent was much warmer and wetter than at present and rainforests were much more extensive. Since then, the continent has become drier, the rainforests have contracted, and savannas have expanded. The extensive savannas and warm, wet–dry climate, key features of northern Australia, have existed for at least the last 10 million years. The broad geological features of northern Australia are also many millions of years old.

Because of a long history of evolution, savannas are highly complex and diverse ecosystems. Although they have a simple structure, savannas are rich in species, communities of plants and animals, and habitats. In addition to high species richness, there are numerous life forms (e.g. trees, shrubs, grasses, sedges, herbs, vines), and the savanna plants vary enormously in the ways they cope with life in a strongly seasonal climate.

The savannas also have many different animal species, both vertebrate and invertebrate. Indeed, savannas are richer in many plant and animal groups than are the monsoon rainforests.

Fire has influenced the nature of the savannas over the course of their evolution. Fire has become more frequent as the continent has dried out. Indigenous people have used fire in the savannas for tens of thousands of years, and people continue to use fire for many types of land management purposes. However, there have been many changes to the fire regimes—the extent, frequency, severity and timing of fires—over evolutionary, prehistoric and contemporary times.

Landforms

Most of the savanna region is less than 500 m above sea-level, with local relief generally less than 100 m. Soil types may vary considerably, and the current structure and composition of savannas reflects variations in annual rainfall and in soil texture.

In both higher rainfall and drier savannas there are three broad landforms:

- flat to hilly savanna woodlands
- 'stone country'
- 'black soil plains'.

Within each, there are also 'riparian areas' along river and stream banks; there are important components of the savannas.

Most of the savanna woodlands are flat to gently undulating—the 'lowland plains' country—but there are steeper ranges associated with the Great Dividing Range in eastern Queensland.

The 'stone country' consists of rocky escarpments, slopes and plateaux, and occurs, for example, in eastern Arnhem Land and parts of the Victoria River District in the NT, the Kimberley in WA and north-eastern Cape York in Queensland.

The 'black soil plains', with their cracking clays, are found on the geologically recent flood plains of the major river systems in the wetter regions of the savannas, and on more recent (Quarternary) deposits, or older (pre-Tertiary) fine sediments and basalts in the semi-arid savannas. The riparian areas usually have a narrow, but relatively dense band of trees, often with a grassy understorey.

The soils include sands, loams (e.g. red and yellow earths) and heavy cracking clays (black soils). Each may be locally extensive; loams and clays tend to be more common in the drier savannas, although sands and loams are more extensive in the wetter savannas. The soils of the stone country tend to be shallow and poorly developed, although deep sandy soils may occur on the outwash slopes at the base of slopes and plateaux.

IJP

Flat to undulating savanna woodlands

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Stone country

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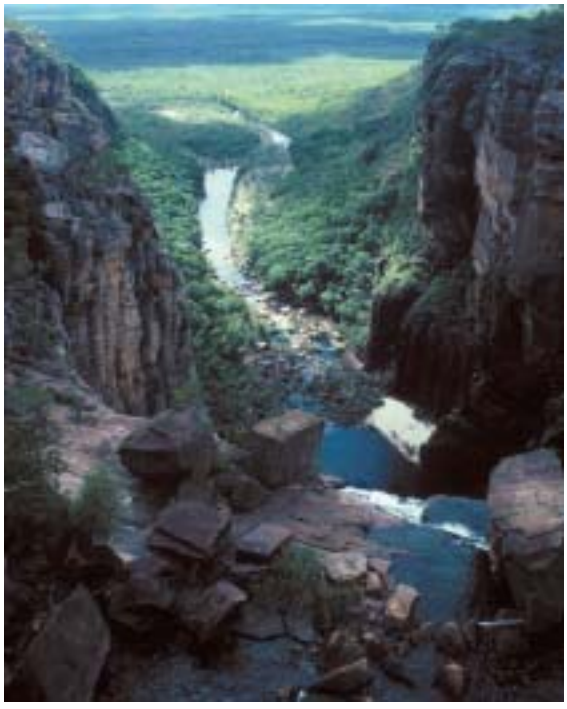
Black soil grassland plains



Riparian vegetation

The climate of the savannas

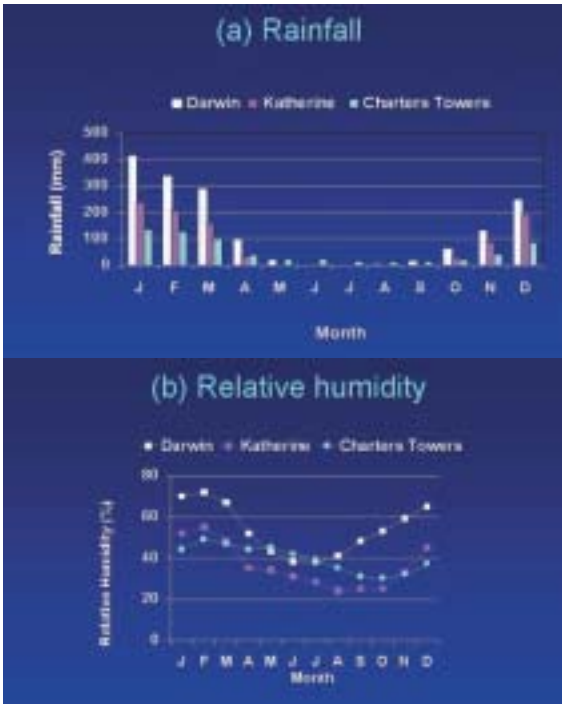
The key feature of the savanna climate is the alternating hot wet and warm dry seasons. This is driven by the monsoon as it moves between the northern and southern hemispheres. The dramatic seasonal variation in climate has a great impact on fire weather through the year (see Chapter 3), and hence on fire regimes.

Savannas may be relatively wet (mesic)where annual rainfall is greater than about 900 mm, or semi-arid/arid where it is 300–900 mm. The long-term average annual rainfall is strongly related to latitude over most of the savanna region (Figure 2.1). In the Top End, Kimberley and Cape York Peninsula, average annual rainfall declines sharply with increasing latitude, in places at a rate of 1 or 2 mm/km south. Rainfall also declines very sharply from east to west on the eastern seaboard near Cairns and Townsville.

The onset and duration of the wet season varies considerably between years and regions, and the amount of winter rain varies between the east and west of the savanna region. Rain generally commences during September–October. It has usually ceased by May in the western Top End of the NT and Kimberley regions, but may continue well into June further to the east of the continent (Figure 2.2). In general, the dry season starts rapidly, with sharp declines in both humidity and surface soil moisture.

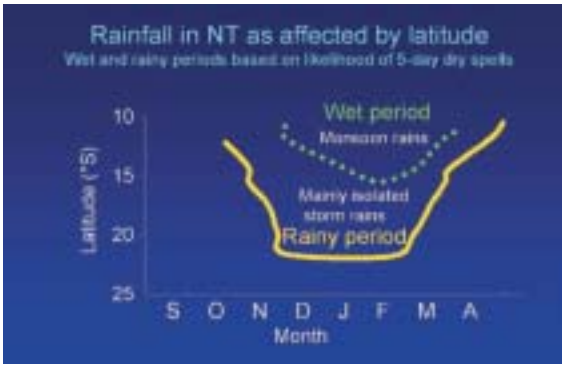
Most rainfall in the savannas comes from the monsoonal troughs and/or from isolated convective storms. In both the wet and semi-arid savannas, cyclones may also be a source of heavy rainfall. The influence of the monsoon is stronger in the near-coastal areas than in inland areas (Figure 2.3).

Figure 2.2 Seasonal variations



(a) average monthly rainfall and (b) 3 p.m. relative humidity at Darwin (NT), Katherine (NT) and Charters Towers (Qld). Note that the savannas of the eastern seaboard receive more winter rain than do those of the north-west of the continent.

Figure 2.3 Length of the wet season



The length of the wet season in the NT increases with decreasing latitude. Rain comes from both the monsoon and storms in the north, but generally only from storms further south and inland.

Figure 2.1 Rainfall map of northern Australia

Total rainfall declines with increasing distance from the coast and increasing latitude.

In the Top End of the NT for example, the strong monsoonal influence during the wet season around Darwin and Katherine (the 'wet period' of Figure 2.3) means that there is not only more rain than the more inland areas, such as in the Elliot/Tennant Creek region, but that the wet season (the 'rainy period' of Figure 2.3) is also longer.

Aboriginal people further subdivided both the wet and the dry seasons. In Kakadu, for example, they recognised the 'build-up' period between dry and wet seasons, the wet was divided into the early storm and full monsoon period and there was the period of 'knock-em down' storms at the very end of the wet season. The dry was divided into the early-cool and late-hot dry seasons.

Figure 2.4 Pasture types of northern Australia (Tothill and Gillies 1992)

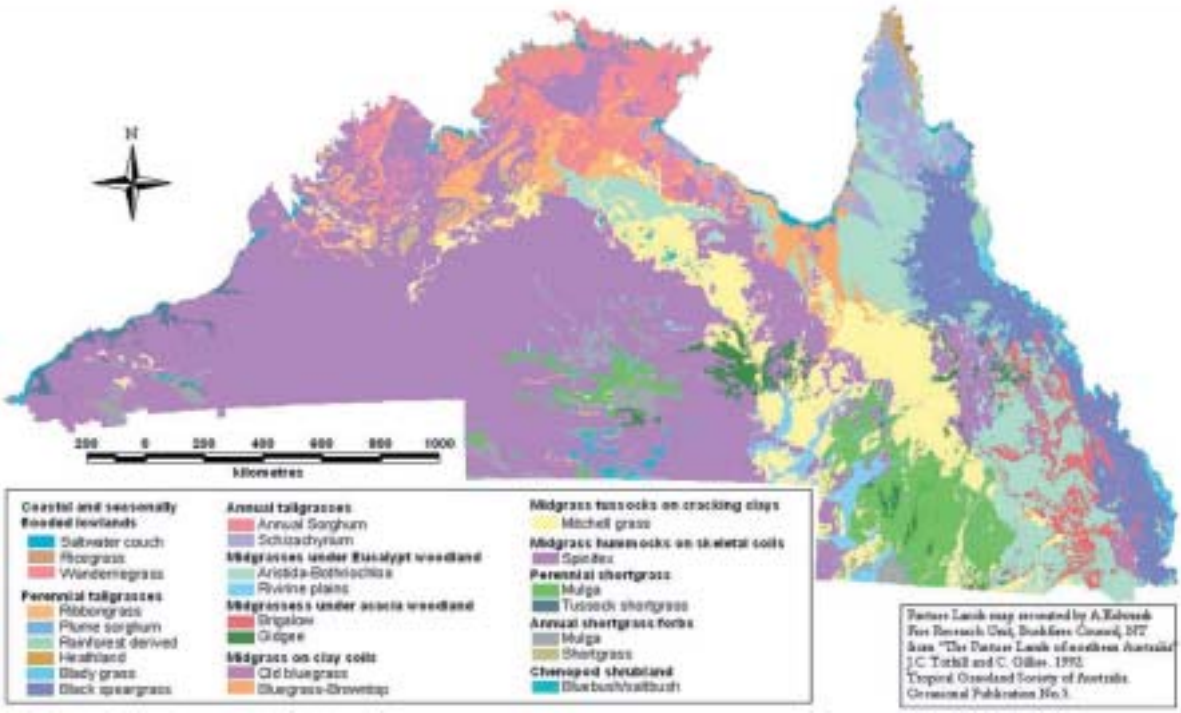
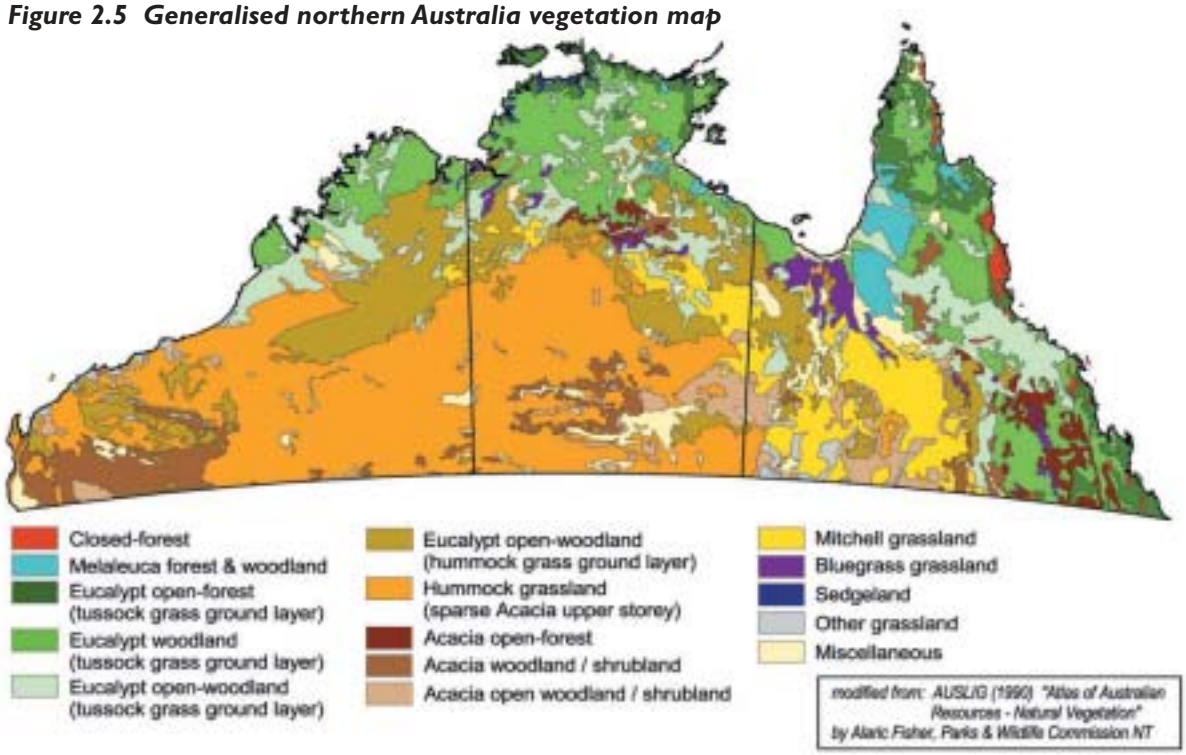


Figure 2.5 Generalised northern Australia vegetation map



The savanna vegetation types

The many and varied savanna types reflect both the amount of annual rainfall and the soil types. Variation in these two key factors determines both the dominant trees of a savanna and the associated combination of grasses (the 'pasture types') in the understorey.

The savanna types have been mapped extensively, for example the 'Land System Maps' of the 1950s and 1960s, and the maps of the different 'pasture types' (Figure 2.4). Recently, a generalised vegetation map of northern Australia has been produced (Figure 2.5).

Monsoon patch of vine forest JR-S

Sandstone habitat NTDPIF

Riparian corridors adjoining watercourses Andea Johnson

Variation and diversity in savannas

The savannas range from 'open forest' in the coastal and sub-coastal regions to 'woodlands' in the semi-arid regions to 'open woodlands' with scattered low trees in the arid interior (Figure 2.5). Treeless grasslands occur on heavier soils and where drainage is impeded. Most ecosystems in northern Australia are 'grassy landscapes'. Notable exceptions are the rainforests (the Wet Tropics in north Queensland and the monsoon forests and vine thickets of Queensland, Top End and Kimberley), some of the wetland ecosystems and the most rugged and rocky landscapes of the Kimberley and western Arnhem Land where the vegetation is sparse scrub or heath. These environments make an important contribution to both plant and animal biodiversity of northern Australia, and the health and management of these landscapes cannot be readily disentangled from that of the surrounding savanna. Variation in the structure of the savannas of the north is illustrated in the series of photographs on pages 10 and 11.

Forests and woodlands

Most Australian savannas are eucalypt open forests and woodlands, but they vary considerably because of variation in annual rainfall and soil texture. Broad-leaf trees and shrubs such as *Terminalia* (billy goat plum), *Brachychiton* (kurrajong) and *Erythrophleum* (ironwood) may also occur together with the eucalypts in both the wetter and drier savannas.

In the higher rainfall areas on the lighter textured soils, open forest is typically dominated by eucalypts 10–20 m tall with a canopy cover of 40–60%. The understorey consists of annual or perennial tall grasses. In the Kimberley, Top End and Cape York, such forests are dominated by *Eucalyptus tetrodonta* (stringybark) and *E. miniata* (woollybutt); open *Melaleuca* forests and some patches of monsoonal vine forest fringe the treeless flood plains. Heaths, with a few trees, and hummock grasses (spinifex) grow on the 'stone country'.

In the semi-arid regions, the savannas are woodlands and open woodlands. The eucalypts are shorter (5–15 m tall) and have lower cover (5–30%) than those of the forests. There are numerous species that dominate, but common ones in north-western Australia are bloodwoods and boxes, e.g. *E. tectifica* (grey box), *E. pruinosa* (silver box) *and Corymbia terminalis* (bloodwood). Common species in north Queensland include the iron-barks and boxes, e.g. *E. crebra* (narrow-leaved ironbark), *E. melanophloia*

Open forest

Open forest of woollybutt with annual Sorghum *understorey, Kakadu, NT*

Open forest

DPIF

Open forest of woollybutt with annual Sorghum *understorey, Katherine, NT*

Woodland

Woodland of bloodwood over annual Sorghum *and perennial grass, Kakadu, NT*

Woodland

IJP

Wiregrass under lancewood (Acacia shirleyii)*, Daly Waters, NT*

Woodland

DPIF

Eucalypt woodland (bloodwood) over tall perennial grass ('Tippera' system), Katherine, NT

Woodland

IJP

Wiregrass/firegrass under eucalypts, Boroloola, NT

Woodland

IJP

Black speargrass under eucalypts, Charters Towers, Qld

Woodland

IJP

Wanderrie grass under eucalypts, Normanton, Qld

Open woodland

DPIF

Eucalypt woodland with arid, short-grass understorey, VRD, NT

Open woodland

IJP

Ribbon grass under boab trees, Ord River, WA

Open woodland

IJP

Eucalypt and bauhinia (Lysiphyllum) *woodland with annual* Sorghum, *Katherine, NT*

Open woodland

IJP

Spinifex (Triodia) *under snappy gums, Cloncurry, Qld*

Open woodland

IJP

White grass under eucalypts and Terminalia, *Kalkarindji, NT*

Grassland

IJP

Barley Mitchell grass (Astrebla) *on inland black soil plains, Kalkarindji, NT*

Grassland

DPIF

Ribbon grass grassland adjacent to eucalypt and Terminalia *woodland, VRD, NT*

Grassland

IJP

Bluegrass-browntop on coastal black soil plains, Burketown, Qld

(silver-leaved ironbark) and *E. brownii* (Reid River box), and bloodwoods, e.g. *Corymbia erythrophloia* (red bloodwood). Perennial grasses here include kangaroo grass (*Themeda triandra*), black spear grass (*Heteropogon contortus*), ribbongrass(*Chrysopogon fallax*) and white grass (*Sehima nervosum*) on the lighter textured soils. On the poorest and most shallow soils in the lower rainfall areas, tree cover is sparse (1–2%) and spinifex (*Triodia* spp.) predominates.

Some *Acacia*-dominated woodlands provide the exception to the rule of eucalypt predominance in northern Australia. Notable examples were the extensive areas of brigalow open forest (*Acacia harpophylla*) on clay soils in eastern Queensland, large areas of which have been cleared and sown with pasture grasses such as buffel (*Cenchrus ciliaris*) and rhodes (*Chloris gayana*); lancewood (*A. shirleyi*) on lateritic soils of the Sturt Plateau in the Northern Territory, and pindan (*A. eriopoda* and *A. tumida*) on sandy soils in the Dampierland region of Western Australia. Woodlands and open woodlands dominated by gidgee (*A. cambagei* and *A. georginae*) also occupy substantial areas of fine-textured soils in central and western Queensland.

The grassy understoreys also vary with rainfall and soil. Annual sorghums (also often called 'speargrass') are common beneath the eucalypt woodlands and open forests of the wetter areas of the western Top End of the Northern Territory and parts of the Kimberley. In eastern Arnhem Land and Cape York, in contrast, annual *Sorghum intrans* is uncommon, and perennial Sorghum (*S. plumosum*), firegrass (*Schizachyrium fragile*) and other tall grasses predominate.

In the semi-arid savannas, perennial grasses predominate, with common species being ribbongrass, white grass, kangaroo grass and black speargrass. Black speargrass communities occur on free-draining duplex soils (sand over clay), and cover a huge area of eastern Queensland. As rainfall declines westward in north Queensland, *Aristida*, *Bothriochloa* and *Chrysopogon* spp. begin to dominate. In the driest savannas of northern Australia, where soils are skeletal, the grass layer is dominated by 'spinifex', under either open eucalypt woodland or mulga (*Acacia aneura*). Unlike other perennial grasses, which have a tussock growth form, spinifex has a hummock growth form.

Grasslands

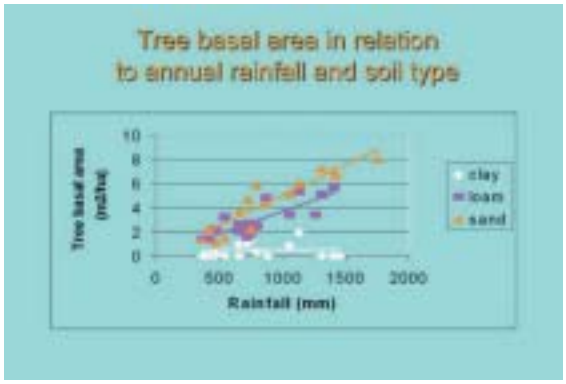
Under some conditions, trees are absent and the savannas are grasslands. The most extensive of these grasslands occur in the semi-arid regions on cracking clay soils, such as on the Barkly Tableland, and are dominated by Mitchell grasses (*Astrebla* spp.).

JJP

JJP

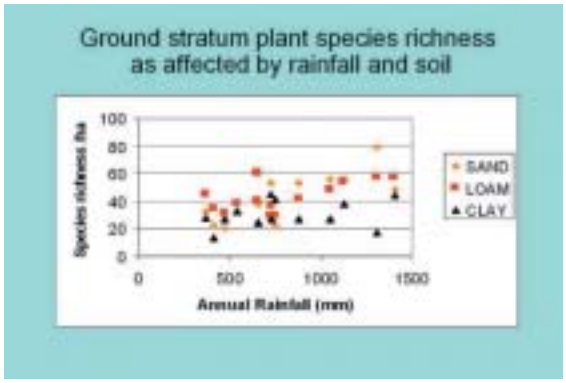
Savanna woodlands become less dense as average rainfall declines. ***Top****—coastal eucalypt woodland over annual* Sorghum. ***Bottom****—inland eucalypt and* Terminalia *open woodland over white grass*

Figure 2.6 Tree density



Trees are denser under higher rainfall and on lighter soils (sands) than on loams and clays.

Figure 2.7 Plant species richness



Biodiversity—increases with increasing rainfall and is generally greater on lighter (sandier) soils than heavier (clay) soils.

As annual rainfall increases, Mitchell grasses are replaced by blue grasses (*Dichanthium* spp.) and, in some parts of north-western Australia, by annual sorghums.

Other true grasslands in northern Australia are far less extensive and include those on sub-coastal flood plains (dominated by *Hymenachne*, *Oryza* and *Xerochloa* spp.) and littoral zones (dominated by *Sporobolus virginicus*). Other grasslands, such as blady grass (*Imperata cylindrica*), may result from tree clearing, often in conjunction with sown, introduced pasture species.

Spinifex may form true grassland, but is more frequently a ground layer under scattered trees dominated by acacias. These occur on very large areas of generally sandy soils in the driest savannas of northern Australia, such as parts of the Tanami Desert.

Structure and diversity—the importance of annual rainfall and soil type

Tree height, cover, density and basal area (the total cross-sectional area of all tree trunks) increase predictably with increasing rainfall and declining soil clay content. The pattern for the Top End of the NT is illustrated in Figure 2.6.

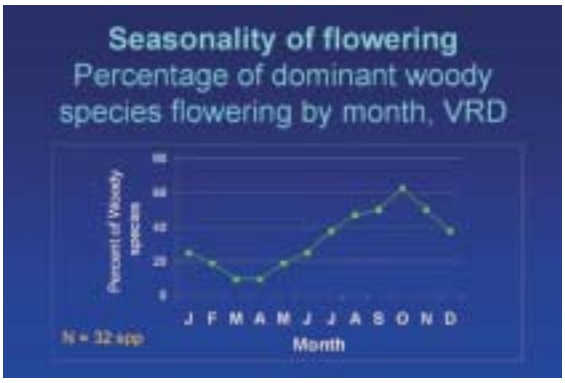
The diversity of plants and animals and the mix of species in a given area are also related to annual rainfall and soil clay content. Figure 2.7 illustrates such a pattern for plants in the NT. Tree cover, the cover of tall annual grasses, and the diversity of plants and some vertebrates increase with increasing annual rainfall, and are generally lower on the clay soils than on the sands and loams.

The vertebrates of the woodlands on the lighter–medium textured soils tend to be more diverse than those of the more nutrient-rich clay soils. The composition of mammal populations, in both space and time, may vary with long-term changes in the distribution of permanent water. The mix of invertebrates may also vary with annual rainfall and soil type, but are also strongly affected by the seasonal patterns of water.

Seasonal patterns

Growth and reproduction in both plants and animals are strongly linked to the seasons. In the ground layer, growth, flowering and setting of seed in herbaceous plants occurs during the wet season. With the onset of the dry season most of these plants begin to die off or become dormant. However, the trees behave in a different manner. Most species flower and fruit and produce their main leaf flush in the dry season, usually peaking late in the dry season (Figure 2.8). This is an important food resource for animals during the dry season.

Figure 2.8 Seasonality of flowering



The dominant trees tend to flower during the dry season with a peak in the late dry season. Monthly pattern for 32 tree species in the Victoria River District (VRD)

Many tree species hold seed-bearing fruit in the canopy for several years; seed is dispersed after fire. However, most savanna tree species hold their fruit for only a few months; seed is dispersed by the early wet season, and thus is ready to germinate with the first rains.

The animals of the savanna also show seasonal patterns. Invertebrates may have distinctly different species mixes during the wet and dry seasons. Vertebrates reproduce primarily in the wet season, but some do so in the dry season. There is some dry season dormancy, but this is limited to certain vertebrate groups (e.g. frogs and lizards).

Conclusion

Although the savannas of Australia are diverse, they all share a wet/dry climate and broad vegetation structure. These fundamental landscape characteristics make the savannas prone to frequent fire. The savannas are biologically 'active' throughout the year, including the dry season—the period when most fires occur. The interactions between fire and both the structure and seasonal patterns of growth and reproduction of the plants and animals are important factors that affect the impacts—both positive and negative—of fires in the savanna. The fires, their impacts, and the ways we can manage these interactions will be explored in detail in subsequent chapters.