WILDLANDS

ECOLOGICAL GARDENING FOR WILDLIFE IN DARWIN

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Wildlands – Gardening for wildlife in Darwin

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If you don't have a deep love for nature in your heart, then you really have nothing at all.

This book is a labor of love, free, a work still in progress and aimed to benefit local wildlife.

I claim no credit since the text grew on many sources. Hopefully you learn something new. I still do.

WILDLANDS -

ECOLOGICAL GARDENING FOR WILDLIFE IN DARWIN

MEANING

WHY ECOLOGY?

“When a piece of nature is left undisturbed it will manifest by itself a mutually connective and self-sustaining ecosystem.”

and

“The simple biological fact is that nature does not need humans, but humans need nature” Dr. Grainne Cleary

The idea of 'Ecology' as a branch of science with a name of its own appeared in 1869 through Ernst Haeckel and the corresponding word “Ecosystem” much later in 1935 through A.G. Tansley. The dictionary defines ecology as a scientific branch of knowledge that deals with the relationships of living beings amongst themselves and with their nonliving environments and vice-versa. The name comes from the Greek words 'oikos' for home and 'logos' for science.

Over the past two decades, we all have heard of Greening Australia and their activities and also of Landcare, all home grown versions of concepts for rehabilitation or restoration of expanding degraded lands against a background of declining biodiversity. Looking back at the results of these activities, it also has become painfully clear that simply planting trees and removing weeds is not enough to halt or reverse the rapid decline of our environment. We now know that in order to overcome the worldwide human inflicted damage to life on planet earth we require a much stronger and more scientific approach. Accordingly 'The Convention on Biological Diversity (2016)' calls for the restoration of degraded natural and semi-natural ecosystems, including urban environments, as a contribution to reversing the loss of biodiversity, recovering connectivity, improving ecosystem resilience, enhancing the provision of ecosystem services, mitigating and adapting to the effects of climate change, combating desertification and land degradation, and improving human well-being while reducing environmental risks and scarcities. We really need a comprehensive system of scientific “ecological restoration” of entire landscapes perhaps as much as 30 % of terrestrial land surface. Comprehensive ecological restoration, as the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed, when implemented effectively and sustainable, will hopefully contribute to protecting biodiversity, improve human health and wellbeing, increase food and water security; deliver goods, services and economic prosperity and support climate change mitigation, resilience and adaptation. The UN has recently declared the period of 2021 to 2030 the decade of ecological restoration.

The smallest self-sustaining unit of planet Earth's biosphere is called 'Ecosystem'. For example it includes a forest, a lake or a coral reef all self-sustaining units and hence ecosystems. With only sunlight from outside these units can largely sustain themselves. The main components of an ecosystem are two - the living beings or biotic components and the non-living or abiotic components.

I consider a proposition on a much smaller scale: Wouldn't it be nice to have a garden that self sustains itself, enlivened by a surprising variety of animals, flowering and fruiting plants without the mowing, weeding, watering and chemicals? It wouldn't be called an ecosystem, but nevertheless simulate and thus support some of the functions and relationships typical of an ecosystem. The thrust of this book is then to put forward ideas on how to create such a garden that is a bit like a natural ecosystem and that is based and designed for an enhancement of relationships among the organisms including the human that inhabit such a garden. You may laugh at this proposition or just be skeptical that this is at all possible. To this I say, consider that we humans tend to think on the human scale. However, from the viewpoint of a nematode or bacteria living in your backyard, your garden is a universe and any such microbic organism will likely never venture outside the boundaries of the garden. It's all a matter of scale, thus ecosystems do exist perceptually right down to the microscopic level. We can adopt a reference of a native ecosystem as a model for our ecological garden to be created. The reference model, derived from multiple sources of information such as soils and floristic composition, informs us on character and condition of the ecosystem and inspires design ideas to be adopted on the smaller scale. Under such a conceptual context, ecological gardening takes into account the relationships of organisms that live in the garden and then makes it a priority to adjust treatments to move towards resembling natural processes as far as possible in order to improve the wellbeing of those organisms. Some processes may be inappropriate to an urban setting for obvious reasons such as fires and in this case would exclude adopting a Savannah woodland reference system but other reference systems or habitats are quite feasible such as wet monsoon vine thicket for example.

Plants, animals, fungi, bacteria together form the bulk of the biotic components and soil, water, air and sunlight together form the abiotic components of an ecosystem. Besides sunlight, which comes daily from the sun, all these components are integral parts of the ecosystem. The biotic components are divided into three main categories, the green plants who manufacture food materials from simple inorganic ingredients by using energy from sunlight, the animals who live on food manufactured by green plants and the fungi and bacteria who, after the death of plants and animals break down the biomaterials locked up into their bodies into simple inorganic materials and return these to earth to be picked up and recycled once again by plants in a repeating cycle of life. The ecological processes of recycling of nutrients from abiotic to the biotic components of the ecosystem, and then again from biotic to the abiotic and so on and on - one cycle succeeding another as the 'ecological garden' matures are akin to a piece of art with the gardener being the artist. By creating this artwork, the 'ecological garden' we learn more about how these processes work and how extraordinarily amazing nature really is and that knowledge effectively becomes a catalyst that leads us to respect and appreciate the natural world.

According to the Stanford Biochemist H.R. Hulett the carrying capacity of Earth for human beings living in U.S. standard of living is about 1 billion people (Ehrlich and Ehrlich, 1970, W.H. Freeman and Co., San Francisco). If this is true something needs to change, like reducing part of the human population which on the current rate of increase will double within 40 years or alternatively lowering our standards of living or levels of consumption of goods. The logic of ecology states that a struggle for existence and thus suffering results at a rate at which all organic beings cease to increase against a backdrop of limited resources and level of predation. According to this proposition growth of a specific organism will stop when an ecosystems carrying capacity for this organism is reached. In an ecosystem, predator - prey relationships are mutually beneficial and generally self regulating. Predation helps to keep prey population to be physically fit (by removing mostly the old and weak ones) and also by keeping its size small. The problem with us humans is that there are no longer any predators of the human species other than pathological organisms such as viruses or bacteria. For humans the carrying capacity will be most likely determined by the availability of food and not predation. Food availability is dependent on a stable climate and suitable growing areas the latter being increasingly compromised by anthropogenic pollution. It's easy to see the evidence, just look at our 'plastics oceans', the pollution by aircraft, ships, from cruise ships to oil and gas tankers for heat and power, the neverending building of roads for mining and movement of goods that we really do not need, to the air pollutant embedding in the worlds ice caps. The fallout of the urbanized 'human animal' is omnipresent in the world today, in fact there are no longer any true 'natural systems' or 'wildlands'. Extinctions of the wild animals are apparently happening at a thousand times the natural rate. The transformation of what little is left from 'quasi wilderness' to anthropogenic landscape is relentless, ongoing and going until the day this great culture of mindless consumption will eventually collapse, perhaps a lot sooner than later if you believe the predictions of science. Darwin, thousands of kilometers away from any large city and surrounded by empty land and sea, seems so far removed from these worldwide problems and so the majority of its occupants will find this talk of doom and gloom of our future a little bit unreal. Here we still shoot geese and ducks by the thousands just for sheer fun of it and with excitement intend to frack the apparently unlimited body of gas out of the earth in full knowledge of the damage it is doing and then cheerfully drown ourselves in grog and other stuff when we are not ripping and shooting. People simply get on with their mobiles glued to the ears or staring into their gigantic 75 inch plasmas all day long so not miss the latest on the 'Corona' and other dramas somewhere else. Life's great. So why bother with ecological gardening for wildlife? Why bother at all? Well, perhaps I think we could have more fun and happiness working with nature rather than against it. Let's look more closely at the situation for wildlife the topic of this book.

Loss, fragmentation and degradation of habitat for wildlife, interruption of ecosystem processes, edge effects, changes in animal behavior and proliferation of environmental weeds or exotic animals can all be linked to the loss of native vegetation. Most types of development particularly urban residential developments have the potential to result in a complete loss of native vegetation, depending on where and how they are constructed. Habitat splitting occurs when urban developments are nestled in between natural habitats, and is a common impact arising from development that often results in barriers to movement and dispersal between the resulting fragmented remnant parkland. As a result habitat fragmentation then causes a sudden division of wildlife populations, isolation of key habitat resources, loss of genetic interchange and ultimately the local extinction of species as it reduces the viability of populations. Further ongoing habitat degradation of fragmented sites ultimately can lead to complete habitat loss. The ongoing degradation of habitat can be caused by interruption of ecosystem processes, edge effects, environmental weeds, exotic animals and artificial lighting. Processes that simplify habitats can result in habitat degradation. Physical changes to the abiotic environment (Light, noise and soil compaction) can also degrade habitats. Clearing land in the direct footprint of a development can also directly result in physical trauma (injuries or fatalities) to animals using the habitat at the time. Even on a much_smaller scale such as clearing a tree in your backyard may destroy bird nest, eggs, nestling and thousands of insects that live on the tree. The disrupted ecosystem processes that sustained functioning ecosystems including climatic processes, primary productivity, hydrological processes, nutrient cycling, interactions between species (competition and predation), movements of organisms and natural disturbance regimes (e.g. fires and floods) are replaced with artificial largely energy consuming processses such as mowing lawns, heating or cooling buildings, street lights and maintenance of infrastructure. Rainwater is mostly drained away by roofs and roads into the drainage system rather than absorbed by the soil.

Even where remnant vegetation is retained the potential consequence of development is an increase or decrease in fire frequency. It is well established that fire is an important component of many Australian ecosystems. Particular fire frequencies and intensities are needed to maintain natural vegetation communities (assemblages of native plants in a relatively uniform patch) and species in the landscape. Inappropriate fire frequency and intensity can lead to certain species being lost from an area. Some flora species require particular fire regimes to stimulate seed germination (some sclerophyll plants), while others are destroyed when burnt (e.g. some rainforest plants) as is often the case and amplified through weed investations. Environmental weeds are plant species from a different locality such as urban residential areas that invade natural areas and adversely affect the indigenous flora and fauna. It is generally well accepted that weeds are a considerable threat to nature conservation as well as an economic problem worldwide. Many developments have the potential to escalate environmental weed progression, including those with gardens that harbor weeds, especially when adjoining habitat areas. However, it should be remembered that developments do not need to be directly adjoining natural areas to cause an impact because birds and other vectors disperse many varieties of weeds.

The impact on ecosystem is not just limited to clearing and physical modification. Artificial lighting too can cause disruption of foraging behavior of a variety of organisms, increase potential for collision with made structures and disruption of reproduction and movement. The effect of artificial lighting on most Australian native fauna has not been sufficiently studied. Nonetheless, inferences can be made regarding the susceptibility of each species by understanding the biology and ecology of the species in relation to how they use the nocturnal environment.

Birds are particularly susceptible to collision with structures at development sites (bird strike). Birds are known to frequently collide with power lines, cars and windows. I come across numerous birds with head trauma or broken body parts every year and the result for the animal is almost always death.

A wise man once suggested that "we should not kill, eat, torture, and exploit animals because they do not want to be so treated, and we know that. If we listen, we can hear them". Listening in practical terms means direct observation coupled with empathy to understand the fundamental needs of other animals. Like humans, animals too have needs beyond the minimum for sustaining their lives. To be able to listen is important not only for being able to directly ameliorate the hardship of animals, but also for changing the prevailing psychology in our consumer society that has alienated us from fellow humans just as it has from other animals, and from nature at large. But to be able to learn to listen we need a place where we have the opportunity to do so on a daily basis and that is where our garden comes into play.

Your home, the place that you own or rent and spend most of your time, is usually embedded within a garden. Most people view the garden as an extension of the house but I think it is the other way round. As a species of animal, 'Homo sapiens' or 'the wise man', we have lived for at least 200,000 years under the open sky or under the canopy in a forest somewhere in Central Africa, naked, huddling against each other on a starry night. Then later after dispersing into colder climates we build little bow shelters or mud huts for better protection or took to natural caves, in most cases warmed by fires. It took another few thousand years and we ended up with houses built of steel, timber, bricks or concrete. But be it in bow shelters, caves or houses we were always surrounded by a 'nature garden' when stepping outside. After 200,000 years our DNA really hasn't changed much, physically we are still the creature of the African tropical forest where we originated, although we no longer feel that way because our brains are now filled with different stuff, such as how to use mobiles, switch on the television and steer a pile of moving metal. However deep down we are at our happiest to relax in a natural area or a beautiful natural garden, where we are able to turn off the inner dialog and enjoy the world of plants, animals and a breath of fresh air out in the open. There, in an instant, we connect through our natural senses with the life of a more natural world. This alone is one good reason to surround us with a small patch of wilderness, simply to feel more happy, content and secure. Watching wildlife in particular has extraordinary effects because it helps us to focus on something other than our daily worries.

Looking around with a critical eye, to me it seems that for a lot of urbanized areas in Darwin the principal objective of managing semi-natural and natural biology in both gardens and urban parks has been to ensure eradication of wildlife, especially where it may include species that are directly or indirectly hazardous or at least perceived as such, like for example mosquitoes, termites, ants, spiders, snakes and rodents. I term this practice as ‘un-wilding’ and in urban Darwin it occurs in both, private and communal space, where many unkempt leftover bits of natural vegetation are progressively tamed by an army of slashers, whipper-snippers, pesticide sprayers/injectors and blower wielding council workers or their contractors. But by killing one species we also kill all the species that live on the one species. Such spaces may look pretty in a decorative sense but are the native bees still there?

In other areas, predominantly rural subdivisions, it is common grow fruit and vegetables for consumption or sale. Here likewise, the biodiversity of natural biology is often low, particularly where it is perceived as competing with or preying upon these products and is treated accordingly.

In the public green-spaces of Darwin with the exception of dedicated urban conservation reserves, the vegetation is predominantly managed with a view to improving its amenity value and in only a few rare cases such as East Point Reserve or Casuarina Coastal Reserve the notion of landscaping for biodiversity is actively pursued. So it is often in the backyard gardens where land owners participate in some form of nurture of wildlife, although in many cases this participation takes the form of planting a few nectar or fruit providing native plants or simply in the feeding wild birds and other animals.

The gardens that you find in Darwin's backyards are contrasting. Some may consist of a neglected patch of lawn, a few exotic shrubs and a couple of trees that have seen better days. In such cases the sun burns down and not much else is happening. Others resemble a world of painstakingly manicured lawn, perhaps a rose bush or flower bed, trimmed hedges and a raft of exotic looking palm trees, a garden which on the whole is still pretty life-less and not much better than the previous example. And then there are also many other gardens in the mix that could serve as an illustration of the jungle book, showing a lush green shady world of rainforest plants both exotic and natives. One can find some other yet different types of gardens perhaps a water-wise garden with water saving eucalypt's and wattles, but whatever gardens you may look at, they are the reflection of objectives of the people that own them. People have built those gardens for themselves within the limitations of personal philosophy, likes and dislikes, and rightly so, after all they are paying for the garden's establishment and maintenance with their own time, labor and money. So why would anyone create a garden specifically for wildlife and not for themselves? Thats a fair point but only if viewed from the homo-centric viewpoint that most of us operate from. Let me throw in a different proposition. None of us lives in isolation, we breathe the same air, have the same sensation of light and temperature in a given location and time. Every moment in a given location you literally become your experience to the extent of your sensory information. So when you sit in your garden you really are your garden, when you watch a bird you really are the bird. Everything is connected. Being yourself, being your garden, being a bird, being of the 'what is' to the extent of your perception in a given place and given moment of time. Being in this sense means listening with your senses at your personal level of understanding to the forms and manifestations of life. Birds, animals and plants are beautiful expressions of the vitality and excitement of the living natural world, which on the whole is the mother that has created you and us arising from as a tiny piece of genetic code together going back to the original code at the beginning of life over 3 billion years ago. Not only is the 'all of life' connected in the now, it is also genetically related. Ecologists think of this related and connected web of life in terms of unique and sometimes extremely intrinsically linked complex food chains. The human species has been extremely destructive to this natural web of life. To this day we have already destroyed over 85 % of wildlife, over 50 % of wild forests and typically replaced these with vast agricultural monocultures, roads and urban settlements including our mostly manicured gardens and continue to do so despite full knowledge of the consequences. Now more than ever we increasingly and uncomfortably are coming to the realization that change is desperately needed and that this change can only come when we trade our homo-centric business driven domination of the world with a view of the human as a 'nurture-being' that cares for what is left of the natural world, our mother. The scientists now agree that in order to halt or slow down the degradation of bio-diversity, we would need at least 30 % of the land surface including agricultural areas return to 'wildland' in form of managed natural conservation reserves. When I look at the mental states and egotistical attitudes of the majority of my fellow citizens all with vested interest in keeping the 'consumption madness' going, I ask myself is this minimum requirement even possible. Probably not given our history. But it is better to carry on even in the face of adversity than to give up and do nothing and become a suffering participant in the great extinction to come. We can put to work immediately over what we have control. And the closest thing that we can control is our own house and garden. Our garden has the potential to become the pivotal point to change our own personal homo-centric view of the world to one of 'being' more deeply connected to all of life. As we create the conditions conducive for a more diverse life in our gardens, we learn by observing this diversity and inter-connectivity of the involved organisms directly as it returns to us, indeed we become more alive and as we do so we understand that there is more to us than just being an isolated piece of DNA. Making your garden more livable to all kinds of creatures will help you to become more aware of how you are connected with everything around you. The joy in the song of a little Brown Honeyeater to a flower before it touches its nectar, can also become manifest within you specifically in your heartspace. Making your garden more enjoyable to a greater family of creatures also creates ripples of joy as you learn to sense their joy and so become more connected to them. When you feel this for the first time a great realization manifests in you.

There is another reason why we must learn to listen to non-human animals. In their natural environment, animals left to themselves maintain a perfectly balanced ecosystem, a natural system that is a totally renewable, a no waste economy that is powered by the sun. These non-human animals teach us a lesson of how it is done, how to live in balance with nature and not to make a mess of it like we do. Even in our gardens we can learn from these interactions of animals and plants right there and draw conclusions on how we ought to see the world, treat each other and the environment that surrounds us. Sadly today many urban dwellers have diminished their interactions with nature and thus their understanding of the natural world. In the Top End many of the older indigenous people and other country folk still have an acute awareness of the environment that surrounds them compared to other societal groups here. These simple 'earth people' are still able to identify native plants in precise context, bird calls and other signs of nature that we forgot or have never learned. They are also different because they may not share foolish assumptions with modern man such as that the consumption of resources and goods on top of essentials improves lives, that nonhuman life has no intrinsic worth and that humans are the center and purpose of the world. Interaction with your 'ecological' garden will teach you that you are not the center of the world, that the feeling of harmony comes from the respect you show to your surroundings and that your personal consumption of goods is always to the detriment of other life elsewhere. When we look at animals in our garden we realize our commonality with other animals. We realize that we too are embodied beings who depend for our continued existence on interrelationships with other organisms and the physical environment around us. If we don't, we might overlook the fact that we are violating their nature, something that inevitably leads to their suffering as well as ecological damage. When we look at animals we can improve our mental health by contact with the nature around us, and find ways to fulfill higher human needs without excess consumption. When we look directly at animals we transcend the symbolic such as expressed through our language, photos and other representations of those animals. In their natural state animals fit seamlessly into ecosystems that absorb energy only from the sun and produce no waste, and we could gain inspiration for designing sustainable human systems in similar ways. And ultimately we need to discover who we are by discovering our communality with fellow lifeforms.

Although we can do quite a bit to improve our gardens, parks and urban green space we should guard ourselves from the assumption that it is possible to continue to increase human populations, technologies, and economies and deal with the resultant environment problems separately, through cosmetic changes such as beautification projects, rubbish collection initiatives, recycling, more efficient cars, and technology such as carbon capture and storage to mop up the problems. We should not pin our hopes on technical fixes so that our fundamental cultural values, such as the love of the automobile, for instance, do not need to change. However we can start with changing our garden, then our garden will help us to set new priorities and reset our view of the world. Ultimately humanity needs to abolish the consumption of goods we don't really need, curtail traveling that burns carbon and spreads disease and last but not least we urgently need to temper the growth of our populations. As an individual we are too insignificant to facilitate such changes at global scale but we do have the power to control your own consumption, our own carbon footprint and create the perfect sustainable garden for us and wildlife. The crisis brought on by the Covid virus with its drastic lockdowns dramatically demonstrated how important gardens really are. When confined to house and garden the quality of these has a magnified impact on our peace of mind.

While the protection of remaining natural areas and perhaps expansion by adding new 're-wilded' land or ecologically restored sites, should always be the number one priority for providing wild animal habitat, urban habitats too have the capacity to support a range of species and become important components of the conservation network and act as an educational tool to re-connect people and particularly children with the natural world. We should especially aim to provide habitat for those native animals that were once common in the urban landscape but are now in decline. Providing structural and plant diversity by using local native species is fundamental for supplying this habitat. We should be moving away from the traditional Darwin garden of exotic palms and open manicured lawns which tends to diminish and impoverish habitat for the less common and less adaptable species, An understanding orientated towards ecology, that is the relationships between specific fauna, flora, soil and hydrology in relation to your location will help you identify opportunities for design of your garden.

Although we cannot replicate a large, continuous, nature area of vegetation, and therefore cannot encourage all animals into urban spaces, we can create niches that can be used by a wide variety of native animals including microorganisms. While preserving and enhancing the remaining remnant natural vegetation patches in urban areas is important, they could be coupled with the development of a series of corridors connecting these patches throughout the urban matrix. In this context the value of suburban parks, streetscapes and gardens for providing animal habitat must not be underestimated when considered as a whole landscape by providing for a different species needs. In order to change the culture of gardening in Darwin and encourage the voice of citizens to promote the necessary landscape scale changes, individual residents should be encouraged to make their gardens wildlife friendly in the first place. The more residents that create these gardens, the better the neighborhood will be for wildlife. Establishing an emotional connection with our urban wildlife is important for implementing long term management change at the whole spectrum of scales; the city, the suburb and the individual household level. All people who make management decisions about our urban landscape, whether they are developers, local council employees or residents, can benefit from education about the value of these habitats and the best way to manage and conserve them for native wildlife. To use the language of 'rewilding', ecological gardening for wildlife if it were to become a movement could allow 'Keystone Species' to move to establishing 'cores' and 'corridors' within the urban environment from which they were displaced. Every plant and animal needs a specific amount of space, food and water to survive. A 'core' is a stretch of land large enough to support all forms of life that would exist there in its natural habitat in the wild. 'Corridors' are routes that connect cores so wildlife can travel across built-up areas to find food and mates. 'Keystone Species' are a biological term for an animal or plant that, more than most, keeps its habitat or ecosystem in balance. For example top carnivores are keystone species because their hunting prevents the population of prey animals from getting to large and crowding out others in the habitat. For example bees and other major pollinators are keystone species too, because many plants rely on them to reproduce. When a habitats pollinator disappears or changes, so do the plant that grew up there and the creatures that need those plants for food and shelter. We need to learn to think in these terms and formulate a philosophy that achieves beneficial ecological outcomes. However wildlife is much more than just animals but also includes microbes, fungi, bacteria, insects and a myriad of other organisms because what we consider wildlife depends on these.

Human health and the natural garden:

Making our own garden, better for wildlife - cleaner and more nurturing for a higher level of biodiversity – is also good for your own health. Every time you enter wild bio-diverse spaces and breathe the air, microbes carried and floating through the air land on your skin and enter your lungs and making their way into your gut, joining many billions already living in your personal 'microbiome' - the community of symbiotic microorganisms inside each human being. Australian research has recently determined that the more diverse the microbes living in the soils around us, and the more you are exposed to them, the healthier you become. The human body is made up of some 37 trillion individual cells. But the number of microbes – microorganisms such as bacteria, viruses, protozoa and fungi – living in and on our bodies are thought to be more than double that. Called the 'human microbiome', it is really an enormous invisible cloak both inside and outside that acts like a giant organism that helps us digest plant matter, manufacture vitamins, regulate our immune system, form new blood vessels, coordinate hormone activity, store fat and modulate brain signals. There is a marked difference of gastrointestinal microbes between people living in rural or natural surroundings compared with city residents, with city folk have less diverse microbiomes, due to the reduced exposure to a high diversity of microbes in the soil, in the air, in the food we eat and the animals we interact with. Ecological gardening for wildlife with its emphasis to a more bio-diverse garden can lead to a kind of personal 'microbiome rewilding' that encourages a re-balancing of microbes, thus restoring the imbalance within yourself. Poor or degraded gardens of a low level of biodiversity can be returned to more natural and more diverse presence of microbes mainly through planting of a structurally diverse choice of native plants and measures specifically aimed to improve the natural soil food web including the fungi and bacteria. Everything in life is connected and just because your parents have given you a name and you feel you are such and such doesn't mean you are a standalone entity. You are always connected to the microbes in your own body and also through their presence in your immediate surroundings and by making them more naturally balanced and healthy you too may become healthier.

Ecological garden design takes into account the interactions of all organisms embedded in your gardens food web, including bacteria, fungi, protozoa and many other beneficial microbes, aiming to increase the gardens productivity and diversity. Microscopic organisms really are the good stuff and the more you have the better. Productivity is the rate at which biomaterials are being produced by the green plants. For example the productivity in kilocalories per unit of time per area of a tropical rainforest is about three to four times higher compared with cultivated land including average gardens. Communities (composed of all populations of species living together in a particular area) with a higher diversity of habitat – which should offer more potential niches – will also have a higher diversity of species such as is found in rainforests. For example a garden with higher foliage density at different heights will support a more diverse bird species assembly. Increasing the number of plant species increases the stability of communities because the high plant diversity provides more consistently available food and habitat for herbivores, predator and parasitoids. In summary ecological gardening aims to create a higher level of producivity while achieving enhanced diversity, fitness and health both physically and mentally for all its inhabitants including the human.

SENSE OF PLACE

Gardening for wildlife becomes meaningful when you consider how your place or site fits into the bigger picture both historically and in the present. On a geological scale much of the Top End is very old and very stable with some of the most ancient formations more than 2 billion years old. Over this long period the landscape has weathered and soils leached with most of the nutrients such as Calcium, Potassium and Magnesium removed, which on the whole has led to generally infertile, inert silica-dominated and iron-dominated soils. As a result of the weathering processes much of the Top End is relatively flat, with seasonal creeks, small seasonal rivers and larger tidal rivers providing the only relief. The are however also some scattered rugged erosion resistant sandstone escarpments adjoining the coastal floodplains, particularly between Darwin and Kakadu that have formed as recently as 15000 years ago, when the coastline was believed to be about 300 km further north than it is now. Eventually sea levels rose after the ice age and many of the large rivers were then inundated by advancing seawater. The annual deposition of sediments by wet season run-off has added materials to the coastal plains, and slowly transformed them into freshwater wetlands during the last few thousand years..

Darwin was invaded in 1869 by the British and originally named Palmerston, then renamed 42 years later after the the famous biologist Charles Darwin. Curiously Charles Darwin himself never came closer to a few thousand kilometers near the Top End, a region that is situated on the northern coastline of Australia a landscape that is subject to the annual monsoon where the seasons are driven by rainfall, not temperature, as the region is evenly warm some may say hot all year round. Almost all of the 1700 mm average annual rain falls in the six months from November through April. The majority of gardens in Darwin are watered making the city of Darwin from the air looking very green for most of the year but especially so in the wet season. The Darwin 'hinterland' or called the 'Greater Darwin' as well as the underdeveloped and undeveloped remnant surrounds are still dominated by the relatively dry open forest to woodland landscape of eucalypts, wattles and speargrass interspersed by low lying lagoons. Most of Darwin's denser urban development has been placed on a flat upland plateau that naturally would support just dry open forest and woodland apart from a sprinkling of drainage depressions where water accumulates and other vegetation types such as monsoon forest, grasslands and paperbark forests have established. In addition there are also the narrow fringing habitats of mangrove, vine-thickets, beaches as well as adjoining floodplains. Against this historical natural landscape most of the Darwin has undergone a dramatic change from Savannah to 'urban wet forest'. If we were to define the sense of place of Darwin we would have to distinguish historic and contemporary sense of place. A clear idea of what is a desirable 'sense of place' is helpful before embarking on changing the landscape even if it is just your own tiny patch of garden. So let's for a moment consider the sense of place in terms of what has been, what is it now and what ought it to be including the perceptions of landscape in peoples mind.

Prior to invasion, the Greater Darwin Area embracing the Darwin Harbor was (and still is) the home of the Aboriginal Larrakiah people living of the coastal lands and waters rich natural resources for thousands of years. They were the first humans occupying this area. The traditional Larrakiah know their country very well, they know a whole pharmacy of traditional herbal medicine, they utilized a diverse range of natural food sources and developed a cultural belief system underpinned by a view of being the body of the country, which allowed them to live relatively harmoniously with the land without unduly disturbing its natural order of balance. I once read that the Greater Darwin Area including the harbor can only support a mere 10,000 people living of the land natural resources at best. Today we have in excess of 100,000 people and most resources such as food, raw materials and energy are trucked in from thousands of kilometers away across the entire continent. Water for Darwin's lush gardens too mostly comes from far away, the Darwin River Dam, a once natural area sacrificed to keep the grass going in Darwin. As Darwin is still pushed forward on a seemingly open ended growth path, water supply at times is running low and soon we will have to build yet another dam or alternatively lower our water consumption or curtail ambitious planned developments. We now see a picture emerging of a contrasting sense of place, one the pre-invasion natural order of being and the other, the energy and resources wasting homo-centric modern culture of post invasion. Contemporary homo-centric thingking doesn't waste a thought on the fact that we kill countless creatures in the process of clearing and devloping land. We satisfy our own vested interests and not those of other life forms. If I were to think like an indigenous person I could image that what we do through clearing and developing the natural landscape is akin to cutting into our body to get blood because we are thirsty. We have long ago departed from living sustainable off the land like the Larrakiah once did and feeling comfortable in our nice lush tropical gardens and air conditioned houses in any case seems to be a far better option. We are stuck, we cannot go back and we can no longer go forward on a consumer based way of living trajectory although the technocrats seem to think they can. Darwin in particular has always been living beyond its means, for the most part relying on a most generous handout from the federal money bucket and partly fueled by a ballooning internal debt strategy. So my sense of place of Darwin today is also that of a near bankrupt community living beyond its means in a artificial oasis and that as a community it will have to face the need to make tough choices in the near future. Every year our leaders deny this reality and postpone needed frugal action by borrowing more and manipulating people with ever newer clever rhetoric to allow them to continue to live on borrowed time. Before they used Inpex as the supposedly holy grail out of debt and now it is the fracking of vast gas resources which will be ripping our beautiful landscapes even further to bits.

But what has your garden to do with all of that?

Well, for a start your garden is a consumer of water, particularly so if it consists of lawn and exotic water hungry plants to manifest tropical lushness. Such a garden has lost authenticity but also consumes energy when you mow your lawn every week or use fertilizer to keep it green. This type of garden may have taken away the resource of the creatures that lived here before your garden came into being such as insects, lizards, birds and mammals. By excluding the creatures we sterilize and deaden a place. The pollinators such as native bees now have mostly gone from Darwin as have a range of birds leaving only a few species that can cope or even thrive in impoverished places. Having said that, I'm not implying to restore the urban fabric to the natural that was there prior, namely dry sclerophyll open forest and woodland, because to do so would create unacceptable fire hazards. I rather envisage a place created through the use of an array of local monsoon vine thicket plants that replace all exotic introduced plants in a way that allows us to achieve an array of desirable objectives including;

- A sense of place of belonging to the Top End's natural environment through the assembly of natural local vegetation communities.

- The provision and restoration of an attractive environment for all creatures particularly pollinators, and insect eating animals.
- The provision of plenty of shade, shelter and interest accomodating Darwin's popular outdoor living culture and that will ameliorate the conditions of a warming environment
- The provision of linkages and extensions to the last natural or semi-natural remnant vegetation patches such as Casuarina Coastal Reserve, East Point Reserve, Holmes Jungle and Charles Darwin National Park to provide wildlife with stepping stones to within the wider habitats and beyond.

If you create your garden in a way to achieve these objectives, every single native tree or shrub you have planted is helpful because it is truly belonging to the Top End and it will remind you again when you find the same tree or shrub in the wild outdoors of our national parks and urban nature reserves. If I see the trees flowering in my garden I know they are flowering in those places as well. Both the plants in the wild places, the plants of my garden and my mind are in tune. A clever wildlife garden has the potential to connect you with nature in very subtle and pleasurable ways linked with experiences in the bush. Contrast that with the experience of the old style Darwin Garden with its lawns, Golden Canes, Coconut palms, variegated Hibiscus shrubs. Bougainvilleas, Ixoras, Crotons and Frangi Pangi. Can you feel any connection with these exotic plants, perhaps because they are pretty and different and give you the impression of living in the tropics, but really, do they contribute for your feeling of truer sense of place and belonging to the Top End? The exotic garden may give you a sense of place but it is false and superficial, not lasting. A prisoner in a beautiful jail may also have a sense of place but it would not be one of belonging and authenticity.

If you create a natural garden with local plants you can more easily foster a growing feeling of identity tied to the natural landscapes of the Top End. You learn to better appreciate what we really have in the Top End and build on it by getting out into the local natural conservation reserves or the beaches mindfully listening what this landscapes tells you. When you see something beautiful in the wild like a bloodwood tree in full flower you can transfer this experience into you own home by planting a bloodwood there. The bloodwood in your garden will help you to establish a sense of belonging to the Top End. Sense of place lives in your heart. When old aboriginal custodians visit sites of importance in their country you can see the sparkle in their eyes, they literally light up, that is because their hearts and emotions are firmly interwoven with a strong sense of place. I have seen this over and over again. To them a sacred place inspires awe and reference.

CONNECTIVITY

First and foremost, wildlife including the human animal must feel safe in their environment, and while the amount and type might vary greatly, all life needs food and water, shelter and a place to nest, whether that is a dense thicket, tall tree, hollow, a bit of mulch or dead tree on the ground or a built structure. Most of these requirements can be met by the availability of suitable vegetation, whether that is a large tract of remnant forest, an appropriately landscaped and managed urban or residential area or even a small garden. In a fragmented environment the size of these habitat patches, and their connectivity to one another, is important as most animals will need to travel in some cases considerable distances to find mates, avoid predators and search for food.

The process of urbanization removes, fragments and isolates natural vegetation, replacing it with roads and buildings and then it also introduces exotic plants, predators and competitors to the native wildlife. The result is typically a landscape vastly different from the original, with the original vegetation often surviving only in small pockets scattered throughout the city. It is unsurprising that, given the dramatic impact that urbanization has on the natural environment, some animal species simply cannot make the transition into urban areas.

While a few wild animals are benefiting from our urban environment it is clear that the majority is in decline or have already disappeared. Many of our smaller animals require a shrubby understorey and rotting organic materials or the presence of remnants of natural forests near urban areas to survive and that is sadly lacking in a world of sterile crew-cut lawns and bewildering array of exotic trees and palms. The fragmented nature of our existing urban environment means that we can never really restore a natural wildlife community in our urban habitats, the only exception to this being the large remnants of native vegetation within urban areas where the original community is largely intact, and in the case of Darwin that is areas such as Charles Darwin National Park, Casuarina Coastal Reserve or Knuckey Lagoon.

Most people view their gardens as their property, a separate fenced entity belonging to them. So we think whatever we do with this plot of dirt is our business only. That is the classic homo-centric understanding of the world and underpinned by common property law. Not so however from a 'being' standpoint, in which no living entity owns anything at all with the exception of the space that they occupy within the confines of their skin at any point of time. You are a certain shape and volume occupying a clearly defined space within the universe and all that is within you, is under your control, well, minus the trillions of organisms such as bacteria, fungi and viruses that similarly own their own space in between your space of 13 trillion human cells. Perhaps the space an organism, such as a human or a bacteria occupies, could be expanded to the concept of 'habitat' which the dictionary defines as the 'native environment of an animal or plant' with 'native' meaning 'belonging to a place or thing by birth or nature'. I consider that every creature claims a right to the habitat it was born into and which it needs for its existence. Habitats are not equal. For some creatures they are huge and for others very small but in almost every case they would share such ownership with others. Our habitats are overlapping and connected. For example the odd cockroach in your house may never leave that space and so your house is its entire habitat and is shared with the human habitat which is a lot wider and includes the garden, your workplace and the landscape you move about regularly. Birds not unlike humans also have huge habitats usually spanning several kilometers or more and in the case of migratory birds entire continents. Even tiny creatures such as bees fly several kilometers to get to their favorite flowers. In any case it is quite clear that habitats, no matter what species of animal or plant overlap to some extent with the habitats of other species and are therefore shared and connected. Isn't it miraculous how nature maintains this complex interconnected web of habitats? Your garden is part of this story whether you like it or not. Perhaps you have concreted the lot but then it is no longer a garden just an inert slab of paving. The dictionary defines the term 'garden' as a 'plot of ground for the cultivation of plants'. However a garden is not just a collection of plants it is also a habitat for many trillions of creatures including microscopic living forms and also many millions of insects, perhaps a few birds and lizards and the odd mammal. So we see that a garden is not just a plot that you legally own it is also the 'being' space of a multitude of creatures. Most of the native wildlife is also protected by law just as is your right to your property. Killing a protected bird on your plot of land, because it happened to be too noisy and has annoyed you, could theoretically result in a heavy fine. Whatever happens on your land comes with some degree of responsibility and moral duty to care, that means your ownership is constrained. The Aboriginal culture of regarding themselves as integral part of the body of land has worked very well for thousands of years because it prevented indiscriminate treatment and exploitation of natural resources and nurtured respect to the land and its creatures. There is a lesson to be learned.

When the human species started with agriculture and the development of settlements and cities, we destroyed and disconnected habitat of countless creatures on a massive scale. In doing away with natural habitat we violated the resident creatures will to exist. You may say, just too bad, that's the law of the jungle. But the other animals don't destroy habitat that they don't belong to. Only we humans seem to do so as we take away and change it into something to suit ourselves. Our habitat used to be the jungles of Central Africa not to long ago, now it is the whole world and soon we reach out to populate far away stars and planets as well, just because we can. All of our actions have often fatal unintended consequences. We have failed to improve nature or contribute anything useful in any way but instead continue to exploit limited resources until the world is reduced to rubble. Make no mistake, this will come to an end as the science of ecology teaches us that ultimately we will all be suffocating in a sea of waste, disease and starvation in not too distant future. Everything in the web of life is connected and natural feedback loops unfold constantly according to universal natural laws. We have now figured that the burning of fossil fuels has increased atmospheric carbondioxide, which in turn traps more of the energy contained in sunlight, which in turn warms the oceans, land and air, which in turn melts the ice and releases even more carbondioxide and methane from the vast permafrost areas of the northern hemisphere, which in turn raises the sea levels even further, inundating low lying coastal areas and destroying vast amount of crops that are grown there. That is only a few of thousands of known and yet to be researched feedback loops unfolding at increasing pace and much faster than they would naturally.

Everything is connected and your garden is no exception. Every action or non-action has repercussions no matter at what scale they manifest. The proper action in relation to your garden from a 'being' perspective is to improve the patch over which you have control, so it supports as many creatures as possible without indiscriminate waste of imported resources while fitting harmoniously into the larger surrounding environment, that is your neighborhood and perhaps the remnant natural vegetation communities of your locality. The art of gardening in this context is to allow nature to do its thing after you have put he right plants into the right place, are recycling materials and nutrients naturally and otherwise interfere as little as possible. One practical example of how not to interfere with nature is frequent mowing of the lawn. Mowing the lawn on a frequent basis disrupts the connectivity of the natural world in more than one way. Not allowing the grasses to develop seed heads denies food to the little seed eating birds and also denies a large number of insects access to the resource for the required time. The lack of insects discourages the presence of birds and lizards that feed on them. A better option would be to divide your lawn and mow different sections on alternate weeks at a monthly or longer rotation. This way you provide a resource of grass at different stages, appealing to different types of creatures. For example Magpie Larks and Lapwings prefer short cut grass to feed on worms and the like, while the finches go for seed heads and the doves feel happier on the between stages. You will also cut the petrol usage of your petrol mower. Collect the clippings and use for mulch or put into a composting bin rather than to discard the valuable nutrients contained in it. Inviting the finches and other creatures back to your garden will connect you to their worlds by direct experience and will leave you satisfied of having done a little to help them to return where perhaps they were before. By drawing in wildlife, you connect with it, as simple as that.

STRUCTURE

A garden is a spatial living entity which is constantly moving and changing. Some plants are fast growing, usually short-lived and others take centuries to reach maturity. Some plants may get disease and suddenly die and others will affect other species of plants sometimes positively and sometimes negatively, known as companion plant relationships. Some eucalyptus species take ten years until they develop seed and over a 100 years to develop natural hollows the latter being critical nesting places for some birds and mammals. Some plants tolerate shade and wet conditions and others don't. In nature structure at any given time is a complex response to geology, land form and climate and expressed using terms such as land units, vegetation communities and habitats. Structure is reflected in patterns that can be observed from the air and analysed in terms of likeness as land units.

LAND UNITS

Land Units are defined as an area of land in which soils, landform (slope and aspect) and vegetation communities are relatively uniform and when looked at from an aerial perspective forming a distinct mosaic of like patches across the landscape. This patchwork has been surveyed for the entire Greater Darwin Area since around the 1970's by using aerial photography combined with field sampling of soils and vegetation. The consideration of land units can help to see how your patch of land fits into the bigger picture on a landscape scale.

The Greater Darwin Land Units have been determined as 37 distinct land units classified as follows:

Rugged Low Hills & Slopes: 1a, 1b, 1c
Undulating Rises and Side Slopes: 2a1, 2a2, 2b1, 2b2
Gently Undulating Upland Surface: 3a, 3b, 3c, 3d, 3e
Gently Undulating Low Slopes: 4a, 4b, 4c, 4d, 4e1, 4e2, 5f
Alluvial Plains & Drainage Lines/Minor Levees: 5a, 5b1, 5b2, 6a1, 6a2, 6b, 6c, 6d, 6e, 7a
Swamp & Floodway: 8a, 8b
Tidal Flats & minor Beaches: 9a, 9b, 9c

A full complement of digital mapping data and report is including a map is available through the web free of cost. Here is the download link:

https://ftp-dlrm.nt.gov.au/main.html?download&weblink=c918db0dffa5b17cd83e96cf8a75c7e4&realfilename=LandUnits_gtrdw_25.zip%0D

If you are familiar with Google Earth you can overlay the lines of units over your area of interest and so gain valuable insight for your patch of land and how it relates to surrounds. The updated data set relevant to Darwin is called 'Land resources Greater Darwin Area, 1984'. There is an attached technical description of the Land Units which will inform you about slope, soils and original vegetation as well as other aspects. For example I live within a patch of Land Unit 3c, typical for most of the suburb of Nightcliff with the following characteristics as extracted from the report:

“Land Form: Flat to very gently undulating upland surface with a gradient of 1-3%.

Soils: Shallow to moderately deep gravelly yellow massive earths, minor lateritic lithosols. Loamy sand to sandy loam surface grading into sandy clay loam subsoil. 20-40% ferruginous gravel in surface, 30-50% in subsoil. Well drained. The massive earths have developed on highly weathered parent material, and have undergone intense leaching during their formation. Soil nutrient status as a result is very poor. Available phosphorus and potassium as determined by bicarbonate extraction, and sulphur as determined by phosphorus extraction, are deficient. Available phosphorus is present usually at levels which average 4 ppm in the topsoil, potassium at 40 ppm, and sulphur less than 2 ppm. Total nitrogen was also deficient, with levels averaging .04% and not exceeding .1%. In the case of the massive earths 9 the binding agents of clay and organic matter are present at relatively low levels, with the consequence that soil erodibility is moderately high.

Vegetation : Woodland, minor Open Woodland; moderately large *Eucalyptus miniata, E. tetrodonta* and associated *E. bleeseri, E. foelscheana, Erythrophleum chlorostachys;* frequently well developed shrub layer with *Terminalia ferdinandiana, Xanthostemon paradoxus, Planchonia careya* common throughout; generally dense grasses including *Sorghum intrans, S. plumosum, Plectrachne pungens, Eriachne avenacea, Chrysopogon latifolius, Panicum mindanaense, Themeda australis"*

As valuable as such information is, it has to be taken with a grain of salt, because it represents generalizations at a relatively large scale that don't take into account smaller scale local variations. For example within the polygon extent of my Nightcliff Land Unit 3c, I know of small local depressions within the generally flat upland surface that concentrate run-off and as a consequence had in the past supported tiny patches of monsoon vine forest rather than the dominant Open Woodland. Such subtle variations are lost in the large scale mapping.

Equally important to the consideration of the land unit that your garden is located in are the considerations to adjacent land units because they will give you clues on what kind of vegetation and wildlife can be expected there. The land unit mapping data and information is particularly useful to larger landholders (over 2 ha) especially where topsoil, vegetation cover and landform have been retained post subdivision.

Generally the consideration of the links between soil types and vegetation community are useful. Although many Top End trees and shrubs are adaptable to a range of soils, better results can be obtained if they are grown in a medium similar to their natural substrate. For example in areas which remain wet throughout the year, organic matter has built up, due in part to exclusion of fire. In such situations (which include land units 2al, 2a2, 3a and parts of 6b), friable mottled yellow duplex soils have developed in which a highly organic loam surface soil overlies a clay subsoil. In the closed forest communities, around spring-lines and perennial streams, organic matter buildup is also quite considerable. These soils have a uniform clay textured profile, with a very dark, organic rich topsoil. They show a highly acid soil reaction trend. Monsoon and riverine vegetation that grows there has adapted to such soils which you should take into account when using such species in shallow highly leached dryer gravelly/sandy soils for example. Conversely plants from the woodland and sandstone escarpment may face difficulties in more fertile clay/loam soils mentioned above.

How should you use land unit information? First you identify what land unit your site is. The description of the land unit will allow you to understand about what soils and vegetation were present prior to development. Using my Nightcliff landunit 3c as example, if I were to to grow monsoonal vine thicket species I would be advised to add both clay and organic matter and perhaps phosphorus to my soil to help bring it closer to the natural condition that such monsoonal vine thicket species prefer or require. Alternatively if I wanted to restore the floristic makeup of the original vegetation the soil would be just fine depending on the retention of the original topsoil layer and absence of compaction between clearing and the present. The land unit survey will help you to understand the history, make-up and potential of your site and give you clues on how to improve the soil pending on intended use.

VEGETATION COMMUNITIES

While the concept of surveying land units mainly centers around soil and contour, the 'Remnant Vegetation Survey Darwin to Palmerston Region by John Brock, 1995' offers a more detailed 'botanical' snapshot of remnant vegetation communities within the two municipalities. Remnant vegetation here is defined as an area of land which contains native vegetation in a natural state. The area surveyed for Darwin Municipality and Darwin south region was 15,390 ha, of which 7,556 ha (49%) was identified as remnant vegetation (including mangroves and coastal flats). This represents a substantial bushland component however it is greatly reduced within areas of urban concentration where remaining bushland cover is only approximately 10 - 159 ha and especially in the Darwin' city peninsula where only less than 20 ha of native bushland remained at the time of survey. Since 1995 there was substantial urban expansion so it is likely that those remnants have shrunk even further.

Floristic groupings described in the survey were based upon the recurrence of recognizable species assemblages. Overall structure and life form classes are provided along with an estimate of the abundance of characteristic species. Mapping units were described by examination of the site data which included both interpretation aerial photography and on-site sampling of vegetation. The survey identified 42 distinct vegetation communities categorized broadly into the following groups:

Monsoon Rainforest	4 types
Mangroves	6 types
Melaleuca communities	4 types
Eucalypt communities	10 types
Lophostemon communities	3 types
Pandanus community	1 type

Riparian community	1 type
Mixed species woodland to shrubland	2 types
Herbland	1 type
Grassland	7 types
Sedgeland	3 types
Total	42 types of vegetation communities

While the survey and mapping data had been aimed at bushland management and rehabilitation projects by landcare, community groups and Government management agencies, they are also a good source of information and interest for small land owners that wish to model the landscaping of their gardens on specific floristic assemblies described in the report. It makes good sense to do so because floristic assemblies can appeal to wildlife more directly because of a wildlife's familiarity to it.

Monsoon forests in particular are of special interest since many people wish to closely emulate this type of shady vegetation in their gardens. Monsoon forests are 'closed forests' that rely on the Top Ends monsoonal rains in the wet season. During this time they develop a closed canopy of tangled branches, leaves and vines which shades the forest floor. However in the dry season they usually rely on a lesser quantity of spring fed water and in response many of the plants shed leaves to conserve water, This allows more light to penetrate to the forest floor. In the NT there are about 15,000 remaining forest patches amounting to just 0.2 % of land, all now threatened by the effects of increasing hot fires, weed intrusions and climate change. While small, these little areas are really important for fruit eating animals such as the Torresian Imperial Pigeon, Rose-crowned Fruit Doves, Figbirds, Yellow Orioles, Common Koels and Great Bowerbirds as well as a range of mammals such as flying foxes and possums. They are also displaying a high bio-diversity of plant species. The Aboriginal people traditionally protected these monsoon forests by carefully burning early dry season firebreaks in order to safeguard food and medicine resources important to them and only found in those patches. It makes sense to create a 'miniature' monsoon forest around your house as it generally helps to conserve energy by reducing air-conditioning costs, slow down run-off and facilitates out door activities in relative comfort. Given the effects of global warming, with Australian average temperatures already increased by at least 1.44 degree Celsius by 2020, we need to seriously consider protection from heat in the near to medium term future. The ambient temperature of the shaded Monsoon forest floor compared to open woodland is an estimated 10 degrees Celsius lower.

The report and data of the 'Remnant Vegetation Survey Darwin to Palmerston Region by John Brock' is publicly available for free and includes details the floristic makeup and location of the four local monsoon rainforest types. You can ask the friendly staff at any of Darwin city libraries to get a digital copy for you. The vegetation units in shape file format can be imported into Google Earth to identify the position of remnants relative to your property while the description of vegetation units are useful to be applied as a reference system in your design of the garden. For example you may be interested in creating a little version of the East Point Monsoonal walk in your own garden using species assemblies encountered there. An even more to date vegetation survey done for the East Point Reserve is also available from the Darwin City Council Online Resources Website.

HABITATS AND ECOSYSTEMS

As we remove more and more natural vegetation and as our climate changes, urban habitats are going to become increasingly important for many birds and other animals. When combined, domestic gardens are one of the largest patches of vegetation left in man-made landscapes as distinct from agricultural and industrial landscapes. Therefore they have potential to be important wildlife conservation locations. However our gardens are not always friendly to animals. We expose them to a wide range of potentially harmful disturbances and impoverished habitats that provide few resources.

The term 'habitat' is defined as 'the native environment of a plant or animal'. We should keep in mind the need to distinguish between habitat of an animal and habitat of a plant and not automatically assume they are linked. The city of Darwin released a booklet named 'Creating habitat for Darwin Gardens' which is a succinct and useful source of information about recommended native plants for planting in residential gardens. Here plant species are grouped into six habitats that of Monsoon vine thicket, Wetland, Riverine, Coastal, Sandstone Escarpment and Woodland. The guidance in the book gives the impression that by planting a number of plant species of a certain category we can create a habitat for the wildlife of a certain category. That is a little bit misleading because habitat is more than just an assembly of plants but also includes the soils, aspect, elevation and contour of the land, water regime and environmental conditions such as absence of pollution, absence of urban predators, absence of exotic plants and noxious invasive weeds, absence of light pollution and noise pollution all of which together make up a habitat for a species of wildlife. A garden is a garden, but can never quit be a habitat, the same way a painting of a landscape will always be just a painting but not the landscape itself. The ever present high frequency noise level in the urban environment relative to a natural habitat is extreme in some locations and therefore such urban areas can never become a true habitat for certain songbirds which rely on audible acoustic communication within a relative quiet environment. Habitats of animals can in many instances cover more than just one vegetation habitat and plant species too can occur in several habitats. In this sense reducing habitats down to seven categories as in the booklet 'Creating habitat for Darwin Gardens' is a an over simplification. There are many significant variations within a habitat some of which would fall in between any two of the seven classes. For example the Darwin Remnant vegetation survey mentioned earlier identifies four different types of Monsoon Forest, ten types of Eucalypt woodland and some other vegetation community types the latter which don't fit into any of the seven categories of the booklet.

Another source of information on Top End native vegetation and habitats is John Brook's comprehensive book 'Top End Native Plants' in which he uses a classification system of ten habitats which are described in detail and summarized in the books reference table. I highly recommend the purchase this book. John Brook describes several hundred native plants in terms of three wider habitats of Sandstone, Lowland and Coastal habitat which then further subdivided into two types for Sandstone (Woodland and Monsoon), five for Lowlands (Eucalypt Forest, Eucalypt Woodland, Wetland Streams, Wetland Floodplains, Wetland Monsoon) and three for coastal habitats (Beaches, Monsoon, Mangroves).

Be aware that the use of the word 'habitat' can be somewhat confusing since it is commonly used in the context of habitat for a single species (be it an animal or plant), or in terms of a specific floristic assemblies as well as in a wider sense as habitat of broad vegetation or land unit classes. Another modern word commonly confused with habitat is ecosystem, the latter defined by the dictionary as a 'community of organisms, interacting with one another, plus the environment in which they live and with which they also interact'. Generally habitat is the environment of a particular species whereas ecosystem is used in a wider sense and incorporating the native environment of many interacting species. For example a lake can be considered an ecosystem but a certain species of fish in this lake may only ever live in the deeper portion of the lake, its habitat.

Urban areas can also be considered as an ecosystem. They receive inputs from distant ecosystems, often from overseas, with considerable cost of labor and non-sustainable fossil fuel consumption while its outputs include toxic compounds or highly concentrated nutrients that disrupt neighboring and downstream ecosystems. Furthermore, whereas vegetation in natural ecosystems shades the ground, reduces surface temperatures, and facilitates infiltration of water into the ground, urban ecosystems replace most vegetation with impervious materials that absorb solar energy, create heat islands and increase runoff and flooding downstream. Yet the human that occupies those urban ecosystems tend to believe that they are somehow divorced from the natural world and out of ignorance are oblivious to such impacts until something goes wrong as a result of these practices that over exploit, undermine and alter ecological processes. Our alteration of ecosystem conditions inevitably impoverishes even fatally threatens future ecosystem conditions. Its web of interaction among species is so complex we simply do not know how a lack of any species will cascade through the ecosystem. Forests have considerable capacities to reduce local temperature and increase precipitation. This capacity is lost when forests are removed from the landscape, exacerbating global warming.

Ecosystems processes are largely controlled by the network of interactions among species that result in the exchange of energy and matter. The sequence of energy and material transfer from plant to herbivore to predator to decomposer is called a food chain. The integration of all food chains involving all species in the ecosystem constitutes a food web. The members of a food web mutually regulate each others populations through positive (mutualism) and negative (competition, predation, parasitism) feedback loops that contribute to sustainable primary production and the ecosystem services it supports. Insects are critical components of such food webs, consuming resources at trophic levels below them and providing food for a variety of insectivorous invertebrates and vertebrates at higher trophic levels.

Ecosystems typically develop through a process of ecological succession. Primary succession is initiated typically by pioneer plant species on new substrates resulting from volcanic deposits, sediment deposition, or erosion, whereas secondary succession is initiated following disturbances that leave legacies of soils, seed banks and surviving individuals from the previous community. Pioneer plant species typically are short but widespread, have high light, water and nutrient requirements, and reproduce rapidly in order to colonize other disturbed sites before larger, more competitive species overtop them and suppress them. Conversion of natural ecosystems to urban ecosystems or paved surfaces is one of the most extreme change in ecosystem conditions. Three-dimensional structure and low albedo surfaces increase local temperature, air turbulence, and vertical sheer. Urban heat islands can be as much as 10 degree C hotter than surrounding ecosystems. This effect induces stresses on plants, animals and humans which are now further amplified by global warming. Fungi and microbes decrease in diversity and abundance with urbanization thus decreasing decomposition rates. The construction materials and pesticides used in urban and agricultural areas and their degradation products (often equally toxic) subsequently wash into drainage systems to affect aquatic ecosystems downstream.

Gardening for wildlife seeks to remedy some ill effects of urban ecosystems at the small scale. Every bit on the individual level counts if they are followed by many as they all add up. We do this in practical terms by establishing a sustainable structure of vegetation, soil management and water management preferably sympathetic to the land unit and floral structure of your site and surrounding area. Designing our gardens we need to think in terms of creating 'habitat' for wildlife species but also by creating 'tiny ecosystems'. When we build a house with a roof akin to nature forming a mountain plateau in a flat landscape we increase runoff of precipitation to the surrounding area and so altering the moisture status and thus supporting monsoonal type vegetation rather than open woodland provided you retain runoff in combination with dry season watering. The same goes for an hard paved surfaces such as the driveway and swimming pool. Ecological gardening seeks to use such manmade alterations of landscape to advantage by catching runoff and channeling into the garden.

WATER

What is the story of water? Out of all state and territory jurisdictions in Australia, the Northern Territory is the biggest user of domestic water with an annual average household use of approximately 1500 liters per day. Half of that consumption is used on gardens. We also know that the average garden in Darwin is watered for half an hour every day especially during the dry season between May and October when there is close to zero rainfall during this period. Although the average Darwin household water consumption appears surprisingly high in view of natural annual rainfall exceeding 1700 mm it probably isn't when you look at evaporation rates. If you want to reduce your water consumption you can easily do so by reducing the amount of lawn in your garden perhaps replacing such areas with native tree and shrub planting either mulched or in combination with water-wise ground-cover plants such as herbs and native decorative grasses. The water savings from such action would help reduce the need for government to build more water infrastructure, A wildlife friendly water conserving garden is meaningful as a strategy to conserve resources.

Most native plants in their natural habitats in the Top End, unlike many water hungry exotic plants, are adapted to some degree to withstand a six month or longer dry period as well as seasonal flooding during the monsoon period. The degree of adaptability varies, largely due to differences of soil substrate and drainage between different habitats. For example plant species growing naturally in well-drained landforms are less likely to be able to endure water-logged conditions compared to floodplain plant species. Each plant species is unique in its response so either inundation or drought. Some species that naturally cope well with dry conditions in a well drained habitat or deciduous plants may not need any watering at all, others may be adaptable in that they can handle both wet and dry conditions at any time of the year and yet others may require watering throughout the year. You have to consider the need of each plant and best place them into your garden in areas with similar requirements. For example create a dry zones, irrigated zones and wet zones where you desire them and then decide what kind of watering technology would be best suited to them. You can consider hand watering, mobile larger sprinklers on tripod stands, stationary pop up sprinklers (where mowing is required), micro sprayers (planting beds) and drip irrigation (best suited for dry zones).

The structure of water as your specific watering routine is expressed in terms of amount applied, in its frequency and time of application and also in the natural rainfall pattern which varies substantially form year to year.

Apart from irrigation of vegetated areas, there are also water needs for wildlife both for drinking and bathing, particularly towards the end of the dry season when natural drainage lines, springs, billabongs and other water holding substrates or structures dry out. During this period, often called the 'build up' or 'troppo season' some of the more mobile wildlife in the vicinity of Darwin contracts to irrigated Darwin to literally find the relief in 'greener pastures'. During this dry period almost all types of naturally occuring food sources are sharply reduced including seeding grasses, fruits with some exceptions and the presence of insects. This is a difficult time for all creatures including birds the most mobile of animals. The influx of birds to Darwin from its surrounding areas and 'hinterland' competes with the resident population and so compounding the shortage of food resources. One of the best known examples in this regard is the annual migration of thousands of Magpie Geese towards the city of Darwin and its rural outskirts between September and December taking over grassed sporting ovals, public parks, school green grounds, mango plantations and even backyard gardens eager to source drinking water and anything edible. These iconic and intelligent birds usually arrive in a starved miserable condition, driven by instinct they have come to survive.

You can help such wildlife greatly by providing drinkers and birdbaths. I have at least three, two on the ground, simple flat shallow glass bowls loved by the smaller finches and doves as well as the smaller lizards and one on higher ground as a pedestal bird bath which appeals more to the honey, insect and fruit eaters.

FOOD

Ultimately every living and inert matter on planet earth can be regarded as an entity that can be eaten and taken into another entity's body for nourishment. Consider the whole of the crust of living organisms on planet Earth as a gigantic web of food chains where every living thing is part of series of organisms dependent on each other in their feeding habits and including humans. You are part of it during your life and even for a short period after death. There exist literally trillions of organisms at any one time within your body along with your own 13 trillion cells happily chewing away on your dead cells while you are alive and these organisms include bacteria, fungi, protozea, viruses and even worms in some instances. Constantly millions of cells are dying within you on a daily basis and being replaced by others through cell division in accordance with the unfolding of your genetic code. As this occurs inside your body the same story also unfolds on the inside and outside of every other body. The web of life as a whole consists of near infinite individual food chains resembling a giant digestive system (the living planet Earth) that is constantly recycling and changing itself in accordance with the natural laws of physics, chemistry and evolution. A backyard garden is a microcosm of this system and can be simple or complex depending on what it contains and how the contents are structured in relation to each other. For example insects are a dominant factor in topsoil formation on which the health of plants depends, the plants which in turn provide food for many other creatures in a temporal structured sequence of processes. For example wood provides food for fungi, termites and other insects, leaves and stalks provide nutrition for sap sucking insects and herbivores, flowers provide nectar and pollen for insects, mammals and birds and fruits provide nutrition for fruit eating creatures. Organic matter is picked up by bacteria, protozoa and countless other microorganisms. Even the air we breathe is full of live. One cubic meter of air contains approximately 100 million bacterial cells, almost unbelievable. Every living something, be it a bacteria or an animal on top of the food chain is in a state of constant growth and decline depending on the stage of its development and its ability to locate sources of nourishment within the extent of its perception at the location it currently occupies. All of these activities, trillions multiplied by trillions in number, happen simultaneously in a self regulating manner and resulting in equilibrium and apparent order. That simply is the reality of life on planet earth a marvelous kaleidoscope of foods that are constantly changing into new manifestations.

A beautiful and species rich ecological garden with a high complexity of food chains provides you with a wealth of knowledge and learning if you are willing to just sit down, relax and observe this spectacle of life unfold right in front of you. Compare the experience of such a garden with the one you get from a simple uninspiring crew-cut lawn with few, mostly toxic, exotic shrubs. Such a garden is sterile and lifeless because it lacks food and shelter to nurture diversity including on the microscopic level while the ecological garden is alive with diverse creatures especially in the soil. The lawn requires constant attention through mowing, watering and fertilizer applications all coming at an environmental cost elsewhere while the ecological garden recycles its nutrients in a natural way and on the whole requires very little input otherwise. While a lawn with clippings removed constantly draws nutrients out of the soil exacerbated through the leaching effect of irrigation, the ecological garden in stark contrast enriches soils with increased organic matter, leaf drop and animal droppings thereby encouraging micro organisms to recycle the nutrients back into the soil.

When we design our garden, analysis of the required structure of food is helped by considering wildlife in terms of broad nutritional categories that describe the natural diet of organism for example such as birds, insects, microbes such as protozoa and nematodes as well as fungi. The categories relate to the main foods normally eaten, however most species do not strictly fall into one particular category. For example many birds include insects in their diet in order to improve protein intake and also to have a flexibility to forage on something else in time of scarcity of their natural staple food with a tendency to eat foods they would normally not eat at all. The specific food requirements of bird, insects and other animal species are considered in the chapter animals. Below the categories of food consumption applies for birds for example.

- Insectivores: Many small to medium sized birds fall into this category, that is they forage largely on flying insects and invertebrates such as spiders, beetles, worms and snails, as well as insect larvae, manna, honeydew and lerp. In general, insectivores roughly consume an estimated fifth of their bodyweight daily in such foods.

- Carnivores: They live on vertebrate prey such as mammals, birds and reptiles
- Frugivores: Frugivores eat native fruits such as figs and Lilly-pilly (Syzygium spp) that contain high levels of carbohydrates including sugars which are readily digested, Frugivores have a simple digestive tract and rapid gut transition time, Fibre, skins and seeds are not absorbed and are excreted in feces. The fruit doves and fruit eating pigeons area strictly frugivorous. Most other species in this category are partially insectivorous or omnivorous. However nestling frugivores are usually also fed a high protein diet which include a large proportion of insects.
- Nectarivore: Nectarivores obtain nectar and pollen from flowering plants providing carbohydrate and protein.
- Granivore: They consume a variety of seeds from grasses, herbs, shrubs and trees. Seeds are the energy dense nutrient store of plants and contain a high level of carbohydrate in the form of starch, the latter considerably more difficult to digest than simple sugars found in nectar or cultivated fruits. These birds store seeds in the crop which allows hydration of the starch granules for breakdown by the gut enzymes. They also have a muscular stomach (gizzard) to facilitate grinding and digestion of their food. Most granivores also supplement their diet with insects and larvae which provide an important source of protein.
- Herbivores: Plant material, grasses, leaves, shoots and aquatic vegetation
- Omnivores: Any of the above categories of food can be consumed.

There are also some specialized foods that are not very well known, but important to many birds. These include manna, honeydew and lerp. Manna is the sugary sap that exudes mainly from eucalypts when sap-sucking insects pierce the leaf stems and branchlets. The sugary sap later crystallizes forming 'manna' and resembles white sugary blobs. This is an important from of carbohydrates and protein for many birds when nectar is scarce particularly honeyeaters and pardalotes, some of which also feed manna to their young. Honeydew is mostly excess sugar secreted as a waste product by sap-sucking insects and is an important source of food for all honeyeaters. Lerp is a sugary protective cover produced by psyllid larvae, an important source of food for many birds.

Insects are an integral part of the diet of many birds, mammals, lizards and other insects. If we categorize insects into broad nutritional requirements like we did with birds we will have to include extra categories because many insects consume foods that birds don't such as leaf litter, wood and many soil based micro organisms. This is an important consideration for the design of your garden. For example if you desire insect eating birds, lizards or mammals in your garden you will have to create a habitat for the insects they require as well, such as providing mulched areas, leaf littered areas with fallen rotting branches in addition to plants that attract insects and even more importantly you must ban the use of pesticides in your garden. Many insecticides don't discriminate from the targeted pest. Bees for example are very sensitive to pesticides which they can pick up from nectar or pollen and then feed to their queen possibly resulting in the death of the queen and thus the decline or even death of the hive. There is some anecdotal evidence that bees in particular are rapidly disappearing from urban Darwin possibly because of the excessive use of pesticides including termite treatments. Every plant or thing including poisons you put into your garden becomes a food source to something else. Generally we aim at providing greater diversity structured in a way that satisfies our objectives. Simply put, to attract diverse wildlife we will need to establish a diverse garden to provide many different natural sources of food.

On the microscopic level of microbes there is a lot going on, particularly in the soil, a drama that is totally invisible to us. Bacteria are eaten by protozoa, tiny unicelled organisms, which in turn are eaten by nematodes. There are also archaea, fungi, algae, slime molds, arthropods, earthworms and gastropods, all reliant on each other and crucially important to the development of a healthy soil that in turn supports healthy vegetation and the parts that are visible to us humans. A web of diverse life is not for granted indeed it is largely dependent on the nature of our management actions.

<u>SHELTER</u>

In a world where every something is a 'food' to be gobbled up by something else, safety from predation is equally important to other vital needs. You may have witnessed the sheer panic that hits smaller birds or mammals such as doves or rats when a goshawk appears in the sky with such startled animals instantly shooting off into all directions oblivious of windows, cars or anything else in the way of their escape route. Such existential threats and how to escape from them are deeply encoded into a creatures genetic code and known as instinctual reflex or fight and flight syndrome covering a wide range of behavioral patterns. Seeking refuge or shelter in the relative safety of dense vegetation is a common instinctual action perhaps because it has proven successful in a species survival and so as a behavioral instinct being manifest in a species genetic code. Seeking shelter in vegetation is not just a means of escaping predation it also can serve the purpose of protection from the elements such as heat, strong winds and heavy rain as well as providing a place to rest and for other quiet activities. For example birds seek shade during the warmest part of the day while scheduling feeding in the early morning and afternoon. The need for shelter varies from species to species and should be considered when designing the structure of your garden. Structure in this context includes aspects such as:

- The vertical range and position in the form layers of overstorey (over 8 m high, midstorey (2-7 m) and ground cover (below 2 m height) vegetation. Using birds as an example there is a clear preference of many species to seek out specific niches of vertical habitat with some birds living exclusively in the domain of overstorey, others feeding mostly on the ground but roost in trees and yet other spending the majority of their live in the relative safety of shrubs often coordinated with the whereabouts of their main foods. To attract a certain species you will have to create the niche it prefers.

- Textural and plant specific patters related to values for camouflage or as food source. Some birds have very specific needs such as the Mistletoe Bird, found only where mistletoes are present or the Crimson Finch found mainly in Pandanus woodland.
- Density of shelter determined by size and form of leaves and perhaps the prickliness of the plant, providing effective shelter for relatively small birds by plants that provide a solid mass of foliage from ground level to three meters or higher. When used for this purpose planted trees and shrubs close together are more effective than scattered plants.

In any case wildlife diversity is encouraged through the provision of a variety of shelter options and these are best considered in relation to the proximity of food sources. The specific requirements of each animal species are noted in the chapter 'Animals and their behavior'.

A general recommendation is to provide at least one area of overstorey with tall plants such as groups of palms and one or more larger canopy trees combined with a midstorey of fruiting and flowering shrubs or small trees while allocating other areas with dense clumps of shrubby vegetation bordered by ground covering plants such as creepers, native clumping grasses and perennial flowering herbaceous plants. Such or other strategies will also need to consider the distribution of sunlight. Very few Top End native plants will grow well in deep shade but quite a few of the local monsoonal forest species will tolerate part shaded areas. Other more specialized shelter options includes rocks, fallen logs or simply leaf littered areas especially when placed adjacent to ground cover plants.

BREEDING

The term nest is generally understood as a structure used by a bird for incubation and rearing of its young. However here I'm also applying it to 'nesting' of insects and mammals where they construct or use structures for breeding similar as birds do for example wasps or possums. Some birds also use nests to roost at night. Nests whether elaborate purpose built or natural structures such as tree hollows are critical 'breeding infrastructure' necessary for the long term survival of the animals that use them. They need to be structurally sound and hold together at least for the incubation period and in case of purpose built nests, made of the exact materials to a species specification embedded in the animal's genetic code.

Birds by instinct choose their location carefully not only to provide them with a source of food but also to find nest building materials and good opportunities to nest. The breeding season of many birds coincides with the peak flowering or fruiting period of their favorite food source and in the Top End that is in most cases the wet season between December and March. A breeding pair usually defends their site against intruders of the same species and it is mainly the male who warns others of their own species through his song and so improving the sites resources by reducing potential competition. If you happen to desire breeding pairs of animals on your property you may need to locate nesting opportunities in a more quiet location of your property away from food sources where possible.

There are a range of reasons why nests differ from species to species such as size of the animal, clutch number, preferred location of nests, resistance to bacterial contamination, structural strength to discourage nest robbing animals and very importantly, camouflage requirements. Many animals including birds show distinctive colorations and subtle markings that give them a protective camouflage that blends with the textures and colors of their preferred native plants and/or surfaces. For example birds who mainly live in the foliage of trees generally have olive or grey upper parts, while ground dwellers have earth-tone upper parts with patches of darker colors. This enables them to merge with stones, plant litter and dappled woodland shadows, Birds who live in grasslands usually have striated foliage. Birds that nest in tree hollows are generally brightly plumed, for example kingfisher and cockatoos using hollows in order to remain inconspicuous during the nesting period. Protective coloration is one reason certain plant species may be preferred nesting plants for specific birds.

Birds choose specific materials to for nest building and usually for a good reason. For example most finch species use spider webbing to tie up twigs and grass stems used to build the structure in order to strengthen the nest to withstand strong winds, rain and to deter nest robbers from tearing the nest apart. Many property owner remove spider webbing in their grounds or gardens resulting in a shortage or lack of spider webbing for nest building. It could be argued that as a consequence breeding success is impacted as nests without the webbing fall apart more easily. My advice is to leave spider webs alone not just for this reason but also because spiders, by trapping flying insects such as mosquitoes in their webbing, contribute significantly to population control of such insects.

Another example for the choice of material are leaves of certain plants that have intrinsic anti-bacterial and anti-fungal properties and if included in the bedding of a nest will reduce bacterial buildup from the feces of the baby birds.

Plants with dense prickly foliage are often preferred as nesting sites by smaller birds. Such plants do not support the weight of predators but at the same time provide dense cover and protection. In general most nesting sites ideally would have some protective cover to limit the exposure to predators.

A widespread and largely man-made problem in urban areas is the removal of old growth trees in conjunction with termite pest control measures. While such action may deemed to be necessary for public and personal safety reasons, it also removes or destroys the natural tree hollows or cavities critical for the breeding by many animal species such as tree dwelling mammals and a range of birds both large and small. Hollows are usually found in dead limbs of mature trees. Consider that it take a hundred years or more for such cavities and hollows to develop naturally often following the activities of certain termite species and other insects. As a consequence some of the animals that need such cavities for raising young such as parrots and lorikeets have nowhere to go and consequently are in decline in developed areas. We can enhance existing dead limbs of trees by creating nesting holes. The holes should face away from the sun. Alternatively you may install man-made animal specific nest boxes. The diameter of the entrance hole and the dimensions of the cavity determines which species of animal can use the hollow or nest box.

While the above focussed on the breeding aspect of birds, like considerations can equally applied to any organism including insects. For example butterflies tend to lay their eggs on specific plant species commonly known as LFP or larval food plants for each species of butterfly. Some boring beetles lay their eggs inside wood. Breeding requirements for each species are described in the chapter 'Animals and their behavior' while examples of specifications for nest boxes for some animals are detailed in the chapter 'Landscaping – Process and Materials'.

CLIMATE CHANGE

The changing climate is a dire reality although ignored by most people who carry on living in the business as usual mode regardless of consequences. At the time of this writing in 2021 the average annual temperature in Australia has already arrived at least at 1.44 C above since records begun in 1910. The frequency of heat events is sharply increasing and has more than tripled compared to prior 2000 and is doubling every decade for the past two. There have been 43 extremely warm days in 2019 according to the Australian Bureau of Meteorology. As mainstream Australia has painfully become aware during the fires in 2020, which caused an estimated 3 billion animals to die in Australia, there has been an increase in extreme fire weather and in the length of the fire season. Rainfall in the south-west and southeast has shifted to a negative 16 % while there was above average rainfall in the north and in Tasmania. Three quarters of the Australian hydrological reference stations show a steadily declining long-term streamflow. Sea surface temperature has risen by 1 C and sea level rise is 25 cm since the late 1900's. Such was the state of the climate in 2020/21. In August 2021 the Internationl Panel of Climate Change has raised the red alert by admitting that their modelling has grossly underestimated the pace and severity of changes and flagging some of the change to be irreversible already.

Humanity is apparently unable to take real and effective action and change the situation because of the tenaciousness of vested interests, the interests that control not only individual but also business and thus media and politics. Some of our best scientific brains predict the extinction of all of life on planet earth as the most likely outcome only differing in timing of such an event ranging from beginning in 2050 to the end of this century. We are ultimately looking at an 18 C increase of temperature and 50 m sea level rise mainly driven by the now accelerating natural feedback loops such as the melting of ice, permafrost and frozen methane in the arctic as well as cloud feedbacks. We may have already breached the so called tipping points from where natural processes take over from man-made greenhouse emissions which has initiated the 1.44 C in warming in Australia to date. There is no way we can stop the further rise of temperature in the next ten years in any case because it takes 10 years for a greenhouse gas molecule to travel from the earths surface where it was generated to higher atmosphere where it causes the greenhouse effect, the trapping of light. Since our emissions have steadily increased during the passed 10 years the global warming will likewise for at least the next ten years regardless of whether we manage to reduce our emissions or not unless of course we manage to somehow take the accumulated CO_2 out of the air.

Against this background of a rapidly warming climate it becomes imperative for us to increase shade in our gardens as the number one priority not just purely out of self preservation but also to help our wildlife to cope. Consider you may not much longer have the option to retreat into the air-conditioned comfort of your house since much of the electricity infrastructure in the Top End has not been designed to function properly at substantially increased temperature. Be prepared for frequent power outages in the near to mid term future, Many of our electronic devices struggle above 35-40 degrees and so do we given the added factor of humidity in Darwin. At times I have witnessed people not accustomed to local conditions collapsing suddenly in Darwin's hot and humid build up conditions. How would you cope if your job involves working outdoors? Some wildlife will not be able to adapt and simply disappear from Darwin such as our much loved Frilled Necked Lizards which rely on a certain temperature to determine gender of hatchlings, the same fate of other reptile species. Already our 'Frillies' no longer produce females in above average warm years. According to the science, the tropics now move away from the equator towards the poles at an average of 10 km per year. This means wildlife species too will have to migrate this distance if to survive. While photosynthesis is declining in the tropics despite higher carbondioxide levels it is increasing even more rapid in the 'greening' arctic and antarctic. Overall photosynthesis seems to be decreasing worldwide on average thus exasperating the rise of greenhouse emissions.

In a hotter world our water consumption will increase because of increased evaporation rates, apparently an increase of 6 - 7 % for every 1 degree warmer. After a couple of relatively dry wet seasons the Darwin Dam which is our main source of potable water has fallen to near 50 % capacity in 2020 as has the groundwater level of our aquifers. Can our cash strapped and deeply indebted authorities keep up supply or are we facing water restrictions and rising cost for water in the near future? The cost of water and availability will be an important consideration for your garden. You need to have trees with tap roots that are able to survive dry spells when future restrictions come into play. Consider it takes time to grow trees to establish a shade canopy, perhaps more than 10 years. In 10 years we may reach a rise of 3 degrees and perhaps more. It may pay to consider the installation of large water tanks to capture roof run-off in the wet to use as emergency water supply backup during the dry season should restrictions arise.

While the previous text has dealt with conceptual terms and issues the following will take you on a journey through five kingdoms of life that is Archaea and Eubacteria, Protoctista (algae, protozoa, and others), Animalia (animals that develop from embryos formed by fertilization of eggs by sperm including the human), Fungi (mushrooms, molds, and yeasts), and Plantae (mosses, ferns, and other spore- and seed-bearing plants). The text includes information on how these organisms all could inhabit your garden, their specific requirements on habitat and what the relationship amongst them is. You will learn many new interesting facts and be amazed about the wonder and complexity of life and how to improve their foothold and diversity in your own garden.

WILD ANIMALS & THEIR BEHAVIORS

The word 'animal' refers to any living thing of the kingdom of animalia, that is not a plant or member of another kingdom of life and includes us, the human species. Emerged close to 200,000 to 300,000 years ago most likely in Africa, humans dispersed in several waves, with the southern dispersal beginning 50,000 to 70,000 years ago. Both in Asia and Eurasia, 'homo sapiens (the wise man)' met with and interbred with more archaic humans such as the Neanderthal.

All the animals present in your garden excluding humans but including insects make up its 'wildlife'. The aim of this book is to provide targetted information on how to cater for a more balanced and diverse range of wildlife in a garden. To achieve this aim of creating gardens for wildlife we need to know the natural habitat and food requirements of the animal in order to provide something that resembles habitat. Importantly we need to become familiar with the animals habits and shelter requirements in order to faciliate its daily routines. Last but not least we should have knowledge of its nesting and breeding behaviors if we wish your wildlife to become fully resident.

But are we really talking about 'wildlife' any longer? We know from research that many 'urban' animal life forms are changing their behavior and to some extent also their physical appearance as an adaption to an urban environment that is very different from its natural habitat. The urban environment differs in that is is warmer (heat island effect), noisier, drier, poorer in biodiversity, more polluted with hazardous substances (pesticides, fumes and other chemicals) and featuring new introduced predatory species (cats, dogs, Cane Toad, rats and many other introduced animals) not found in their natural habitat. For example studies show that bird communication by calls and songs are changing both in frequency, intensity and content in reaction to the ever present loud high frequency background noise generated by traffic, air conditioning, parks and garden maintenance equipment (lawn movers, blowers and whipper snippers), construction activities and so forth. The adaption to their songs was found to transferring into their genetic code, meaning that the new generations of urban birds communicate in a different way than their 'wild' counterparts. And it is not just the adoption to noise, there are like adaption to foods in particular, nesting materials and locations, artificial light, movement patterns, predation and may other factors. Is it any wonder that we still have birds in cities at all? In the USA researchers found that light pollution altered bird reproduction. It showed the light pollution causes birds to begin nesting as much as a month earlier than normal in open environments. Normally breeding coincides with peak food ability but the consequence of this mistiming of nesting/breeding is that hungry chicks may hatch before food is available. How such effects play out in Darwin with local wildlife is unknown since to my knowledge no research has been undertaken on such factors.

Adaption of animal species to an urban environment differs markedly from species to species with some species, particularly animals with specialized niches finding it increasingly difficult to make a living and therefore commonly are in severe decline or have disappeared altogether. Others, the so-called 'generalists' are thriving as in the case of birds or exotic introduced species, more aggressive species with omnivorous tendencies and helped by a poor selection of fashionable hybrid garden plant species in combination with feeding to the extent of becoming a nuisance and frequently displacing smaller birds. While this has developed into a really sad state of affairs in some southern cities, urban Darwin in the Top End of Australia still has a healthy variety of wildlife, naturally helped by Darwin's relative small urban size and proximity of many surrounding natural bushland areas, the latter providing a genetic sink within close vicinity of the backyard gardens. When we design gardens to attract wildlife we aim at greater diversity through the provision of a range of niches which helps to help numbers of dominant generalists at bay. However here too there have been changes in the last decade and some animals are now disappearing locally, in my opinion mainly due to the concerted efforts to sanitize the Darwin landscape by removing all little pockets of bushland remnants. I have yet to spot any bees for many years now where I live, although they used to be present before. Sanitary efforts are suspected to remove healthy insect populations on which many other animals such as our Frilled Necked Lizards and many birds depend on. Termite pest control is applied without much consideration on other wildlife and so missing the fact that it also wipes out the populations that feed on termites such as ants and many other soil microbes. The effect ripples on resulting in sterile lifeless soils and poor wildlife diversity. But we still have some diversity although becoming more patchy.

The following chapters provide the most essential information on a range of selected resident animal species commonly found in Darwin's gardens in the broad categories of birds, butterflies, beetles, bees, other insects, spiders, reptiles, mammals and amphibians. I have excluded many migrating species, rare species as well as species unlikely to be found in gardens such as coastal wading birds for example. I have also omitted a detailed physical description of the selected animals since such descriptions have been dealt with in an excellent book; 'Guide to Wildlife and protected areas of the Top End' by Lindley McKay and published by the Environment Centre NT. I strongly recommend that you obtain a copy and use it in conjunction with the text that follows, particularly so since this first edition does not contain pictures of the animals. While this text provides information about an animal and its basic needs the real learning will commence with direct observation of wildlife in your garden or or in natural areas.

Nowadays very few people have this first hand knowledge and experience with wild animals and perhaps including 'livestock', because in an urbanizing world, wildlife and 'livestock' is being pushed out or killed and thus removed from us. That of which remains in the metropolis often becomes re-classified as pest or a nuisance by those that manage public areas. As the animals disappear from our direct experience they are effectively erased from our memory and replaced by symbols or signs such as words, pictures, books, 'Sir David Attenborough documentaries' and Youtube clips, all secondary copies without the original. This is the new 'fantasyland' of urban people eating dead cows, cows they have never seen in real life. Our organic atonement to the local wildlife and nature is thwarted by this ever increasing intercourse with secondary depictions of the real thing to the extent that we have become oblivious that through our lifestyle we contribute daily to the destruction of whole ecosystems and many nonhuman animals. In this 'fantasyland' animals are socially constructed by human words in a way that justifies their exploitation. Even those charged with the protection and management of wildlife are falling into this trap of treating wildlife in the language of a commodity such as by using the word 'harvest', 'capture', 'catch', 'eliminate' instead of killing or 'damage' instead of injury. I'm actually disgusted by such a language that contributes to an ideology that disregards or falsifies suffering. It's the language that describes the swollen liver of a force-fed goose as 'pate'. Wildlife are 'free-living non-humans' with a right to let them live in the way nature has intended. Oppression of animals is often justified quite literally as sanctioned by God through the much quoted verse from Genesis (1:28) where God gives humans 'dominion' over animals. Holy crap! Ask the billions of near crazed chicken crammed into tiny cages with artificial lighting and heat mixed with ammonia and dust. Many years I too was fond of eating eggs and chicken drumsticks but after taking care of a flock of chicken for a few years some decades ago, thus directly becoming a part of their lives, I changed my mind and became vegan as a result. Through hands on direct experience of chickens in my garden I realized that chickens are all individuals with minds and feelings just as we humans have. From there it did not take long for me to understand that all animals have intrinsic value of something in and for itself irrespective of its utility for the human animal. I no longer have chickens or a pet for that matter and instead prefer to offer habitat for wildlife rather than a cage for domesticated pets.

BIRDS

'Birds are defined as any of the class of warm-blooded feathered vertebrates with wings by means of which most species fly'.

Birds are the most conspicuous wildlife feature of any urban landscape that supports native species. Compared with most other animals their power of flight allows them to flee from any urban threats. As a group, birds are also the most tolerant to a new environment and because of their mobility the most easiest to draw into new habitats, provided the habitat offers something to a species.

THE STATE OF BIRDS

"Australian woodland birds, including many species generally regarded as common and widespread are declining at an alarming rate" (State of Australian Birds Report – 2009). Despite alarm bells raised back then, affairs have not improved but worsened. In the Top End Savannah south of Darwin, the trees may not have been cleared to a large extent like in the developed South, East and West of Australia, but Savannah is increasingly degraded by live stock grazing (in the NT cattle outnumber humans by 10 to 1), the effect which is exacerbated by invasive grasses in combination with inappropriate fire regimes in tandem with exacerbated by climate change. As a result seed eating birds continue to decline unless grazing, invasive pasture grasses and fire are better managed. Seed production is highly seasonal and there are few seeds available in the late dry to early wet season, lean times for most obligate seed eating birds. The protection of out of season grass species in particular is crucial for he survival of seed eaters. Since for every 100 ha of woodland cleared an estimated 1000 – 2000 birds painfully perish together with many other organisms, we must resist attempts to excessive land clearing, such as is planned for the proposed gas fracking infrastructure in the NT covering a proposed 200,000 fracking wells coming with a plethora of new access roads, another nail in the coffin for many birds.

Like all biota, birds express preferences for different types of habitat, some species show broad preferences, while other have narrow requirements. One of the perhaps surprising results coming out of recent research is that birds may not be fuzzy about the size or location of a patch of artificially created habitat as they are about the quality of the habitat that the patch provides. Birds show a preference for higher quality of created habitat but do not mind if it is close to natural habitat or isolated from it or if the shape of the patch is long and narrow or of a more round or square shape. There is greater bird species abundance in mixed species re-vegetation compared to monoculture. Some aspects of the quality of created habitat tend to develop with age such as canopy height, tree hollows, accumulated litter and woody debris. Creating habitat networks also has a significant positive effect of bird diversity within small patches. Interestingly 95 % of birds depend on insects to feed themselves and their offspring during breeding season. Bringing back wildlife to cleared abandoned sites or into developed urbanized areas is not as easy as simply planting trees, because individual species responds to different floristic and structural features and as a configuration also includes other associated specific biota such as insects, arthropods and bacteria and all of these features need to be considered in detail in the design of gardens for wildlife.

Council and government departments 'greening' strategies are of little value if plant species chosen are exotic and its planting diversity is structurally poor. Inevitable, such plant cover does not attract the right insects and does not provide shelter or roosting sites for native birds. The same applies to private gardens and multi-complex landscapes. We don't need non-natives and decorative plants from other states or countries to embrace a fashionable and decorative look.

THE VALUE OF BIRDS

Birds are the most obvious and frequently encountered wildlife found in man made landscapes. Whether taking a walk through a park or simply sitting in a garden, we have the opportunity to observe birds on a daily basis. They can be joyful, beautiful, funny, cute, melodic or raucous and provide us with an amazing opportunity to connect with the natural world, even that tiny bit just outside our front door. They play a myriad of important roles in an ecosystem, assisting with pollination, seed dispersal, the control of insects and the recycling of nutrients. Some do the gardening for us, turning over leaf litter and soil while searching for worms and other soil fauna. So valuable are they to the health of ecosystems, including urbanized ones, that their status forms part of the Australian Government's "State of the Environment" report.

Birds are very intelligent animals with complex behavior. As a group, birds equal or exceed the intelligence of mammals. Birds are also very sociable and engage in extensive context dependent communication through a range and rich variety of subtle signals relating to courtship and emotions. Local emotional signaling is often accompanied by visual information, such as the positioning of feathers and head to convene an unambiguous message of displeasure, fear, anxiety, anger and general arousal) and alarm calls (often functioning across avian species). The structure of such calls is usually short, repetitive and loud and may be understood also by mammals and other vertebrates. Such calls are usually given when a predator has been detected. Only a select group of birds are singers, called oscines or songbirds. Song can be a very important component in a females choice of mate, often the complexity of the song revealing that the singer is experienced and healthy by decoded messaging. Generally birds learn their songs but not their calls. Songbirds learn their songs by copying model songs heard earlier in their life while calls are decoded in their genetic code.

Mirror neurons in the brain allow birds, as well as humans, to understand and copy the behaviors of another. The primary role of mirror neurons is in action understanding. In essence that is understanding actions performed by others and in knowing what given actions mean. Birds are the only non-mammalian group to exhibit high amplitude slow wave EEG activity during slow-wave sleep. It suggests that when a bird is sleeping – as in humans and other mammals – memories are formed. Birds always contend with the risk of injury or death and reduce this danger by assessing environmental cues to avoid areas of elevated risk. Once predators are detected many birds use specific vocalizations that communicate the type of risk or level of danger and which elicit an appropriate response by receivers.

Passerines, or perching birds have evolved in and around Australia, spreading later to the rest of the world and are the most diverse of the known orders, with about 35 % of the earths bird species a number roughly equaling the number of mammal species worldwide.

From the time of hatching, precocial birds automatically peck at stimuli that resemble quite closely the food on which they will feed. Doves pick on small spherical objects that resemble grass seeds and ducks attention is driven to green objects. These are innate (inborn or inherited) preferences. Further learning modifies their preferences and the bird will learn to take other kinds of foods of different color, sizes and shapes. These modifications can be through social factors such as when a fledgling observes his mothers choice of food pecking. The mother may also make calls and picks edible objects to drop them repeatedly in front of the fledgling for example as with Bush Stone Curlews. Other learning occurs through food tasting. If something tastes unpleasant such items will be avoided in the future. This learning is by trial and error. By contrast, in altricial species, learning about food is often delayed after fledging, since they are fed by their parents. Social learning is also by observing the habits of other birds.

It is difficult to rank species on intelligence or comparing human intelligence to bird intelligence, since each bird is perfectly adapted to its own peculiar ecological niche just as humans are now well adapted to our world of mobiles, cars and our remote controls. All species are fine-tuned to function perfectly within their niche. Pigeons for example outperform humans when they are tested on a task to recognize rotated symbols. Humans have difficulty recognizing upside down faces while pigeons have not. If the measure of intelligence is to identify the nature of a problem and to develop a strategy to solve it, the ability of many birds are equivalent to those of chimpanzees for example. Birds also have excellent abilities to form memories and recall these memories after long periods of time. For example Clarks

Nutcrackers store many thousands of seeds in more than 7000 scattered locations and later they manage to retrieve the seeds with phenomenal accuracy. I would like to meet a human that is capable of a comparable feat of memory recall. Pigeons can learn to recognize over 600 different symbols and remember them accurately for several months. This is a remarkable feat of memory that would be difficult for many humans to perform. Thus, memory it seems is a very special and highly developed aspect of the avian brain. Smaller brains compared to larger brains are much faster especially when they are also more efficiently wired as with birds. The body weight to brain weight ratio in some birds is as low as 12 in 1, while in humans it is 35 to 1 being the same level as rats for example.

Birds have the equivalent of a forebrain. Its called the palladium and performs a surprising number of similar functions to the mammalian forebrain. Birds pack twice as many neurons per unit of mass into their brains as monkeys and apes do, bringing up the overall neuron count to a par with some primates with much larger brains. Because of the smaller brains and hence shorter circuitry processing speed is also much higher. It therefore comes at no real surprise, to know that crows acquire the ability to make tools and that it is likely that they have a mental image of the shape and function of the tool they need before they start to manufacture it. This would mean they have symbolic 'thought' the ability once considered to be a unique human ability. Pigeons for example are able to form abstract concepts which they use to recognize objects in many different contexts. They can recognize 'water' whether it is in a glass, as a drop on a leaf or in a lake. Pigeons are able to discriminate a photograph of water in these various context from photograph showing objects and scenes without water. Using key-pecking tasks pigeons have demonstrated that they have concepts of time and can count. However not all birds are equal. Our smartest birds are the parrots followed closely by the crows, bowerbirds and magpies and even small smaller birds such as honeyeaters. In the NT raptors such as whistling kites, brown falcon and black kites have learned to spread bushfires to flush out prey such as whistling kites picking up burning sticks and dropping on unburnt areas 50 m away to start new fires. Torresian Crows employ as many as 200 different vocal elements to communicate and genuinely appear to have a language, talking to each other all and every day. It is speculated they may even be able to put together sentences.

Birds are useful. Particularly in Australia, flowers have developed in such a way to ensure only the most suitable pollinators are rewarded with nectar, The movement of the Eastern Gondwana Continent resulted in rainforest giving way to Sclerophyll vegetation, the latter dominated by flowering plants that in turn produced huge amounts of nectar found in the flower of trees such as wattles, eucalypts, paperbarks and other. In Australia, honey eaters are major pollinators of many plant groups, including banksia, grevillea, melaleuca, hakea and of course eucalypts. In eucalypt trees, the flowers evolve to make nectar accessible for many bird species as possible. Most grevillea flowers, for example, have a network of fine hairs to protect the nectar from insects and save it for honeyeaters, their first choice of pollinators. The strong slender, curved beak of the honeyeater is able to push through the network of hairs or spread the restricted opening of flowers. When honeyeaters brush their feathers against the stamens or thrust their thin beak into the flower, honeyeaters are dusted with pollen, which they then transmit from flower to flower. Plants relying on honeyeaters for pollination have long tubular flowers and are usually red or orange, colors that are most clearly seen by the birds. Lorikeets have specialized beaks for nectar feeding. The lorikeet sweeps up nectar and pollen from the flower with its brush-like tongue, shallow flowers, such as eucalypts with their open cups of nectar surrounded by radiating filaments tipped with pollen, are pollinated by lorikeets as they can effectively access the nectar with their short curved beaks.

Many birds eat insects but how do they know which insects are good for them and safe to eat? Perhaps the birds take anything small that moves and sometimes they eat the wrong stuff and get sick or even die. For example many birds suffer or die after ingesting maggots which can be a carrier for the bacteria that causes botulism through transmitting a fatal toxin for which the maggot have developed a tolerance but the birds haven't. Even as little as three maggots can cause the death of a medium sized bird. Many birds rely on insects and sometimes their byproducts such as manna, honeydew and lerp as a source of energy and protein particularly during times when other food sources are seasonally scarce.

Insect-eating birds are also attracted to many native plants that are insect pollinated. The birds help cross pollination as they probe the flower for insects.

Some plants are not specialized and rely on a variety of insects and birds for cross pollination. Orchids are the most highly sophisticated, with each variety of orchid attracting separate pollinators. Pollination is sometimes carried out by the wind, as in the case of casuarina trees. In contrast to bird pollinators, bees cannot see red, but they can see colors that the human eye cannot detect (such as ultraviolet) They are most attracted to blues and yellows, which they can see at great distances. Some plants, such as the local Breynia cernua rely on moths for pollination. Their flowers are white, allowing the moths to see them at night and emit a perfume that helps the moth find its way to them.

323 bird species in total have been confirmed for the Darwin region so far, including vagrants and introduced species. Of these, only 19 are considered to be endemic to the Australian Monsoon tropics, including three species that are only found in the Top End of Northern Australia and neighboring Kimberly Regions in Western Australia (Rainbow Pitta, Silver-backed Butcherbird and Yellow-rumped Mannikin). Almost a quarter of the birds that have been recorded in the Darwin Region are associated with freshwater wetlands, located nearby to the east and south but these are not covered in this book since they are rarely encountered in backyards with the exception of a few.

Excluding vagrants and introduced or escaped species, 258 have been recorded in the Darwin Region.

Of this subtotal 105 species appear to be predominantly resident, although only 88 of them have been confirmed as breeding in the Darwin region. My selection of birds in this book includes 49 species of birds mostly residential and which in my opinion are the most commonly encountered in residential gardens. It is worth noting that the majority of Top End birds that feed on aerial insects are dry season migrants. The evacuation of Darwin by these birds before the first rains suggest that aerial insects become scarce during the Wet season, or that they are more abundant elsewhere at this time, all the more the case for encouraging insects in our gardens as strange this may sound to many of us. The information for the 49 species of birds as well as the subsequent animal chapters has mostly be adopted from just a few references including 'A guide to Wildlife and protected areas of the Top End by Lindley McKay' and 'Birds of the Darwin Region by Niven McCrie and Richard Noske 2015 and published by CSIRO'. All other sources of information are noted in the reference listing in the back of the book.

The order of information for individual birds follows the same sequence that is: Common Name, Scientific Name, Chart Reference, Order, Family, Size, Habitat, Status, Breeding, Habits and Notes. The chart number is a cross reference to a shorter version of information provided in charts under Appendices.

BIRD SPECIES OF DARWIN GARDENS

Magpie Goose (Anseranas semipalmata) 1.1

Order: Anseriformes (water-resistant plumage and mostly webbed feet)
Family: Anseranatida (Magpie Goose)

Size: Head and body 70 – 90 cm, adult bodyweight 1.5 – 3 kg

Habitat: Wetlands, floodplains and seasonally in cultivated areas

Status: The Magpie Goose is a very common visitor to the wider Darwin residential areas during the late dry to early wet season, being resident in the NT's Top End wetlands during the remainder of the year. This ancient species possibly evolved 66 million years ago through its ancestor order of 'Varanus', making it a relict of the time of dinosaur era and is Australia's most studied waterfowl. It is endangered in SA, vulnerable in NSW, and threatened in VIC and severely declining throughout south-east Australia due mainly to wetland loss and hunting. In the NT it suffers from lead poisoning due to ingestion of lead shot accumulated in mud of swamps. Lead shot is now banned in public hunting reserves but continues its use on aboriginal land. The government regularly releases a Magpie Goose Management Plan that guides hunting of geese, sadly akin ro controlled slaughter.

Breeding: The Magpie Goose breeds during Feb-May in the NT and maintains family units of dominant male and female and a secondary individual of either sex, often the latest offspring. Dominant pairs bond for life. The geese nest in colonies during in the wet season mostly in well vegetated swamps. A cup-shaped nest is constructed on a large platform of reeds mainly by the male. The female lays up to 16 whitish eggs. All adults of a family group incubate and feed the young for about 25 – 28 days, after the young leave the nest within a day of hatching and then are dependent at least partly on their parental group until one year old, when they begin to form pair bonds although not breeding. Females can breed at 2 years old and males at 4 years.

Habits: The geese are herbivores with a natural diet of grass seeds, wild rice, sedge rhizome and aquatic plants with foraging occurring in small groups and large flocks, sometimes many thousands when birds congregate at nesting colonies around rich food sources or permanent water in the late dry season. During the wet season the geese disperse within the region to feed on grass seeds in the expanded wetlands switching to bulbs of sedges that are the main food during the dry season. Feeding takes place in the cooler hours of the day. Typically magpie geese in the Top End move seasonally between wetlands with wild rice beds on floodplains when breeding during the late Wet, to wetlands with spike rush during the dry season, where they use their hooked bills to dig up bulbs mainly water chestnut. The late dry season influx of Magpie Geese into Darwin is driven by the drying up of subcoastal wetlands, as it becomes too dry to dig up the wetland plants and partly by hunting pressures as birds flee the wetlands when the hunting season gets underway.

Notes: Under certain conditions, such as accessible grassed areas and presence of mango trees, herbs or other suitable foods as well as drinking water, the birds also tend to venture into backyards and rural properties and stay there quite readily if tolerated. If you like these birds and have a large enough property with no dogs you can easily attract them between September and December particularly when also offering supplements of starchy foods such as grains of which they are very fond. You can use water and forage provision as a form of control. When fed these intelligent birds become incredibly attached to the feeder and quite tame with a tendency to stay on the property to roost on palms, large trees or flat roofs. They usually leave shortly after the first or second burst of monsoon in December or January to return to their breeding grounds in the wetlands. If they liked your place you can rest assured for them to return the following year. To me they represent the ultimate expression of vitality of wildlife in the Top End wetlands more than any other wildlife and for their awe inspiring resourcefulness and sheer tenacity. I respect the fact that have been around since the age of dinosaurs despite still being persecuted and shot in the Top End by the many tens of thousands every year by human predators of native wildlife and despite their natural habitats being heavily compromised by clearing for development and through weed invasion as well as climate change.

Orange-footed Scrubfowl (Megapodius reinwardt) 1.2

Order: Galliformes (Megapodes or heavy-bodied ground dwelling birds)

Family: Megapodiidae

Scrubfowls belong to the Megapodiidae, the only group of birds that do not build nests nor incubates, instead lay eggs in mounds of rotting and warming vegetation or warmed by volcanic activity, a similar strategy to those of reptiles. The birds test the temperature of the mound with heat sensitive tongues, palates or heads, and they adjust the mounds temperature by adding or removing material.

Size: Head and body 42 - 47 cm

Habitat: This species prefers monsoon rainforest and to a lesser extent mangrove edges but is now also common in Darwin's parks and gardens.

Status: It still is a common resident in the NT, but becoming either extinct and declining in parts of eastern QLD due to habitat loss.

Breeding: The exact timing of breeding is poorly known and can occur throughout the wet and dry season. Orange-footed Scrubfowl is the most widespread of the worlds megapods or mound-builders, birds that bury their eggs in mounds of decaying vegetation or sand, or lay them in burrows, to be heated by microbial decomposition or the sun, rather than incubate them with body heat. Nesting mounds can be enormous and reach up to 3 m in height often added on and reused over many years. Usually 6 but sometimes up to 12 eggs brownish eggs are laid at intervals of 9 – 20 days, buried in separate holes up to 1.5 m below the mounds surface. The male attends whilst the female lays and helps cover the eggs. Both birds carefully monitor the temperature of the mounds interior by digging a number of holes and testing the condition and if satisfied the female lays an egg and covers it up and leave it to incubate. Young hatch feathered as a miniature version of the adults, are independent and receive no parental care. The chicks have to dig their way out through up to 2 m of material before they reach the outside world and can take care of themselves immediately including the ability to fly. How incredibly tough is that?

Habits: They are mainly insectivorous but also eat some seeds and by doing much of their foraging during the early morning or late afternoon after which they move back into the cooler more densely vegetated areas during the hot part of the day. The birds scratch the forest floor to forage for snails, beetles, earthworms and other invertebrates.

Notes: The abundance and success of nest mounds in suburban gardens depend on the availability of leaf litter and the absence of cats and dogs. Scrubfowls have increased in numbers in the urban area since the nineties despite the chicks being very vulnerable to attack by cats. These birds can become very tame to people, especially when fed. Resident pairs maintain a permanent territory, although mounds are not always within a territory, but may change owners or be used by more than one pair. The birds roost by night in trees. I have a couple of pairs visiting our garden for a short period on a daily basis and often offer them a very small amount of rolled oats next to a waterer and when satiated they depart immediately and leaf the garden unscathed. They are prolific scratchers and therefore scorned on by some people. If you have a pair of these keen natural 'gardeners' you are advised to protect vulnerable plants (seedlings) with stakes or rocks. They make very soothing noises when happy turning quickly to a more animated scream when disturbed or fighting over territory. Because their territory is much larger than an urban garden you may want to make sure they have easy access through gaps under the boundary fence.

<u>Brown Quail (Coturnix ypsilophora) 1.3</u>

Order: Galliformes (Megapodes or heavy-bodied ground dwelling birds)

Family: Phasianidae (Phaesants and allies)

Phasianidae eat seed, green leaves and insects. Parents cooperate to build the nest, a grass lined depression hidden under overhanging vegetation.

Size: Head and body 20 cm, adult bodyweight 70 – 140 g

Habitat: Grassland, sedgeland, woodland and cultivated areas.

Status: They are a moderately common resident in the Top End but vulnerable in SA.

Breeding: During Feb - May up to four set of young are reared in a season and they may lay new eggs 17 – 18 days after the previous chicks hatched. Nests are shallow scraps on the ground, lined with grass or leaves , hidden in grass or other dense vegetation. Clutch size is 7 – 14. Only the female incubates for 21 – 22 days. The male guards the nest. Both parents feed the chicks.

Habits: Quails are herbivorous and to a lesser extent granivorous/insectivorous depending on seasonal availability of food sources with the diet including seeds of grasses, cereal crops as well as some herbs, leaves and insects. In Darwin you can find them mostly in woodland with grass cover and patchily around swamps and the grassy areas of saltflats bordering mangroves but they also tend to venture into the open during the early morning and/or late afternoon to forage. They can occur in groups of up to

30, occasionally alone or in pairs. They are resident in wetter parts of its range but also opportunistic to extend range if good rains promote lush grass growth. At night they roost on the ground.

Notes: You can encourage them into your garden by planting dense lumps of native seeding grasses and sedges if you happen to be located close enough to existing habitats especially in rural properties They then can become quite tame.

<u>Australian White Ibis (Threskiornis molucca) 1.4</u>
Order: Pelicaniformes (Ibises and spoonbills)
Family: Threskiornithidae

Threskiornithidae or Ibis has sensitive sickle or spoon-shaped bills

Size: Head and body 70 cm, adult bodyweight 1.3 -2.3 kg

Habitat: Wetlands, estuaries, mangal and urban parks.

Status: Both a common resident and migrant.

Breeding: This occurs mostly in Mar - Jul, usually in colonies, sometimes with other waterbirds. The breeding birds have long white plumes on throat and pairs bond for up to 3 years. They lay eggs in nests that are platforms of twigs in a tree or other vegetation over water. Up to 5 eggs are laid. At around three weeks old the chicks gather in groups on nest platforms. Australian White Ibis is able to breed at 2 years old.

Habits: Piscivore/Insectivore with a natural diet of small fish, frogs, crustaceans, insects, mollusks, and worms. They occasionally eat carrion as well as food-scrapes in urban areas and can be seen alone or in flocks. They roost in groups in trees near water. The white ibis has a similar diet to the other ibis species but also feeds on shellfish, holding it with one foot and breaking the shell open with his beak.

Notes: A casual visitor to backyard gardens, you can draw them in on a more regular basis, if your garden features a natural pond, grassy and mulched areas and adjoins irrigated parkland where they tend to congregate more frequently.

<u>Straw-necked Ibis (Threskiornis spinicollis) 1.5</u>
Order: Pelicaniformes (Ibises and spoonbills)
Family: Threskiornithidae

Size: Head and body is up to 65 cm with the adult bodyweight of 1.1 – 1.6 kg, slightly smaller than the Australian White Ibis.

Habitat: Floodplains, grassland, open woodland, cultivated areas and parklands.

Status: Common dry season migrant from South Australia with range widening where there is increase in cleared and irrigated land. Some birds stay resident.

Breeding: In Feb - May unless migrating to SA. Nests are platforms of reeds and rushes, usually in a reed bed surrounded by water. Eggs are in clutches of two to five and young gather in 'creches' when able to move around.

Habits: Piscivore/Insectivore with a diet of mainly aquatic invertebrates and insects but also some snails, fish and frogs. Most birds arrive in April or May and after reaching a peak in August the frequency declines. They can be seen alone but usually appear in small flocks to feed on small aquatic and terrestrial animals. They also eat carrion and human food scraps. After their Top End stay they usually migrate annually between coast and inland as well as between North and South Australia depending on resources, but some birds stay resident in Darwin. Flocks roost together in trees at night.

Notes: I have a few regular visitors turning up every year some of which have developed a liking for rolled oats flipping them graciously up in the air one by one and into his long beak. Firstly very cautious and shy they have become tame in time and come flying if they spot me. Straw-necked Ibises seem to be very smart birds, one of the few animals that have worked out how to kill the toxic Cane Toad, which they flip over to eat the non-toxic underside resulting in the local disappearance of the toads. The ibis was a sacred animal to the ancient Egyptians which mummified millions of the birds in special temples dedicated to the welfare and worship of this bird that for the ancients represented Thoth, the god of scribes, writers and artists. In Australia the ibis is know as the 'farmers best friend' for its ability to control pests in agricultural crops although together with the white ibis also receiving a bad rap in some urban areas for its foraging on garbage.

<u>Bush Stone-curlew or Bush Thick-knee (Burhinus grallarius) 1.6</u>

Order: Charadriformes (Thick-knees)
Family: Burhinidae

Size: Head and body 57 cm, adult bodyweight 530 – 860 g

Habitat: Woodland, open woodland, scrubland and grassland, common in suburban parks and sometimes residences where there is sufficient open space such as in rural properties.

Status: Still a common resident in the NT, it has become rare in SA and endangered in NSW where it is in decline due to loss of habitat.

Breeding: It breeds in May - Nov with pairs forming long-term bonds. They are very territorial when breeding. Nests are almost unrecognizable scraps on ground level and usually unfurnished. A clutch of 2 is produced with incubation lasting 21 – 28 days. Chicks move to a sheltered place soon after hatching and are looked after by both parents. If threatened, adults stay their ground when they have young, crouching over them with wings outstretched.

Habits: They are mainly insectivorous and forage for insects, spiders, snails centipedes, crustaceans and occasionally small vertebrates but also take some vegetation and seeds. Their distinctive bone chilling calls are a feature of Darwin nights. The bird is roosting during the day on the ground under a shrub or tree and coming out into open spaces to feed at sunset. They are often attracted to night lighted areas where they find and hunt insects. While they mostly forage on insects they have also been observed to take reptiles, frogs, mice and other nestlings. You find them usually alone or in pairs and sometimes in small family groups. During the day they sit or stand motionless often with eyes half shut in a shady spot.

Notes: I have been observing a resident breeding couple of these birds in our carpark for the past five years and they seem to successfully breed in any month and up to three times a year which is contrary to literature. Their nesting location varies according to time of the year seeking out a shady spot in seeming calculation of the sun's variation between dry and wet seasons. They are a truly impressive bird and you will never see them asleep because of their brains ability to operate continuously by shutting down one of the two brains spheres in alternating fashion, one side asleep and resting the other alert for predators, then switching sides. They are fierce in defending their young and I have seen them victorious in taking on a huge monitors as well as local cat and dogs, working in pairs and simultaneously attacking from opposite sides while raising their wings in threatening fashion. The predator then gets confused and decides to retreat. However out of the usual clutch of two they always seem to loose one chick before the young is able to fly away from danger which is usually 10 weeks out from hatching. The surviving young stays with the parents and get taught how to forage by getting live food dropped before them until they learn to kill and pick it up. The young get chased away when they are ready to be independent shortly before the next breeding cycle for the parents starts. These birds make a lovely addition to larger or rural gardens where they help to keep insects and small vertebrates under control.

Masked Lapwing (Vanellus miles) 1.7
Order: Charardriformes (Plovers and Lapwings)
Family: Charadriidae

Size: Head and body 34 cm, adult bodyweight 230 – 400 g, It is easily recognizable by its very unusual appearance with its bright yellow facial laps.

Habitat: This bird is at home in almost all habitats except in mangroves and monsoonal rainforest and is consequently found in most open areas especially in coastal areas, grassland, parks and gardens even car parking areas,.

Status: It has become a very common resident in Darwin but its wider Australian range too has expanded in the last century benefiting from increased cleared and expansion of irrigated areas.

Breeding: The bird breeds throughout the year but mostly in the wet season with nests tend to be located relatively close to water or are on green areas Pairs form long a term bond and may defend their territory when breeding and are very defensive of nest and young dive bombing potential predators including unsuspecting humans. The nest is a rather inconspicuous depression on the ground, unlined or lined with twigs and other materials with often the same site being used repeatedly over the years. They establish clutches of 1 – 5 but usually 4 and both sexes build the nest and incubate eggs lasting from 28 – 34 days. The birds leave the nest and start feeding themselves soon after hatching.

Habits: They are mostly insectivorous and forage on molluscs, worms, insects including larvae, crustaceans and occasionally seeds, plant material, frogs. Found usually in pairs, sometimes flocks if not breeding while foraging on the ground by day and night. They also roost on the ground at night and have a rather long live of 11 years.

Notes: You find them everywhere on large irrigated grassed areas in urban parks however less frequently if at all, venturing into adjacent smaller sized and fenced residential lawns. You may not want them to nest in your garden in any case because of their territorial defensiveness that would likely be extended to you, your children, your pets and other intruders. To me the young chicks seem to be incredibly vulnerable to aerial predation even with their parents on constant guard given the habit of foraging and roosting in open ground. If you want them to venture into your garden you should allow a gap between your fence and ground level to facilitate movement from adjacent grassed areas.

Brown Goshawk (Accipiter fasciatus) 1.8

Order:		Accipitriformes (Hawks, Eagles and Kites)
Family:		Accipitridae

Accipitridae have strong hooked bills and powerful clawed feet for seizing and holding prey. Their vision is stereoscopic as in humans but for some species the resolving power is eight times that of humans. All raptors can see ultraviolet light.

Size: Head and body reaches to 30 – 45 cm with their adult bodyweight being between 300 – 550 g. The females are larger than males. The collared sparrowhawk is similar in appearance and habits and are often mistaken for a Brown Goshawk from a distance..

Habitat: Woodland, floodplains, forests and open areas

Status: The are a moderately common resident and dry season migrant with a wide distribution in Australia.

Breeding: This occurs generally in Jul - Sept but also in Sep – Dec. A nest of twigs lined with green leaves is built in a tree, measuring 40 – 70 cm wide and 20 – 30 cm deep. 2 – 4 eggs are deposited and incubated for 30 days. For at least two weeks after the young hatch, the male provides all the food for the young and the female, passing prey to the female who then feeds the chicks.

Habits: Carnivorous, the Brown Goshawk's diet consists mainly of small birds, small mammals and reptiles which according to one study mammals make up to 88 % and birds up to 46 % much less for reptiles and insects. They generally target prey that are easier to catch, generally that is young, sick, injured or pregnant animals but also captive or domesticated birds and fish.

Notes: The goshawks in my location are pretty unpredictable, sometimes spreading their reign of terror over the smaller wildlife several times a day for weeks on end only to be absent locally for a similar account of time. I have seen them taking both rats on the ground and birds in flight and they do it at such great speed with the prey almost always dying on impact. From close up their yellow eyes are piercing and one can feel this birds intensity and fierceness. One day a young goshawk landed on my bird bath a meter away from me seemingly unnerved by my presence and went through his bathing ritual for about 20 minutes. They seem to know they are near the top of the food chain and have no fear, although sometimes smaller birds such as Lapwings and Magpie Larks gang up and hassle them enough to move away. They are a beautiful bird and although I like them, I also wish they were not here at my place, not because of the prey they take, but because of the unintentional 'collateral' damage they cause to fleeing birds crashing into windows, cars, fences, balconies and other hard objects causing permanent injury and sometimes death. However I also consider their goodness to be in their action to shorten the suffering of old aged and compromised sick wildlife that no longer has what it takes to carry on, while also helping along the evolution of what is strong and fast in a species to escape its claws. A good defense against the 'collateral' damage in urban areas is to provide sufficient clumps of dense shelter vegetation for the smaller birds to escape too and blocks of high canopy that limits a speedy linear approach.

<u>Peaceful Dove (Geopelia placida) 1.9</u>

Order: Columbiformes (Pigeons and Doves)
Family: Columbidae

The oldest found family of Columbidae goes back 25 million years. Pigeons and doves are small-headed birds and are generally strong fliers powered by big pectoral muscles that may make up to 1/3 of body weight. Pigeons suck up water rather throwing the head back to swallow like other birds and so reduce the time spent drinking that would increase vulnerability to predators. Both parents feed the young on 'pigeon milk' secreted by the crop, another distinct feature of this family.

Size: Head and body reaches 22 cm, corresponding to an adult bodyweight of 41 – 66 g.

Habitat: Eucalypt forest, woodland and suburbia, relatively close to water .

Status: Very common resident, the second most recorded bird of the Darwin Region.

Breeding: This occurs year round and seemingly at any time. The pairs bond for at least one season. Their nests are small loose platforms of twigs or similar material and 5 -10 cm wide, usually built in a shrub or low in a tree in which females lay 1 – 3 eggs while both parents build the nest, incubate and tend the young, incubation lasting two weeks.

Habits: They are granivorous, but in a different way to finches. Granivorous doves do not have strong beaks for de-husking seeds, instead swallow their food whole. They need grit (fine gravel) to aid digestion of their diet of small seeds of grasses and sedges which form over 90 % of their total food intake. Occasionally they eat leaves, buds and rarely insects and are foraging typically in pairs or small flocks that are resident or dispersing in response to rainfall. Doves forage on the ground. At night they roost in trees or shrubs. Along with several finch species, Peaceful Doves suffer food shortage during the early Wet Season in the Top End due to the scarcity of ripe or unspoilt grass seed, forcing them to switch to the seed of sedges.

Notes: To learn more about granivorous birds I fed a flock of resident Peaceful Doves and other small granivorous birds for some years between October and December, offering small amounts of commercial finch mix, the doves usually getting along well with the Double-barred Finch and Mannikins. It helps the birds to make it through this difficult time of the year and perhaps facilitates breeding during this time. An alternative to seasonally feeding grains is to grow certain seeding grasses, sedges or tropical grains in pots and let the birds harvest them. Watering of those pot grown grasses can be timed to seed when there is no seed elsewhere.

I love all the species of the Columbidae family including the local Peaceful Dove,, Bar-shouldered Dove and the Torresian Imperial Pigeon all plentiful in Darwin's backyards and which on occasion I have raised a few specimens in the past as part of wildcare activities. The doves are gentle as are most pigeons, they are also incredibly amiable, smooth and sweet voiced social birds, particularly the fledglings. Pigeons are likely human's oldest domestic bird with urban pigeons having lived near humans for at least 5000 years. They were important to the Sumerians where lifelike images of pigeons were drawn or moulded into figurines, associated with the Mother Goddess. Similar beliefs extended to Crete, Cyprus, were manifested in Roman coins and were part of the Greco-Roman society. The Sumerians bred white doves from wild pigeon populations. White doves were considered sacred by ancient civilizations, at times even worshiped. Mentioned in the Old Testament, it is believed that the Prophet Noah had a dove of peace. A reference to the white dove was also made in the New Testament. It is believed by some to be a symbol of the Holy Spirit. White doves are also a symbol of peace as well as love. A pair of white doves, male and female, still signifies love. On the whole, pigeons are friendly, loyal and passive. There's hardly a case example of pigeons aggressive towards human.

Bar-shouldered Dove (Geopelia humeralis) 1.10

Order: Columbiformes (Pigeons and Doves)

Family: Columbidae

Size: Head and body is 28 cm with the adult bodyweight reaching 110 – 150 g

Habitat: Mainly monsoon rainforest, mangroves and in suburban Darwin.

Status: Resident, it is the most common bird in the Darwin region.

Breeding: Occurs year round with the nest being a flimsy platform of twigs or similar material usually built in a horizontal fork of a tree or bush. Females lay two eggs. Both parents build the nest, incubate eggs and tend young, incubation lasting 2 weeks. Hatchlings are fed 'pigeon milk' produced by both the male and female. This milk is a liquid rich in protein with a fat content greater than that of milk. The liquid is produced by natural flaking off and liquefying of the skin in the birds crop.

Habits: Granivorous with a natural diet consisting of seeds and rhizomes of grasses, herbs and sedges, occasionally also leaves, buds and insects. They feed and nest in most backyard gardens and at times perch on power lines besides busy roads. Like the Peaceful Dove, this species often rests and nests in mangroves but does not feed in this habitat. It is usually seen feeding quietly in the gardens on the ground, often in mixed groups with Peaceful Dove and finches. It tends to stay close to cover and is rarely found far from water. It has a beautiful subtle coloring with black scalloping and rufous patches on the neck and on the wing.

Notes: Bar-shouldered Doves are probably one of the worst nest builders amongst birds and their nests tend to fall apart during storms in the wet season with nestlings becoming prematurely orphaned in some cases. Although doves seem quite social, when they mature the pecking order appears excessively tough and both the young and old are often treated with contempt at least from a homo-centric viewpoint. If you feed them a little bit it is important to spread their feed over a larger area on the ground to allow flocks to 'socially disperse'. It will prevent aggression, feather picking and perhaps reduce the potential spread of disease. I rarely observe any territorial food aggression if individual birds are more than a meter apart. A couple of doves that I have raised to this day still come to visit me every single day four years after being released back into the wild. The two wait patiently at the back door each day until I let them in to access their dose of seeds. Yet they are wild birds by any measure and I'm not allowed to touch them or worse move my hand towards their food bowl. However if I constrain my movements they often settle down next to me for a bit a short afternoon nap and watch with interest my activities such as working on the laptop.

Rose-crowned Fruit Dove (Ptilinopus regina) 1.11

Order: Columbiformes (Pigeons and Doves)

Family: Columbidae

Size: Head and body 23 cm with the adult bodyweight reaching 90 – 110 g

Habitat: Monsoon forest, mangroves, usually spring-fed rainforests, especially those with a high density of Carpentaria Palms with numbers reaching a high during the Wet Season when fruit abundance is also highest in these habitats, but they are also found nearby in open woodland in mangroves as well as gardens pending on fruit availability.

Status: A common resident more abundant in wet vegetated areas, vulnerable in NSW

Breeding: This occurs around September to February in NT on nests that are loose platforms of twigs and around 14 cm across usually situated in a tree or shrub. Females lay 1 egg but both sexes build the nest, incubate and tend the young with incubation lasting between 16 – 18 days.

Habits: They are frugivorous birds, normally in pairs or small groups and foraging in trees for fruit, where they climb nimbly and where they are well camouflaged. At night they also roost in the canopy. The bird is known to eat the fleshy fruits of over 30 species of rainforest trees (Purple colored fruit preferred) which in turn depend on the Rose-crowned Fruit Dove to disperse their seeds. They also eat figs. If you are able to find a fruiting fig tree in the forest you may see several pigeons arrive and climb around the foliage gorging on fruit.

Notes: I don't see many where I live, but if you are located close to one of Darwin's remnant rainforest patches such as Casuarina Coastal Reserve, Holmes Jungle, East Point Reserve or to mangroves and have a variety of suitable fruits to offer in your garden year-round you may have a better chance to draw them in. It may take some time for the fruit dove to discover the source but when they have there is a good chance to turn up frequently. Not only are they beautiful and ecologically important they also have a pleasant sounding call.

<u>Torresian Imperial Pigeon (Ducula spilorrhoa) 1.12</u>

Order: Columbiformes (Pigeons and Doves)
Family: Columbidae

Size: Head and body 31 cm, adult bodyweight 450 – 500 g

Habitat: Rainforest, mangroves, urban areas

Status: Common wet season migrant and in some cases also resident

Breeding: Occurring mainly in Aug - Feb, in the pre-wet/early wet season as single pairs in NT on nests that are loose platforms of twigs, sometimes lined with green leaves or shoots, 18 cm across and 8 cm and deeply built in a leafy tree. The relatively little nests are scanty and pairs will often share the same tree. One egg is laid in the nest built by both sexes, both which also incubate and tend the young. At least one adult guards the chick at all times with incubation lasting between 26 to 28 days. Local birds breeding in single pairs sometimes share their nest tree also with other bird species such as the Figbird, Magpie-lark and Friarbirds presumably to be advantageous for extra protection from predators..

Habit: These are frugivorous birds feeding on fruits of tropical trees and vines, particularly palms, figs, nutmegs, normally alone, in pairs or small groups. Its Darwin area population normally migrates to New Guinea in Jan - Apr although increasingly some birds remain in Darwin where numerous fruiting trees including the native Carpentaria Palm, Weeping Fig, Banyon and Umbrella tree provide out-of-season food. Migrating birds begin to return to NT in August. At night the roost in trees.

Notes: I often observe them to gobble up an incredible 30 to 40 orange-red Carpentaria berries in one continuous feeding and often wondered how they fit them all in. When they have young I see a switch to the fruit of the Umbrella tree and other smaller fruits. The young put their beak into the adult beak and take food by sucking action like that looks similar to sucking a straw. This can take a minute or more. It is a very lovely bird with deep black peaceful eyes, a most gently bird to care for. In Darwin all gardens should have some Carpentaria Palms if only for one reason, to experience the presence of this big white dove. Notably they are a prolific disperser of fruiting monsoonal forest tree seeds which is vitally important for the survival of this most vulnerable patchy habitat in the NT which is often threatened by a combination of fires and weeds. If they are a regular visitor to your garden you may notice a proliferation of germinating seedlings on the ground underneath their roosting, feeding and nesting sites, species such as Ficus virens, Grewia oxyphylla, Myristica insipida, Aidia racemosa, Alyxia spicata (not edible to humans), Diospyros maritima, Syzygium sp, Polyalthia australis, Carpentaria acuminata and Strychnos lucida, an indication of their favored fruits.

Little Bronze Cuckoo (Chrysococcyx minutillus) 1.13
Order: Cuculiformes (Cuckoos)
Family: Cuculidae

(Cuculiformes are solitary birds with zygodactyl feet)

Size: Head and body 16 cm, adult bodyweight 17 -32 g

Habitat: Generally live in forests with dense canopies, although the main habitat is mangroves. They are also moderately common in vine thickets, paperbark forests and other riparian habitats.

Status: Common resident

Breeding: This is a generally in Feb - Apr but also Jul - Nov. The Little Bronze Cuckoo are brood parasites that is the female cuckoo lays an egg in another birds nest (usually by Gerygone species) after removing one of the birds eggs from their clutch. When he cuckoo egg hatches it will eject all other eggs in the nest involuntary hosts incubate the egg of the Cuckoo for 15 days and raise the chick.

Habit: They are insectivorous and usually solitary. Feeding is mostly on small insects, larvae and caterpillars and sometimes on beetles and grasshoppers.

Notes: If your garden resembles Little Bronze Cuckoo habitat with a dense canopy and is located anywhere in the vicinity of the natural habitat patches, you may spot them occasionally in your garden to feed on insects although such birds would be very unlikely to breed there unless you also have one of the host species.

<u>Brush Cuckoo (Cacomantis variolosus) 1.14</u>
Order: Cuculiformes (Cuckoos)
Family: Cuculidae

Size: Head and body 21 cm, adult body weight 20 – 45 g

Habitat: Forest and woodland

Status: Common resident

Breeding: Occurring in Oct - Apr, Brush Cuckoos are brood parasites laying a single egg in the nest of another small bird, particularly dome-nesting Bar-breasted Honeyeater, Northern Fantail, White-breasted and Rufous-banded Honeyeater as well as Broad-billed and Paperbark Flycatchers all of which build cup shaped nests. The involuntary hosts incubates the eggs and when they hatch the cuckoo chick ejects the other eggs or chicks from the nest, leaving the unsuspecting parents to raise a single voracious youngster, which will eventually grown to twice their size.

Habits: Insectivorous they are mostly after small insects, larvae and caterpillars and occasionally beetles and grasshoppers. Observed usually alone,and occasionally in pairs, this bird forages mostly in vegetation. The species appears to be largely confined to wet habitats such as rainforests and paperbark swamps during the Dry Season but spreads into open forest and woodland during the wet season.

Notes: Likely to venture into gardens to hunt insects if present in vegetation that resembles natural habitat.

<u>Barking Owl (Ninox connivens) 1.15</u>
Order: Strigiformes (Owls)
Family: Strigidae

Size: Head and body to 32 cm but sometimes larger with the adult bodyweight reaching 400 – 700 g

Habitat: Monsoon forest and edges, eucalypt forest, paperbark forest and urban areas, open woodland, riverine forest, occasionally monsoon forest, parks and gardens, rare in SA, vulnerable in NSW, threatened in VIC, declining in VIC and NSW due to loss of forests among other factors.

Status: Moderately common resident

Breeding: This occurs between July – September on nests in a tree hollow, where 1 – 3 eggs are laid on a bed of decomposed wood or other debris. Only the female incubates for 34 – 38 days during which time she is fed by the male. Later after the chicks have hatched, the female will also hunt.

Habits: Their diet is Insectivorous/carnivorous mainly consisting of mammals up to 53 % and birds up to 42 % and a secondary diet of insects. Barking Owls spend the day roosting quietly in leafy trees then as dusk falls, the male and female begin calling together before leaving the roost to hunt for mammals and birds, often retiring to the same roost the following day. During the breeding season the species preys on bird species as large as the Tawny Frogmouth, Sulphur-crested Cockatoo, Blue winged Kookaburra, Pheasant Coucal and Blue-faced Honeyeater as well as mammals such as the sugar glider and also bats and sugar gliders,. When not breeding insects are its staple diet. They are usually alone or in pairs, sometimes family groups and hunting mostly from a perch. It prefers large dense trees for roosting, under which can be found droppings.

Notes: Occasionally I see or hear one in trees along the Nightcliff foreshore but because of the general decline of naturally occurring tree hollows in urban areas their future breeding in urbanized Darwin is constrained.

<u>Tawny Frogmouth (Podargus strigoides) 1.16</u>
Order: Caprimulgiformes (Frogmouths)
Family: Podargidae

Caprimulgiformes are big-headed birds. Their large yellow eyes have a reflective layer behind the cornea called the tapetum lucidum, which cause their eyes to shine when torched at night, similar to some night-hunting mammals and reptiles.

Size: Head and body to 40 cm with the adult bodyweight reaching approximately 350 g

Habitat: Forests, woodland, urban areas, open woodland, riverine forest, shrubland, parks and gardens, less often in sparse tree habitats or denser forests. Their territory requirement average is a huge 20 – 80 ha per pair of Tawny Frogmouths and their ideal habitat contains nest, food and roost opportunities, requiring open woodland with plenty of roosting sites and ground cover that contain insects and small mammals.

Status: Moderately common resident, the Tawny Frogmouth used to be the commonest nocturnal bird in the Darwin region but now declining in many areas due to development and pest control measures.

Breeding: Occurs in Aug - Dec with pairs building a platform of twigs, featuring a shallow central scoop line bedded by leaves up to 30 cm wide and 12 cm deep usually in the horizontal fork of a tree. The female lays 1 – 3 eggs, which will be incubated by both parents. Both feed the young and incubation lasts 28 – 31 days. Protective nesting association is thought to exist with friarbirds and figbirds. Many chicks fall out of the nest and from the tree and die. The published attrition rate stands at 70 %. The parents will not feed the fallen nestling unless they are very close to fledgling state, both parents take part in incubation with the male consistently brooding during day time with a shift change to the female at late dark. after hatching chicks are already covered with white plumage that seen from above resemble eucalypt blossoms. Tawny Frogmouth exhibit a significant roosting preference for the coarse and dark-barked stringybark trees but will also frequent smooth barked, light colored gums. On the latter they will sit on dead branches which usually have a coarser structure and generally darker color.

Habits: They are mostly insectivorous, with daily consumption ranging from 40 – 100 g / day, depending on season. The 100 g biomass is the equivalent of eight adult house mice per 24 hours, a rather staggering amount. They eat mainly what humans regard as vermin in houses and as pests on farm and in gardens such as insects, beetles, moths (up to 78 %), spiders and centipedes (up to 18 %) and small vertebrates, frogs, lizards, mice (up to 4 %). As such they could be regarded as Australia's best pest control birds. Their plumage helps these birds to camouflage against their day roost site and enhancement by the Tawny Frogmouth's habit to adopt a camouflage posture consisting of stretching the head and body upwards and aligning them in the direction of the branch rather than at right angles to it, as well as sleeking down at feathers and closing their eyes to a thin slit. They remain motionless until the danger has passed, by day seen alone, in pairs or small parties, roosting on exposed branches, sometimes close to the ground. By night this bird perches alone, waiting to pounce upon invertebrates and occasionally small vertebrates. They can live for 13 years as a resident that maintains a territory while shifting roost sites frequently. Tawny Frogmouth and other nocturnal birds, rarely ever completely sleep and applying uni-hemispheric sleep, in which one brain hemisphere sleeps while the other remains awake.

Notes: There used to be one near Casuarina Beach at Casuarina Drive where the windsurfers park and then also some along Rapid Creek next to the waterpark area. If you are lucky enough to happen to see one of these very unique and interesting birds in your dog and cat free garden try to encourage them to return by planting fibrous barked trees that resembles their plumage closely such as rough flaky barked eucalypts. Not only are these birds very cute, they are not much bothered by human presence and are very capable pest controllers.

<u>Forest Kingfisher (Todiramphus macleayii) 1.17</u>

Order:	Coraciliformes (Kingfishers)
Family:	Alcedinidae

Size: Head and body reach 20 cm while adult bodyweight is between 95 – 180 g.

Habitat: Paperbark and eucalypt forest and wetland fringes with close proximity to wet areas preferred.

Status: Common resident

Breeding: During Sep - Dec in enclosed space. They probably pair for life. Both parents excavate the nest, incubate eggs, feed the young and may be assisted by the grown offspring of previous years. Nest are chambers 23 cm wide at the end of a short tunnel in an arboreal termite mound or less commonly, a tree hollow. Termite mound nests are dug by aerial ramming with the bill sometimes to the detriment of the bird. Birds may cling and hammer at the mound. 3 – 6 eggs are laid on the unlined chamber floor with incubation lasting 18 – 21 days. The species is known to engage in cooperative breeding in which young birds sometimes remain in the natal territory and helping their parents to raise more offspring.

Habits: They are mostly insectivorous foraging on small insects, larvae, sometimes small lizards, frogs and other vertebrates. Usually alone or in pairs and sometimes in small family groups they are active in low light and by day flying out from a perch to seize invertebrates and small vertebrates. Residents defend a permanent territory.

Note: Though rarely seen in suburban backyards the birds have been observed on the edges of ovals and other perches on powerlines. I spotted a few in urban parks, golf grounds, school grounds in areas such as Nightcliff, Marrara and Rapid Creek. If you live next to a large lush green space particularly one featuring arboreal termite mounds and water you may have a good chance to draw them into your garden especially if the birds find a source of insects and water there and have good perching opportunities.

Galah (Eolophus roseicapillus) 1.18

Order: Psittaciformes (Cockatoos and Parrots)

Family: Cacatuidae

Psittaciformes are large headed, fruit, seed and nectar eating birds with hooked bills, flesh tongue and zygodactyl feet (two toes forward, two behind). They nest in tree hollows. Cacatuidae are long-lived birds, some species recorded to live over 100 years in captivity.

Size: Head and body 35 cm with the adult bodyweight reaching 260 – 350 g

Habitat: Floodplains, eucalypt forests and suburbia

Status: Patchily common resident

Breeding: Although it occurs in Jan to Feb, it may also happen at other times of the year. Galahs mates for life and occupy tree-hollows lined with some green leaves or bark, seed parts or woodpieces. They lay 2 – 8 eggs that are incubated by both parents or the female alone with both parents feeding the young.

Habits: Galahs are mainly granivorous, usually foraging in flocks but sometimes alone or in pairs and mostly on the ground, but also in trees and shrubs, preferentially eating seeds but also fruit, nuts, shoots, roots and insects. They drink routinely in the morning or late in the afternoon. When a mate is found pairs group with other pairs from nearby rest sites and forage together. Pairs roost at the nest hollow year-round and may live up to 20 years in the wild. The number of Galahs in Darwin appeared to increase after 1974 when tropical cyclone Tracy thinned out the trees in the open forests surrounding the outer suburbs.

Notes: Occasionally a flock of galahs checks out our place particularly in the wet season. They look very intelligent with their big probing eyes and seem to be relatively tame perhaps being used to be around people in Darwin. However locally they are on borrowed time because of the general trend to remove natural tree hollows and cavities in urban areas by safety conscious local government tree lopping crews as well as garden owners.

Sulphur-crested Cockatoo (Cacatua galerita) 1.19

Order: Psittaciformes (Cockatoo)

Family: Cacatuidae

For comments on order and family see Galah.

Size: Head and body 55 cm, with the adult bodyweight reaching 800 – 950 g

Habitat: Paperbark forest and monsoon rainforest, shrublands, grasslands, gardens and parks.

Status: Common resident

Breeding: Usually occurs between May to Aug the breeding pairs mating for life. Pairs chew the inside and mouth of a tree hollow to their satisfaction and lay 1 – 4 white eggs in the unlined cavity on a bed of chips. Both parents incubate eggs and feed the chicks with incubation lasting one month.

Habit: They are mostly granivorous and forage alone or in small numbers, occasionally bigger flocks. Resident and seeking food on the ground or in vegetation they look mostly for seeds, but also fruit, flowers, roots, insects, apparently the introduced passionfruit Passiflora foetida and the base of Pandanus fruits. Typically they roost communally in large trees especially near water and may live over eight years in the wild.

Notes: I see them occasionally in the tree tops but as a larger and relatively clumsy bird on the ground they are probably somewhat reluctant to enter smaller garden spaces with limited vision to spot potential predators being constrained for a getaway. In any case it is not advisable to feed groups of these birds and encourage them to stay as they can damage trees, woodwork and wiring around your home and those of your neighbors with their chewing habits.

<u>Red-collared Lorikeet (Trichoglossus rubritorquis) 1.20</u>

Order: Psittactformes (Old world parrots)
Family: Psitaculidae

Psitaculidae are colorful social birds of the tropics.

Size: Head and body reach 30 cm and the adult bodyweight is 120 – 140 g,

Habitat: Forests, woodland and suburbs

Status: Lorikeets are a very common resident and are arguably the most familiar and perhaps the most popular of parrots in the Darwin Region, The 'northern rainbows' are known as Red-collared Lorikeets because of the red collar at the nape of their neck as opposed to the green collar displayed by eastern-seaboard birds and were once considered a separate species, but are now recognized as a subspecies, one of four found in Australia.

Breeding: Mating for life their breeding occurs between January and October. Interestingly either male or females may form same sex pairs. Their nest is a tree hollow or cavity (preferably eucalyptus standing near water) with eggs laid on a bed of chewed-up old wood. Two eggs are laid. Only the female incubates for 22 – 25 days but both parents feed the chicks.

Habits: They are mostly nectarivorous with nectar and pollen taken from native flowers particularly eucalypts but they also eat small amounts of fruits, seeds and occasionally insects with foraging usually observed as small flocks largely in vegetation and occasionally on the ground. Like other lorikeets they have fine projections on the tongue tip known as papillae which aid in gathering pollen by extending during feeding and acting like a mop to remove pollen and nectar. When not in use the retractile bristles are folded away. The lorikeet diet is very energy rich and 2 – 3 hours of feeding a day is sufficient. The bird roosts communally excepting breeding birds, which roost in the nest hollow. Lorikeets may live over 10 years in the wild. They are highly mobile chasing unpredictable floral feasts from location to location. Each morning at daybreak they disperse widely in small flocks, sometimes traveling more than a 100 km on daily round trips. The tendency is for them to gather in large numbers in December especially between Nightcliff and Leepoint before they move back to paperbark swamps at Marrara swamps to exploit the nectar of the Broad-leafed Paperbarks which flower profusely during January. During the Dry season Red-collared Lorikeets apparently track the floral nectar of tree such as Darwin Woollybutt and Fern-leafed Grevillea. However during the early Wet Season when the nectar supplies in the Top End is low, lorikeets in Darwin have been found to feed mostly on the seeds of Coastal She-oaks and nectar or pollen from almost 30 tree species both cultivated plants and native eucalypts. Lerp, the sugary secretion of tiny sap sucking insects found on the leaves of eucalypts comprised 14 % of the diet in one study. The bird is also strongly attracted towards the mango fruit as well as the flowers of the Umbrella tree to be only the second most abundant visitor to the Umbrella tree after White-gaped Honeyeaters. The fruit of the Umbrella tree is also eaten but mostly by figbirds and fruit eating doves.

Notes: This colorful bird is both beloved and loathed. Loved for its beauty and liveliness by most people and loathed by a small minority of Mango growers that view this species along with the Sulphur-crested Cockatoo and Magpie Goose as a major pest of mango crops. Apparently lorikeets in urban Darwin, when they roost in large numbers also create a significant nuisance to humans through their screeching and droppings although personally I have not seen evidence of that. In my opinion, their goodness far outweighs the disapproving, after all its not the birds fault if the exotic mango is put on offer in huge irrigated mono-cultured crops that naturally tend to facilitate large bird fruit eating bird concentrations. We have a small group of Lorikeets in our garden annually feeding on a group of flowering Umbrella Trees as well as mango, mainly in the late afternoon and to me they are simply great fun to watch. If present in large flocks they reportedly take over nesting hollows and forcing out other birds as well as native mammals yet they seem to get along nicely when foraging with the friarbirds and other honeyeaters on the same trees. Because of the impending shortness of tree hollows a population explosion to nuisance level seems implausible in urban gardens. If you like these birds to become a regular visitor to your garden consider placing a Lorikeet nestbox and planting clumps of the local Grevillea pteridifolia, a prolific nectar providing plant between May and October together with a variety of paperbarks, eucalypts and also Umbrella Tree.

<u>Red-winged Parrot (Aprosmictus erythropterus) 1.21</u>
Order: Psittactformes (Old world parrots)
Family: Psitaculidae

Size: Head and body 32 cm, adult bodyweight 120 – 210 g

Habitat: Mainly eucalypt forest and woodland but also rainforest and suburbia.

Status: A common resident, the Red-winged Parrot is the only seed-eating parrot in the Darwin Region and is rare in South Australia.

Breeding: During Jan - Jul with some outside this period. They probably mate for life. The nest is a tree hollow, with 4 – 6 eggs being laid on a bed of decayed wood pieces. Only the female incubates for about 3 weeks. Both parents feed the chicks.

Habits: Although mostly granivorous, with the diet consisting primarily of seeds derived from acacias, eucalypts, shrubs and vines, the species also feeds on the fleshy fruits of a variety of plant species including figs, mistletoes and mangoes as well as sampling of flowers, nectar, insects and larvae. It is usually seen in small flocks or pairs. It can be a resident or as moving with the availability of food and foraging mosly in vegetation and only occasionally on the ground.

Notes: I spot them on occasion in the early wet season often along with figbirds, friarbirds and lorikeets sharing the odd fallen mango on the ground. They always strike me as a stunningly colored just as the lorikeets but are relatively peaceful to the point of shyness. Apparently they used to be more common in Darwin gardens but may have been displaced by the more aggressive lorikeets. If you want to attract them into your garden or extend their time of stay you should provide a variety of fleshy fruiting trees and vines mixed with wattles and eucalypts.

<u>Rainbow Pitta (Pitta iris) 1.22</u>

Order: Passeriformes
Family: Pittidae

Passeriformes include nearly 60 % of all existing bird species, with most are being birds that live on land, building a complex nest of interwoven twigs or grass, all hatch together, three forward unwebbed toes and one behind, the tendons in the leg cause the toes to involuntarily grip a perch.

Size: Head and body 17 cm

Habitat: Monsoon rainforests and dense riverine forest

Status: Common resident

Breeding: Breeding occurs mostly in Oct - Feb in the nests of domed structures of wooden sticks and other plant material built with a side entrance at the top of a tree stump or in the fork of a tree trunk, at an average height of 5 m above ground and less frequently lower. Objects such as feathers or wallaby scats may decorate the entrance. Nests are 26 cm wide and 22 cm high. The nest built by the breeding pair contains a clutch of 2 to 5 eggs which are incubated for 2 weeks after which the pair tends for the chicks.

Habits: This bird is insectivorous and feeds mainly on snails, insects and earthworms. A beautiful and shy bird it spends most of its time hopping around on the dense dark monsoon forest floor and scratching in the leaf litter for worms and snails their preferred food, sometimes bolder at dawn or dusk. It also eats other small ground dwelling creatures and occasionally takes fruit. It probably roosts in trees. The bird relies on seasonal abundance of earthworms in the Top End to feed its young.

Notes: Rainbow Pittas are known to occur in some suburban gardens particularly those that feature very dense planting of rainforest species over several adjoining properties, hereby shading out enough ground level and so providing benign conditions for this shy little endemic bird. Such gardens also tend to have very rich cared for organic soils full of mulch or leaf litter and containing earthworms the latter being an indicator organism for a rich and diverse microbial life. You are unlikely to find the Rainbow Pitta in gardens on sterile or compacted soils that have been treated with pesticides that tend to wipe out not only most of the microbes but also ants and termites and the range of organisms that feed on these. Sadly this is the case for most gardens in Darwin especially those in body corporate managed properties.

<u>Great Bowerbird (Chlamydera nuchalis) or (Ptilonorhynchus nuchalis) 1.23</u>
Order: Passeriformes
Family: Ptilonorhynchus

Size: Head and body 36 cm with the adult bodyweight ranging from 165 to 240 g. Males have a pink crest on the rear of the head

Habitat: Eucalypt forests, woodland and rainforests, parks and gardens.

Status: Moderately common resident

Breeding: It occurs during Sep – Jan with males using bowers for courtship. The bowers are made up by thousands of twigs beneath or near shrubbery adjoining open space and a tall tree to serve as a lookout for femals. Bower sites can be used for decades with multiple bowers constructed and reused under the same shrub. Piles of white objects such as shells, bones and pieces of plastic are arranged as decoration, and the internal corridor is usually aligned roughly north-south. When breeding, males spend a month tending their bowers before singing intensively for 5 weeks. Females then visit bowers where males display 3 – 4 times each day. The male postures and shows the female his pink crest, often holding a white display object either at the bowers end, or circling around it with a particular gait, as the female moves to keep the bower between them. While mating occurs in and around the bower, females build a nest elsewhere and provide all parental care. A loose bowl shaped nest is made from twigs, line with a few smaller twigs and leaves, 20 cm wide and 12 cm deep, in the fork of a tree. She will have only one egg and occasionally 2 – 3, with incubation lasting 2 – 3 weeks.

Habits: This bird is mainly frugivorous preferentially eating figs with a secondary diet of flowers, buds, leaves, seeds, nectar, insects, invertebrates and small vertebrates. Spotted alone or in pairs, small groups may congregate at bowers or fruiting trees, foraging in vegetation and the ground for fruit. They can live more than five years. The Great Bowerbird are incredible in that they build an architectural masterpiece, that comprises up to 2000 vertical sticks and an average of 600 decorations in order to attract a female and perform a two-stage audiovisual courtship display to entice the female into the avenue for mating purposes.. While fruit is an important part of the diet of the Great Bowerbird, the species is commonest in eucalypt woodland and riparian forest dominated by paperbarks, not known to provide suitable fruit in quantities.

Notes: I have seen bowers in habitats where I would normally not expect them such as vine-thickets in and behind foredunes but I think if the right combination of fruiting shrubs and trees are on offer they would also appear in suburbia on larger blocks of land and in areas where the garden is placed near reserves with remnant vegetation patches or parkland. Bowerbirds are the quintessential artists amongst the birds not only manifesting their own personal vision of what is artistic through the design of their bower but also with a sexual display that incorporates his bower into his dance by grasping the end of the bower and shaking them during displays.

Red-backed Fairywren (Malurus melanocephalus) 1.24
Order: Passeriformes
Family: Maluridae

Size: Being Australia's smallest Fairy-Wren, head and body measure 11 cm with adult weight reaching a mere 9 – 11 g. Breeding males are black with a scarlet back while females and non-breeding males are brown on upper parts and tail whitish brown below.

Habitat: Eucalypt forests and woodland and most commonly in areas with an understorey of grass as well as treeless grassland. Several surveys have shown that Red-backed Fairywrens prefer unburnt areas to burnt areas.

Status: It used to be a very common resident but now declining probably negatively effected by fire due to the removal of grass and urbanization.

Breeding: Manifest during Jan - Apr during the wet season with pairs mated for life. One or more birds (often the grown young of last season) may help with feeding the young. Courting males present the female with a red pedal. The nest is a domed structure, usually built in speargrass. Females build a side-entranced dome nest of plant fiber and spider web lined inside with other soft material, 8 cm wide and 13 cm high, usually well hidden in low grass or low plants, clutch 2 – 5, only the female incubates for 2 weeks.

Habits: Occurs in pairs or small groups usually foraging on grass or on the ground for small insects and occasionally some beetles, bugs flies, wasps, ants, spiders and other invertebrates. Resident, it defends territory when breeding and roosts by night in dense low vegetation. In the late Dry Season when much of the grassy understorey has been burnt the birds retreat to unburnt grasses often along river banks.

Notes: The Red-backed Fairywren has apparently not adapted to the urban environment although it can often be found on the fringes of suburbs adjacent to bushland or grassland. Many nests are destroyed by late Dry Season fires which may be why this beautiful little bird is becoming harder to find. They are also preyed upon by Goshawks, snakes and cats. These birds need understorey vegetation in which to conceal their nests. If such conditions are met provided you live near their habitat there is a good chance to draw them into your garden when you allow patches of grass allow to seed in rotation with cut areas and in combination with clumps of dense shrubby vegetation.

The 'old Darwin' just before and after cyclone Tracy contained many unkempt spaces of bushland, rich in herbaceous and shrubby cover. I have been witnessing these spaces to be weed infested first and then as a result of human reasoning turned into areas of lifeless slashed lawn or turned into gravel mulch if not incrementally cleared and developed for other urban or residential uses. Unfortunately bird species such as the Red-backed Fairywren depending on seeding grasses and dense low shrub cover were the casualty, simply being eliminated or displaced. The sad thing is, that this process of incremental 'growth and beautification' (speak natural habitat destruction) is going on everywhere where the human animal proliferates, seemingly unstoppable, with our ruling 'aristocracy' unwilling or incapable to effectively incorporate ecology into government policy for development. The disease of 'taming nature' is spreading, whether it is a small parcel of grassland cleared in the municipality for a new cafe or provinding a 'clean-safe' childrens playground. Thousands of parcels of natural bushland are planned to be cleared for fracking bores somewhere in the Beetaloo basin and elsewhere. The cause of the 'disease', 'the human pathogen' is spreading and so are the effects, manifested as pain and suffering of a quickly shrinking natural world replaced by an anthropogenic and mostly impoverished fabric of life.

<u>Dusky Myzomela (Myzomela obscura) 1.25</u>

Order:	Passeriformes
Family:	Meliphagidae (Honeyeaters)

Meliphagidae or honeyeaters which have brush-tipped tongues for extracting nectar. Honeyeaters are important pollinators of many Australian plants in the genera Eucalyptus, Syzygium, Lophostemum, Melaleuca, Grevillea, Hakea, Personia and others.

Size: Head and body 14 cm and an adult bodyweight of 8 – 12 g. The Brown Honeyeater is similar to the Dusky Myzomela but has a small area of yellow behind the eye.

Habitat: All forests and woodland but prefers the denser rainforest and riverine forest.

Status: Common resident

Breeding: Occurring all year, but mostly April – May during which a cup-shaped nest is built from bark, grass, other plant material and spider web, lined with grass or hair and 7 cm wide and 5 cm deep, suspended by its rim in the foliage of a shrub or tree. Two eggs are incubated in 12 – 13 days with the chicks hatching with plenty of down in contrast to other honeyeaters.

Habits: Mainly nectarivorous this bird also eats insects. It occurs in singles or pairs often congregating on flowering trees, foraging in trees and shrubs and feeding on mostly nectar. It may live more than 10 years and has a squealing song. Easily distinguished from other small honeyeaters by its uniform grey brown coloration lacking any markings or other color on the wings or head it has one of the longest bill relative to its body weight amongst the local honeyeaters reflecting the importance of nectar in its diet. However like most other honeyeater species it also takes invertebrates sometimes in the air to supply its protein needs so important for rearing its young.

Notes: They love to take a little drink throughout the day and have an extended bath late in the afternoon plunging repeatedly into the birdbath or other shallow water and then shaking off the moisture on a perch followed by preening feathers. Honeyeaters as a species are rarely territorial over a large area, rather they are territorial over a flower or a plant, even a tree and you see them often chasing each other and other species of honeyeaters but never resulting in injury as far as I'm aware.

<u>Brown Honeyeater (Lichmera indistincta) 1.26</u>
Order: Passeriformes
Family: Meliphagidae

Size: Head and body 14 cm

Habitat: All wooded habitats.

Status: Very common resident and are abundant in Darwin but rare in SA

Breeding: They breed during April to October with nests invariably built in shrubs, typically only 0.5 - 2 m above the ground. In suburbia even pot plants are sometimes utilized as nest plants. A cup-shaped nest is built from bark fibre, grass and similar material, bound with spider web, sometimes lined inside with softer substances, 6 cm wide and 5 cm deep usually in the foliage of a tree or shrub. Both sexes or only the female build the nest and the 1 -3 eggs will be incubated lasting 2 weeks with both parents feeding the chicks.

Habits: Nectarivorous, it is one of Top Ends commonest honeyeaters occurring in singles, pairs and groups. Resident and often noisy and active, it forages mostly in canopy for invertebrates and nectar, while roosting in trees and shrubs at night. The bird becomes more conspicuous during the dry season with their strident songs. The singing is only performed by the male. The males are distinguished by their grey heads and black gape, presumably to attract the female which is recognizable by her olive crown, yellowish throat, yellow gape and smaller size. Of all honeyeater species in the Top End, the Brown Honeyeater is the least fussy in habitat choice as a result they have adapted very well to urban gardens in Darwin and taking advantage of a profusion of flowering plants throughout the year.

Notes: Like most honeyeaters, this birds love to make a splash by plunging repeatedly into shallow water. If you provide a pedestal shallow dish birdbath next to some shrubby vegetation as a perch for preening after the bath, you will see this bird even if there are no flowering plants in your garden.

I have noticed the quality of nests in urban areas being very poor and I belief this is due of the lack of spider webbing compared with nests in natural habitats. Recently I have observed nestlings starving to death in my area possibly attributed to temporal scarcity of insects following pest control and other maintenance control measures.

Brown Honeyeaters seem not fuzzy about the type of flowers, small or large, or if from exotic or native plants but love variety as long as the flowers offer nectar. To attract this bird in numbers plant a variety of flowering plants throughout your garden aiming at temporal, spatial and floristic diversity while presenting nesting opportunities in dense foliage in understorey. More importantly promote the prescence of insects by allowing grasses to seed and by banning the use of insecticides.

Helmeted Friarbird (Philemon buceroides) 1.27

Order: Passeriformes

Family: Meliphagidae

Size: Head and body reach 34 cm which makes this bird one of the largest honeyeater of Australian mainland. The similar Silver-crowned Friarbird has a more protruding knob on the head.

Habitat: Mangroves, monsoon rainforest.

Status: Common resident particularly in the near coastal gardens of Darwin.

Breeding: During August to May, a cup-shaped nest is suspended from a forked branch by its rim made from sticks and similar objects, lined with softer materials 21 cm wide and 18 cm high. 3 – 4 eggs are incubated for 17 – 19 days and both parents feed the chicks.

Habits: Nectarivorous, the friarbird is the most common large friarbird in Darwin. It can be found alone but often congregates at flowering trees, eats nectar, fruit and seed as well as some invertebrates. It is often nesting in large trees on the perimeter of ovals and car parks. As well as consuming nectar and large insects, like mantids and cicadas, the Helmeted Friarbird, unlike the other friarbird species eats figs and other rainforest fruits and regularly raids pawpaws and bananas from backyards. African Mahagonies are favorite trees for nesting in suburbia.

Notes: I have observed friarbirds raiding my neighbor's hot chilli plants and was a little bit worried they would suffer, but to my surprise they returned the next day for more. One must assume they are either not affected by capsin or their gut transition is so fast they only digest the red fruit but not the hot seeds. They also frequent the Umbrella tree both for nectar and fruits. Like most birds they love to bath and splash on a hot day repeatedly plunging into the water.

<u>Silver-crowned Friarbird (Philemon argenticeps) 1.28</u>

Order: Passeriformis

Family: Meliphagidae

Size: Head and body 30 cm

Habitat: Mainly eucalypt forest and woodland

Status: Common resident in Darwin with range contracting in QLD

Breeding: During September to March the female constructs a cup-shaped nest of bark strips and other plant fibers, suspended from a forked branch by its rim and 11 cm wide to 10 cm deep. The 2 – 3 eggs are incubated for 12 – 16 days with both parents feeding the chick.

Habits: It is largely nectarivorous and often observed by itself but also congregates at food sources, eats nectar, fruit, seeds and some invertebrates. The Silver-crowned Friarbird is more common than the Helmeted Friarbird in outer suburbs that border eucalypt forests and woodland, the principal habitat of this species and is thought of as largely resident there. Reported observation of foraging at the Wildlife Park suggested that this species spent about two thirds of its time feeding on nectar and one third on invertebrates. Fruit is rarely eaten, so it visits rainforests infrequently unlike the Helmeted Friarbird. It also shuns mangroves except when the Star Mangrove is in bloom, at which time small numbers may be seen feeding on nectar alongside other friarbird species. It reportedly has a liking for banana flowers and the pandanus plants, the latter providing a source of invertebrates at its leaf-bases. The bird also loves the golden blossoms of Bridal Tree (Xanthostemon paradoxus).

Notes: I haven't spotted any of them where I live in Nightcliff

<u>Blue-faced Honeyeater (Entomyzon cyanotis) 1.29</u>
Order: Passeriformis
Family: Meliphagidae

Size: Head and body 30 cm, adult bodyweight 85 – 135 g, together with the local friar birds they are one of the largest of honeyeaters.

Habitat: Mainly eucalypt forests and woodland

Status: Common resident and has adapted well to urban environment in NT, but rare SA.

Breeding: During April to December pairs may be assisted by other adults in raising young. Nests are often built in the old nests of other birds but sometimes they make their own nest as a cup of bark strips of plant fibers, 15 cm wide and 10 – 17 mm deep which sits in the fork of a tree or other elevated position. The 2 eggs are incubated for 2 weeks and both parents feed the young.

Habits: Roughly two-thirds nectarivorous, nectar extracted from eucalypts, melaleucas, grevilleas and one-third invertebrates. Occasionally they take fruit from native and cultivated plants, usually in small flocks and sometimes in pairs.

Notes: They seem to be of a somewhat sly character and behave mischievous when around other similar sized birds, often probing reactions by fainting attacks.

<u>White-throated Honeyeater (Melithreptus albogularis) 1.30</u>
Order: Passeriformes
Family: Meliphagidae

Size: Head and body 13 cm

Habitat: Mainly eucalypt forest, woodland and paperbark forest

Status: Being a very common resident it is one of a very frequently observed birds of the vast savannahs across the Top End. However the White-throated Honeyeater is only patchily distributed within Darwin suburbs, probably due to its strong association with eucalypts that have been disappearing in this area.

Breeding: During April to September, a cup-shaped nest is made from bark fibre or other materials bound with spider web, 6 cm wide and 6 cm deep and usually attached by its rim to branches or foliage high in a tree. They normally have two eggs and are sometimes assisted by other adults from the group with feeding the young. They are also parasitised by Brush Cuckoo a bird twice its size,

Habits: Mostly nectarivorous, but feeds on invertebrates more than most honeyeaters. Like Dusky Honeyeater has a squeaky call, the bird usually occurs in singles or pairs, sometimes groups and forages mainly in the canopy for invertebrates and nectar. The species is more frequently spotted near remnant eucalypt patches in Darwins older suburbs.

Notes: One or two pairs grace our garden on and off throughout the year to drink or take a bath, their short beaks seem not to lend itself to some types of flowering plants but I can sometimes hear their distinct squeaky voices high in the canopy of River Gums across the road.

<u>Rufous-banded Honeyeater (Conopophila albogularis) 1.31</u>

Order: Passeriformis
Family: Meliphagidae

Size: Head and body 13 cm

Habitat: Mainly paperbark forest riverine forest/vinethicket and mangroves, less common in open woodland and monsoon forest, common in Darwin gardens

Status: Very common resident

Breeding: Year round except Jun - Jul.

Habits: They are nectarivorous/insectivorous usually observed in singles or pairs and foraging mostly in foliage for invertebrates and nectar, invertebrates more so than other local honeyeaters. With pairs occupying a territory year-round they are one of the commonest resident bird species in many if not most suburbs, where they occupy permanent territories as small as 1500 square meters and nest in trees and shrubs in yards. A short bill indicates the bird is largely insectivorous although it takes nectar when available. Like Brown Honeyeaters, this species happily nests in pot plants even when they are near major thoroughfares but their favorite nesting tree in Darwin is the local Black Wattle, commonly planted around parks and ovals.

Notes: Every once in a while I spot a timid Rufous-banded Honeyeater in our area, just wanting a drink or taking a bath and checking the scrub for insects while being here.

Bar-breasted Honeyeater (Ramsayornis fasciatus) 1.32
Order: Passeriformes
Family: Meliphagidae

Size: Heads and body 14 cm

Habitat: All forests especially paperbark forests preferably in a swampy environment.

Status: Moderately common resident.

Breeding: It occurs between October and May in nests of suspended domes with a side entrance that are built from bark strips, grass or other plant material and bound with spider web, sometimes lined inside with other substances. The nests measure 15 cm wide to 10 cm deep and are usually attached to the outer foliage of a paperbark tree. Both parents build the nest and feed the young and probably both incubate the clutch of 1 -3 eggs.

Habits: Nectarivorous, this bird is observed in singles or pairs and is sometimes congregating at rich food sources where it forages mostly in foliage for invertebrates and nectar. The Bar-breasted Honeyeater has a liking for paperbark trees. Apart from feeding on the nectar from the flowers of paperbarks more than any other local honeyeater, it constructs its large pendulous nest almost entirely from the bark of paperbark. The resemblance of the Bar-breasted nests to flood debris has led to the proposition that despite their large nest size, their architecture may be camouflage from potential nest robbers.

Notes: If you live close to a remnant natural patch of paperbark forest you are likely encounter this little bird in your garden and have an opportunity to make it feel at home by planting a few paperbarks. Although I have not encountered this species in Nightcliff they are found nearby along the length of Rapid Creek up to Marrara Swamp.

White-gaped Honeyeater (Stomiopera unicolor) 1.33
Order: Passeriformes
Family: Meliphagidae

Size: Head and body 20 cm

Habitat: All wooded habitats

Status: Very common resident.

Breeding: Year-round but mostly in January a nest is built in high trees such as African Mahagony. Cup-shaped it is constructed from paperbark, grass or similar items and is bound with spider web and sometimes lined with fine, soft grass, either near the ground or several meters up a larger tree. The nests are 9 cm wide and 8 cm deep. Usually 2 eggs are laid with the female incubating for two weeks. Both adults feed and brood nestlings. Old nests are dismantled and used to build new ones.

Habits: They are mainly nectarivorous and found in singles or pairs when searching vegetation and trunks for invertebrates, seeds, fruit and nectar. This bird may live for up to 10 years and in Darwin prefers suburbs where gardens are well established while in its natural habitat they favor the dense cover of rainforest of all types, vine thickets and riparian woodlands as well as Black Wattle groves. Like the Helmeted Friarbird, the White-gaped Honeyeater is partial to figs and other fleshy fruit when they are available, a fact that explains its affinity for rainforests. But its staple diet is insects and nectar which it gathers from a wide variety of sources.

Notes: I see quite a few of them, they seem to prefer larger flowers and more robust vegetation which is understandable given their relative large size. They tend to be noisy and aggressive birds often chasing others out of trees and away from food. They eat more invertebrates and fruit then most honeyeaters. I watch them forage on the small fruits of Breynia spp and Antidesma spp in my area. Another interesting observation in our garden is this birds habit of destroying the fragile flowers on exotic Moringa oleifera, ripping and pinning single flowers to the bark and then extracting the nectar, obviously not what nature intended since that action results in no pollination nor any fruit development. Brown Honeyeaters which I have also observed to feed on the plentiful nectar of the Moringa flowers display signs of territoriality on individual bushes often aggressively chase the much bigger White-gaped Honeyeaters away.

Striated Pardalote (Pardalotus striatus) 1.34

Order: Passeriformes
Family: Pardalotidae (Pardalotes)

Size: Head and body 11 cm, adult bodyweight 9 – 13 g

Habitat: Eucalypt forest and woodland, riparian forest.

Status: Very common resident.

Breeding: In May - Sep, this species digs a hole into earth up to 45 cm deep in the steep side of a creek or cliff, and after lining the nest chamber with grass, the female will lay her eggs. Although nesting in single pairs sometimes other adults may assist a pair with raising the young. Sites are often reused over the years. In a chamber at the tunnels end, pairs construct the cup-shaped nest of bark and grass and line it with fine material to 6 – 10 cm wide. 1 – 5 eggs are incubated and fed by both sexes and are hatching in 15 – 24 days.

Habits: This bird is nectarivorous with an important specialized dietary requirement of lerp, a carbohydrate rich secretion of small insects found on eucalypt leaves common to a nectarivorous diet. Feeding on psyllid larvae and occasionally 'manna', small spiders and insects usually it is by itself or in pairs when breeding and in small flocks at other times. Lerp is gleaned slowly and carefully from the leaves while also consuming some some nectar, seeds and plant material where available on the same tree. This species lives up to 6 years. Having spent the first three weeks of their lives underground, Striated Pardalotes spend most of their adulthood in the canopies of eucalypt trees, until it is their time to breed.

Notes: Cuttings of embankments for example a terrace, and soft mounds may provide suitable nest sites and entice them to become resident in your garden provided you are also approximating vegetation of their natural habitats.

<u>Weebill (Smicrornis brevirostris) 1.35</u>

Order: Passeriformes
Family: Acanthizidae

Size: With head and body measuring less than 11 cm the size makes it Australia's smallest bird.

Habitat: Eucalypt forest, woodland and scrubland, this bird rarely enters suburban backyards but is frequently recorded in fringing stands of eucalypts

Status: Very common resident but has declined in WA due to widespread clearing.

Breeding: Single pairs nest during March to September in rounded nests with a hooded entrance high on one side and made from grass and spider web, lined with feathers or other soft material, such as spider egg sacs and caterpillar skins. The nest hangs from denser outer foliage of dense trees or bushes and are usually 6 – 10 cm high and 6 – 10 cm wide. The 1 to 4 eggs are incubated by the female for 13 – 21 days and both sexes feed the nestlings.

Habits: They are insectivorous and usually spotted in small groups and foraging amongst the canopy for invertebrates and occasionally seeds. The bird may live up 6 years.

Notes: If you have a rural property with remnants of original or planted eucalypt trees you will likely to encounter this bird.

Varied Triller (Lalage leucomela) 1.36

Order: Passeriformes

Family: Campephagidae (Cuckooshrikes)

Size: Head and body 19 cm with wings and tail black in males and brown in females.

Habitat: Monsoon rainforest, paperbark forest and mangroves.

Status: Common resident in suburban gardens, especially where there are mature trees with adequate cover.

Breeding: Year round, the nest is a cup of plant material bound with spiderweb, 6 cm wide and 3 cm deep, in the fork of a tree branch. A single egg is laid.

Habits: Frugivorous, inconspicuous and usually seen foraging in the monsoon forest canopy for fruit, insects, nectar and seeds, picking insects and larvae off leaves and branches and eating small fruits such as Breynia cernua. Usually alone or in pairs, its adaptability to urbanized Darwin doubtless relates to its broad diet centered around insect and fruit. It is a regular visitor to fruiting fig trees in urban parks and schools and food items also include the 'Looper caterpillars' that attack Poinciana and Cassia fistula trees and the fleshy parts of Black Wattle seed pods. Varied Triller moves quietly through the foliaged canopy.

Australasian Figbird (Sphecotheres vieilloti) 1.37

Order: Passeriformes

Family: Oriolidae (Old World orioles)

Size: Head and body 28 cm, adult bodyweight 80 – 100 g, females are mainly brownish while males are distinctly colorful with yellowish chests, a red eyepatch and blackish wings.

Habitat: Monsoon rainforest and suburbia but can also be seen in open woodland. They are a common bird in parks and gardens

Status: Very common resident

Breeding: In Sep - Nov, figbirds nest communally with breeding colonies found in many suburbs of Darwin, in colonies of up to 20 pairs during the late Dry Season and reportedly also in locations where humans gather under large trees. The brightly colored males incubate eggs and care for chicks as do their more somberly plumaged and hence more camouflaged partners. Both sexes share parenting duties and extra males help to feed and brood the young. Soon after the young have fledged, the colony members disperse to take advantage of the glut of rainforest fruits during the wet season.

Habits: They are primarily frugivorous but also insectivorous and to a lesser extent taking spiders, seeds, nectar, small vertebrates. Usually seen feeding in small flocks and calling constantly to each other. They often feed on the red fruit of Carpentaria Palm as well as similar sized red fruit of Diaspyros spp (Australian Ebony), occasionally on opened mangoes lying on the ground as well as very small fruit such as Antidesma species. It is one of the most gregarious of all Australian songbirds with flocks of up to 300 birds forming during the early and mid-Dry season in the Darwin Region. Feeding flocks often congregate around fruiting Weeping Figs and Banyans. They also like the fleshy fruit of the Umbrella Tree. Although the species eats the fruit of a wide range of rainforest plants in the Top End, it has a particular penchant for figs and appears to seek them out across the landscape.

Notes: They cherish picking on fallen mangoes hopping around them together with friarbirds and Lorikeets. I have raised orphan figbirds on a couple occasions and felt that their habit of vigorous 'begging' head shaking and their big eyes starring at you makes them irresistibly lovable and enjoyable to care for. You can attract them in numbers at the beginning of the wet season when they disperse into feeding grounds including gardens if suitable fruit are ripe for picking.

<u>Green Oriole (Oriolus flavocinctus) 1.38</u>

Order: Passeriformes
Family: Oriolidae (Old World orioles)

Size: Head and body 28 cm

Habitat: Mainly monsoon rainforest and riparian forest.

Status: Very common resident.

Breeding: During September to March, the bark of paperbark trees forms the bulk of its large cup-shaped nest tied with spiderweb and other material and suspended from a fork in a horizontal branch of a tall tree, in pre-wet and wet seasons. The nest is 16 cm wide and 8 cm deep with a long tail hanging beneath and contains two to three eggs.

Habits: Primarily frugivorous, it is one of the most abundant birds in rainforest and vine forest patches of the Darwin Region. Quite shy, foraging amongst foliage for fruit, insects and nectar, Green Orioles are usually seen alone or in pairs including in backyard gardens where it is attracted to fruit trees such as pawpaw and bananas. Like Friarbirds, Yellow Oriole often eats the fruits of the Carpentaria Palms and other fruits such as those of Soap Tree, Alphitonia excelsa. They also occasionally feed on nectar, insects and even nestlings of small birds.

Spangled Drongo (Dicrurus bracteatus) 1.39

Order: Passeriformes

Family: Dicruridae (Drongos)

Size: Head and body 28 cm, adult body weight 70 – 100 g easy recognizable black bird with a forked tail.

Habitat: All wooded habitats.

Status: Common resident with seasonal movements.

Breeding: Occuring around October in the pre-wet/wet season, pairs construct a shallow hanging basket nest of loosely woven plant materials such as vine tendrils the nest looking like a hammock between the fork of a branch, with several points of attachment. Often situated high in a tree and out in the open nests are 15 cm wide and 10 cm deep, in a tree and containing 2 – 5 eggs. Both sexes build the nest, incubate the eggs and feed the young.

Habits: Insectivorous and occasionally feeding on nectar and fruit it is found usually alone and sometimes in pairs and eating mainly invertebrates that are taken them from the air.. The bird is known for its daring character and occasionally hassles other birds to take their food. Although insects are the main food item the spangled Drongo often visits the flowers of the Woolybutt and Fern-leaved Grevillea for nectar during the early Dry Season.

Notes: They have a very recognizable sweet song and calling and a rather stylish flight manner.

Northern Fantail (Rhipidura rufiventris) 1.40
Order: Passeriformes
Family: Rhipiduridae (Fantails)

Size: Head and body 17 cm

Habitat: Forests particularly in the vicinity of water especially perennial creeks.

Breeding: Thought to occur in the late dry and wet season. The nest is cup shaped with a dangling tail and is made mostly from bark strips bound together with spider web, 6 cm wide and 5 cm deep in a branch or tree containing 2 whitish eggs.

Habits: They are insectivorous and occasionally venture into gardens of older suburbs of Darwin, especially in areas adjacent to mangal or vine thickets. It perches, often for long periods before darting in the air after aerial insects.

Notes: I observed a few in riparian vegetation along the little creeks and streams in the sandstone escarpment in Litchfield National Park but very few here in Darwin although you should find these birds along Rapid Creek and in Casuarina Coastal Reserve.

Magpie-lark (Grallina cyanoleuca) 1.41
Order: Passeriformes
Family: Monarchidae

Size: Head and body 28 cm, adult weight 70 – 100 g, females have a white patch on the chest.

Habitat: Generally in grassland and woodlands, a minority of birds stay resident during the wet and nests are found in some suburbs, usually bordering ovals and schoolgrounds.

Status: Very common both as a dry season migrant and resident.

Breeding: Although observed in August to April they breed mostly in the wet season. The birds builds a cup-shaped nest of mud mixed with grass, 14 cm wide and 10 cm deep on a branch of a horizontal tree limb or other structures and deposit 3 – 4 eggs. Magpie-larks are also found in mixed-species breeding colonies which probably benefit from improved defense of nests from robbers. They will fearlessly attack any threat to their young.

Habits:They are mostly insectivorous, often seen alone or in pairs and sometimes forming flocks. While they feed mainly on invertebrates (small insects and larvae) they also takes small vertebrates and grass seeds as well as grains and foraging most on the ground, including shallows of waterways. Pairs defend a territory year-round and have been observed to mob predatory birds even outside the breeding season pursuing cats, birds of prey and cuckoos with persistent shrieks. Outside their usual forage they will capture and beat skinks, small bats and frogs to death, then tear them apart.

Notes: Once I found a juvenile with an injured leg limping to the outside of my backdoor and I started feeding him some insects as well as rolled oats the latter which he enjoyed greatly and dunking them into water. Hopping around on one leg it took this bird six weeks to full recovery. He came back the next year still remembering me and at times walking around proudly like he owns the place. When I sit outside and another Magpie-lark has a go at him he darts straight under my chair to safety, which says something about the intelligence of this bird. He has found himself a girl this year and our garden has become their territory.

<u>Mistletoe Bird (Dicaeum hirundinaceum) 1.42</u>

Order:	Passeriformes
Family:	Dicaeidae (Flowerpeckers)

Size: Head and body 9 cm, adult bodyweight 8 – 10 g

Habitat: All woodland habitats.

Status: Common resident, has declined in WA wheatbelt following widespread clearing.

Breeding: During the wet season this bird builds a pendant purse shaped nest composed almost entirely of plant down and silk from spider web and suspended from a twig, hanging limply when empty and being pear-shaped with a narrow side entrance and decorated with skins or pieces of insects and plant parts. The nests are 9 cm long and 5 cm wide containing 2 – 4 eggs which only the female incubates and both sexes feeding the young.

Habits: They are being primarily frugivorous feeders of mistletoe berries, the secondary diet consisting of fruits, nectar and insects. Mistletoebird is the principal dispersal agent of Australian mistletoes and the fruits form part of the birds staple diet. In the Top End, the birds have also been seen eating the fruits of several rainforest plants species as well as insects and occasionally even nectar. They are usually observed alone or in pairs, foraging in the canopy or flying fast between trees. The mistletoe relies almost exclusively on the Mistletoe Bird for colonization, and the bird in turn relies almost exclusively on the mistletoes for food and shelter. This bird finds the succulent sticky fruit irresistible to eat. Its digestive tract is specialized to eject the seed quickly, after digesting the fruit flesh. The habit of moving swiftly and constantly ensures that a good many seeds land on a host branch, where they readily germinate. The bird may live over 9 years. In Darwin the species is abundant possibly partly due o the widespread planting of Milkwoods and Cheesewoods which are sometimes heavily infested with Matchstick Mistletoes, a popular source of fruit for the birds.

Notes: In our garden we do get visits from mistletoe bird not only feeding on a few mistletoe infections but also on the small fruit of Antidesma spp., the plant species which is favoured by many frugivores in urban gardens. Most mistletoe species are also an important food plant for a variety of butterfly species who feed on flowers, flower buds, leaves and shoots of the mistletoe, the butterflies which include Delias argenthona, Eimocides margarita, Ogyris amaryllis, O. zosine, Birthana cleis and Hypolycaena phorbas. For this reason alone it is worthwhile to retain mistletoes and accept some damage to their host plants. You can attract colonization of mistletoes by planting Alstonia actinophylla trees which eventually will attract this bird in turn.

<u>Crimson Finch (Neochmia phaeton) 1.43</u>

Order: Passeriformes

Family: Estrildidae (Waxbills and allies)

Estrildidae are thought to have evolved in the last thirty million years along with grasses in Africa

Size: Head and body 13 cm, males mostly bright red, females red on face and mix of red and brown elsewhere.

Habitat: Woodland, grassland and wetland edges especially where pandanus is present especially at the margin of waterways.

Status: Common resident.

Breeding: Bonding tends to occur in the wet season and a nest is built almost exclusively by males and at times abandoned before the female has laid her eggs. The spherical nest is without an entrance tunnel built from Pandanus shreds, grass or other plant parts and lined with softer materials. The nest is 15 cm wide, and usually situated amongst the leaves of a Pandanus or another plant often above water.

Artificial structures are also known to be used for nest sites, mainly roof rafters The nest usually contains 1 – 8 eggs which are incubated by both birds for 2 weeks and both also feed the young. Crimson Finch is able to breed within their first year.

Habits: A granivorous resident it is usually observed in small flocks and occasionally in pairs. They eat mostly grass seeds but also take invertebrates, nectar, leaves and flowerbuds. The birds may live at least 5 years. No other bird shows such a strong affinity with Pandanus, not only as sites for nectar but also for roosting, foraging for insects and protection from raptors. Although mainly found in Pandanus and other vegetation around waterholes and rivers, following the first rains the birds may disperse into other habitats.

Notes: I see the odd one turning up venturing out from a few Pandanus growing nearby. The Pandanus fringed verges of Holmes Jungle is home to many of them from where they can easily observed.

<u>Long-tailed Finch (Peophilia acuticanda) 1.44</u>
Order: Passeriformes
Family: Estrildidae (Waxbills and allies)

Size: Head and body 16 cm with an red-orange beak.

Habitat: Eucalypt woodland and grassland, this bird is abundant in savannas across the Top End but small numbers also occur throughout Darwin foraging in vegetation fringing the beach and other grasslands.

Status: Modestly common resident.

Breeding: During February to November, the bird breeds primarily when seeds of annual speargrass becomes abundant. Long-tailed Finches build their grass nests in the canopy of eucalypts or in tree hollows at any time depending on food availability. Pairs bond for life but and nest in loose colonies although normally only one nest per tree. The pairs build a dome shaped nest with a side entrance, made from grass or other plant material, lined with softer grass, 20 cm wide and 15 cm high, usually high in the fork of a tree, but also occasionally in grass or bushes, tree hollows or in the base of nests of large birds such as raptors and contain 3 – 8 eggs that are incubated for 2 weeks.

Habits: Granivorous, the bird also consumes insects and termites although annual grasses form the most important part of their diet. During the first few weeks of the Wet Season, when grass seeds from the previous season has germinated and the coming crop is not yet ripe, the birds are forced to feed on both old and sprouting seed spending at least six hours per day foraging. Later in the Wet Season however they exploit the seeds of perennial grasses such as Golden Beard Grass which becomes abundant. Foraging mostly on or near the ground, at night pairs sleep together in a roost-nest which is a rough version of the breeding nest.

Notes: I have not spotted any in Nightcliff where I live but they should still be present in the outer suburbs and rural properties particularly if there are seeding grasses on offer during the late dry and early wet season when natural supplies of this food source are low.

Double-barred Finch (Taeniopygia bichenovii) 1.45

Order: Passeriformes

Family: Estrildidae (Waxbills and allies)

Size: Head and body 11 cm, adult bodyweight 8 – 11 g

Habitat: Eucalypt forest and woodland, mangroves and wetlands. It is the most widespread of our grass finches and is strongly associated with coastal riparian habitats. Unlike the tropical savannah specialized grass finches, the Double-barred Finch is largely sedentary. It is the most urbanized finch species in Darwin, even nesting in post plants on verandas.

Status: This is the most common finch in the Darwin area, although reportedly some population around suburban areas are declining.

Breeding: Mainly Jan - July, but at any time if conditions are good. Although it prefers nesting in dense foliage such as Turkeybush or Weeping Tea Tree the bird can set up nest anywhere else even palm trees as well as pot plants. Nests are domes or pear-shaped with a side entrance, made of grass or other plant material, lined with softer grass, 14 cm wide and 10 cm high. About 4 eggs are laid with both parents incubating for 11 – 15 days.

Habits: Granivorous, like the other finches this species have a stout, conical bill for de-husking small seeds from grasses and herbaceous plants, They are fond on green ripening grass seeds thus their diet consists of small seeds (>90 %) of grasses and herbs, occasional other plant material but also small insects. Commonly they are spotted in small flocks year round. They are very social to the extent of even sleeping together at night crammed into a roost nest which can be an old breeding nest or purpose built rough version. They are resident although sometimes undertaking regular or irregular movements pending on food availability. It may live over five years.

Notes: There are at least half a dozen breeding nests in the tops of small palm trees in our garden and I have observed flocks of up to twenty-five birds during September to December when natural food supplies are low and during which time I may provide them with feed (white millet, french millet, wild oats and canola seeds). They are a very lively bird however rarely seen quarreling amongst themselves and other species. Despite their tiny size and presumably brains they seem to be very intelligent and inventive even cooperatively working together in accessing food sources.

<u>Chestnut-breasted Mannikan (Lonchura castaneothorax) 1.46</u>
Order: Passeriformes
Family: Estrildidae

Size: Head and body 11 cm, adult bodyweight 12 -15 g

Habitat: They live in grassland, sedgeland and disturbed areas but also in dense sedges or rushes, mostly near water and occasionally in open woodland.

Status; Common resident although has declined in many parts of its range.

Breeding: During December to April this species nests in loose colonies sometimes with other finches with pairs mated for life. The dome-shaped nests with a side entrance are built from grass and lined with softer plant material and/or feathers built near the top of a clump of tall grass. The nest measures 10 – 20 cm in height and width and contains 3 – 8 eggs incubated by both sexes for 2 weeks,

Habits: Granivorous, they have similar food requirements to the Double-barred Finch however unlike many other grass finches which build small roost nests for sleeping outside the breeding season, the grassland dwelling Chestnut-breasted Mannikan roosts in long grass or reeds, often in very large flocks. They tend to make seasonal movements. Observations suggest they breed during the wet in small colonies, after which they aggregate into flocks that move towards the coast in the late Dry Season. As the wet approaches they disperse once again to breed though how far is not known.

Notes: There used to be a regular seasonal flock of about 50 to 100 mannikans feeding on seeding grasses behind the barrier along Nightcliff beach cliff near the swimming pool usually between October and January. When council contractors started slashing the grasses after an early rains at the beginning of October 2020 the flock subsequently failed to turn up here. If you want to attract Mannikans to your garden, grow native grasses and let them seed. I like this birds melodic calls that are easily distinguishable from any other bird. They get along very well with other finches sometimes seen foraging together. They like the other finches are also very fond of shallow waterer for bathing and splashing.

Rainbow Bee-eater (Merops ornatus) 1.47
Order: Coraciliformes
Family: Meropidae (Bee-eaters)

Size: Head and body 25 cm, adult bodyweight 20 - 33 g

Habitat: Airspace above all habitats.

Status: Very common dry season visitor with some birds resident.

Breeding: Observed during September to October as well as between May and July in loose colonies, the pairs may be assisted by other birds and dig a nest burrow 1 – 3 m long ending in an unlined chamber in sandy or soft earth, often in steep river banks or cliffs. 3 – 7 eggs are deposited and incubated by both parents for 21 days. Related birds will nest to each other. The young leave nest at about 4 – 5 weeks old and remain with the adults for another 4 – 5 weeks. The presence of Cane Toads has reduced breeding success in bee-eaters by taking over nest burrows and consuming eggs and chicks. Non-breeding birds roost in groups in a tree at night. They are known to survive only 2 years in the wild. Four weeks of growing up underground seems a weird start for a bird that forages in the air, but soon after emerging from its nest burrow, the young Rainbow Bee-eater is catching bees and other aerial insects and within a month is ready for migration.

Habits: Insectivorous, foraging mainly bees, wasps, occasionally dragonflies and beetles they are seen alone, in pairs or small flocks. Venomous prey is rubbed against a branch to expel the venom and the insects head is knocked against the branch. Some birds are resident, others spend winter months in New Guinea and may form large flocks before migration. They take flying invertebrates by cruising on the wing or flying out from a perch. The species roosts in dense colonies mostly located in Black Wattles or African Mahagonies situated in parks and school grounds.

Notes: Some bee-keepers consider them as having a big negative impact on their hives particularly in the Katherine area where bees are used to pollinate crops. The birds set up near a hive entrance in numbers for an easy pick.

Oriental Dollarbird (Eurystomus orientalis) 1.48
Order: Coraciliformes
Family: Coracilidae (Rollers)

Size: Heads and body 28 cm, adult bodyweight 96 – 180 g

Habitat: Woodland, forest edges and clearings including parks.

Status: Common late Dry and Wet season migrant

Breeding: This occurs between October and November perhaps extending to January depending on seasonal onset of the monsoon. Nests are unlined tree-hollows or often the old hole in a termite mound made by another species. 3 – 4 eggs are incubated by probably both parents and both feed the chicks.

Habits: They are insectivorous mainly feeding on flying insects, beetles, wasps, ants, cicadas and grasshoppers by flying out from a perch. The species is absent from Darwin for only three to four month, mainly from lat May to late August. They are usually seen alone or in pairs. After breeding some stay together in small family groups. However most birds migrate to New-Guinea and Indonesia leaving Feb -April and returning Sep - Nov.

Notes: I haven't seen any in urban Nightcliff probably because of a lack of tree hollows in this area, They may benefit from the installation of tailor-made nestboxes. The bird is normally attracted to tall well established trees in gardens. However many tall trees are now being cleared in new subdivision or removed or trimmed in existing gardens in order to reduce potential cyclone hazards so this bird may disappear from backyards in future. They have a good presence in local natural conservation reserves such as East Point Reserve towards Dudley Point and Casuarina Coastal Reserve.

<u>Torresian Crow (Corvus orru) 1.49</u>
Order: Passeriformes
Family: Corvidae (Crows, jays and magpies)

Size: Head and body 49 cm

Habitat: Mainly woodland, shrublands and grassland also rubbish tips, paddocks and cattleyards.

Status: Scarce resident

Breeding: It usually occurs from January to May but possibly at any time of the year. They are territorial and sedentary and form monogamous, permanent pairs with pairs building a bowl-shaped nest of sticks lined with grass and other soft materials, about 38 cm x 19 cm in the fork of a tree canopy or on a power pole or pylon. The clutch size 1 - 6, normally 5 with only the female incubating the eggs and broods chicks but both adults feeding the young. Incubation takes 3 weeks. After fledging the parents chase them away.

Habits: Omnivorous, they found alone or in pairs eating invertebrates, small vertebrates, seeds, fruits, food waste and carrion and at times road kill. The bird is well known as a scavenger in cities and towns across the Top End. The learning ability and memory of crows is considerable. Torresian Crows have figured a way to eat the potentially deadly Cane Toad with no ill effects by rolling the toads onto their backs and consuming the intestines and thighs, thus avoiding the poison glands on the head, a behavior observed in three separate regions of the Top End during 2002 only two years within the toad's invasion which suggest that the behavior was culturally transmitted among Crows. They can live at least five years.

Notes: I noticed a crow visiting our garden in Nightcliff on rare occasions to raid the nests of finches and other birds by simply tearing them apart.

This concludes the chapter on birds. If your garden faces the shore you may have an opportunity to observe resident and migratory shorebirds with a short walk to the beach, mangrove or mudflat. These birds are not covered in this book although it is worth mentioning that 28 migratory species make Darwin their home during the months of September through May. The most common include the Grey-tailed Tattler, Pacific Golden Plover, Ruddy Turnstone, Common Greenshank, Greater Sand Plover, Red-necked Stint, Great Knot, Whimbrel and Bar-tailed Godwit but are unlikely to be spotted in a residential garden.

You can use the information on birds to attract them to your garden? First you should observe and take note of the bird species that are already present in your garden. These birds are there for a reason and perhaps attracted to food sources, water, shelter and nesting opportunities or materials. Study their requirements and habits, the range of habitat requirements for a wild bird which are also relevant for urbanized birds. According to your personal preference you may either discourage certain bird species, desire different bird species or also to encourage your resident birds to stay longer and perhaps breed. In either case it is a matter of tweaking or re-creating your garden to enhance or change the floristic mix of your vegetation towards a natural reference system of those bird species that you want in order to encourage them through familiar plants, food sources, appropriate shelter and nesting opportunities. How to do that is explained in the gardening for wildlife part of this book.

Now on to an often overlooked component of gardening that is the world of insects and other arthropods. Together as a type of organism they have true omnipresence in the world and live in the air, water, on and in plants and more importantly in the soil but wherever they are, they play a hugely important role in the food web. First to a definition of arthropods.

ARTHROPODS

Arthropods are defined as any of the primary division (phylum) of segmented invertebrates (animals without a backbone), having jointed legs, as the insects, arachnids, crustaceans and myriapods. Of these, insects, the most diverse grouping, are defined as any small air-breathing arthropod with a body clearly divided into three parts and with 3 pairs of legs and usually 2 pairs of wings. Bees, ants and flies are insects, but spiders and ricks are not even though some people call them insects.

Around three quarters of all living organisms are arthropods including flies, beetles and spiders, although in terms of biomass they are behind nematodes and protozea. Arthropod is greek for 'segmented feet'. All arthropods have in common an exoskeleton made from chitin, the same material that makes up the walls of fungus cells. As arthropods grow they shed their exoskeleton and grown a new larger one.

Besides of being food for other members of the soil food web, soil arthropods are important to the community as shredders, predators and soil aerators. Fungal and bacterial activity is increased when arthropod shredders are at work because shredding gives more exposure to surface. While moving around the arthropods also act as a taxi to attached microbes. Mites and springtails are responsible for recycling 30 % of the leaves and woody debris on the forest floor. Mites are one of the soil arthropods to play a significant role in the soil food web, feeding on fungi and algae and decaying plant material and are thus a major recyclers and decomposer. Some types of mites are a major predator to most of any other arthropod in the soil and important to keep balance. Spring tails, known as soil fleas lack wings but possess a forked tail, that allows them to propel up to a meter backward out of harms way. They eat bacteria, fungi and decaying matter as well as nematodes and dead animal matter and in turn themselves are the favorite food of mites. Termites and ants shred and decompose organic matter and by moving mix surface and subsurface soil in the construction of tunnels and mounds. Ant and termite tunnels provide a path for water and air to get into the soil, and for other animals to move about as well as making it easier for roots to penetrate soil. An understanding on how to nurture a diverse range of arthropods and how to get them into your garden ultimately makes the difference between a great and a poor garden.

INSECTS

Insects are not very well understood at all nor appreciated by the average person yet they play a huge and vital part in the ecology of natural areas and life itself. With few exceptions, insects are perceived in industrialized countries as undesirable pests. In reality, relatively few insects interfere with humans or our resources. Most have benign or positive effects on ecosystem services, and many represent useful resources in non-industrialized countries. Some insects groups indeed are critical to sustained supply of ecosystem services that keeps life as we know it going.

"Insects affect virtually all ecosystem services in complex, often complementary ways. In fact human life on this planet probably would not persist more than a few months in the absence of insects and their contribution to ecosystem services (Wilson 1987)."

Considering our urban residential areas against the ecological context, that is the relationship of all organisms, I belief we cannot have a healthy garden without a healthy and diverse presence of insects. The term 'pest' has no meaning outside of human perspective or value systems. I propose the motto 'lets bring back the vermin' which may seem strange at first but not when we learn a bit more about insects and perhaps gain a better appreciation of the 'little crawly ones'. Insects are the most successful creatures in the animal kingdom due to their size that allows them to fit into a very small place with little need for food thus enabling them to occupy all types of habitats both on land and in the water. There are at least one million of different species of insects in total with currently known species numbering 751,000. Estimates for the actual total number of insects species even ranges from 4 million to 30 million. It is estimated there are one billion of insects in total for every human being. Clearly we are a little outnumbered here.

The number of known species in the world other than vertebrates (organisms with a backbone):

insects	751,000
plants	275,000
other arthropods	123,400
other invertebrates	106,000
fungi	69,000
chordates	42,300
protozoa	30,800
viruses & bacteria	5,800

The diversity of invertebrates species is breathtaking, some scientists say 200.000 – 500.000 in Australia alone, many of which are unstudied, unidentified with no information available to us, particularly so for the world of invertebrates in the Top End. We know they are a hugely important part within the food chain and ecology yet our attempts to control them manifests in ever stronger measures, increasingly undermining the insect dominated ecosystems that provide the services such as food, water and organic building materials, which we depend on. For example if we were ever successful to eliminate mosquitoes we would also eliminate the primary food supply for dragonflies, insectivorous songbirds and major fisheries among many others groups of organisms.

Pollination by insects is essential for reproduction of many plants including 35 % of fruit and seed production. A rich diversity of insects, including bees, flees, beetles, butterflies and moths is especially critical for many tropical plant species. Many pollinating birds also rely on insects as a food source of protein to supplement the carbohydrate based nectar obtained from flowers.

Invertebrate species include snails and slugs, clams and mussels, millipedes, scorpions, spiders, prawns and crabs, flies, dragonflies, stickinsects, grasshoppers, locusts, mandids, earwigs, cockcroaches, termites, thrips, aphids, leafhoppers, cicada, many bugs, wasps, bees, ants, lacewings, beetles, ladybirds, moths, borers, butterflies and their forms as caterpillars, mosquitos and many others. The breath and diversity of insects and other invertebrates and their exact relationships to many birds that eat and rely on them as a source of food is largely unknown.

Healthy diverse ecosystems often contain a great diversity of invertebrates. For example the many Top End species of frogs rely on the relative abundance and diversity of invertebrates as their main food source and in turn many birds and reptiles then eat frogs and other amphibious and thus depend on them. The foodchain consists on many links and even if one link, particularly if it is as vital as insects, breaks the entire chain may go down.

Insects clearly are the most successful group of organisms on the planet in terms of diversity and ecological function. Their success reflects adaptations to major changes in temperature, atmospheric chemistry and geographic distribution and habitats over 400 million years. They have survived extinction events that have eliminated other major animal groups. Their adaptive ability makes them extremely hard to control. Their adaptive attributes includes small size, exoskeleton, metamorphosis, and flight. Small size allows exploitation of habitat at microscopic scale. The exoskeleton provides protection against predation and desiccation or water logging and innumerable points of muscle attachment. Metamorphosis, while it is necessary for growth, permits partitioning of habitats and resources among life stages. For example many butterflies and beetles feed on foliage or wood resources as immatures and on nectar as adults. The pupal stage facilitates survival during unfavorable environmental conditions. Flight permits rapid long-distance movement that facilitates discovery of new resources as well as escape from predators or unfavorable conditions. Insect populations are governed by relatively predictable responses to changing environmental conditions. The small size, sensitivity to temperature and moisture conditions and high reproductive and dispersal capacities of insects allow them to respond rapidly, and often dramatically to environmental change. However, under adverse conditions, populations can virtually disappear for long periods or become extinct. If environmental conditions change in a way that favors insect population growth, the population will increase until regulatory factors (including predation and habitat carrying capacity) stop population growth rates. As of yet we don't know the full extent of repercussions due to global warming and climate change. However we do know that declines and extinctions are now accelerating rapidly.

INSECT CHARACTERISTICS:

The word 'insect' comes from the latin word 'insectum' meaning 'with a notched or divided body' or literally 'cut into'. Insects are arthropods, that is a type of invertebrate or animal without a backbone. Instead they have a hard protective exoskeleton and jointed legs. Unlike other arthropods insects only have six legs, that is three pairs of jointed legs, two pairs of wings and three distinct body regions – the head, thorax (chest) and abdomen. The abdomen contains the digestive system, heart and reproductive organs. Insects have compound eyes, each consists of hundreds of tiny, simple eyes, which can detect movement in every direction at once. An insect's head houses the brain and important sense organs such as the eyes and the antennae, the latter to detect smells and air movements. Insects don’t have lungs but instead get their air through spiracles extending into a network of tubes called trachea. Insects also shed or moult their hard external skeleton several times during their lives and undergo either complete or incomplete metamorphosis.

Insect Evolution:

The first winged insects appeared more than 300 million years ago. Early fossils show that a few of these insects, such as dragonflies and cockroaches looked very similar to the present-day versions. The arrival of flowering plants about 100 million years ago created a new source of food for insects, pollen and nectar and from then on both flowering plants and insects florished on reciprocal synergy the insects providing pollination in return for food.

Wings and flight:

Insects were the first creatures to fly, enabling them to search for food and to escape quickly from predators.

Insect eyes:

We do not know what sort of image insects have of the world. We know that some bugs are attracted to ultraviolet light and the color yellow. But do they see colors or shades of black and white? Many flowers rely on ultraviolet vision to attract pollinating bees, the bees are guided to the nectar by lines, called honey guides which are visible only in ultraviolet light.

Touch, smell and hearing:

For many insects the world is probably a pattern of smells and tastes. Ants lay down a chemical trail and constantly touch each other to pass on their nest odor. Female moths produce chemicals capable of attracting males from great distances. This world of smells and tastes is further enhanced by the insects perception of vibrations and sounds and facilitated by the sensory organs of the insects antennae and special sense hairs all of which is undetected by the more limited human perception compared directly of what is being sensed.

Mouthparts and feeding:

Most insects have three pairs of jaws, the mandibles are used for chewing, while the maxillae help push food into the mouth. The third pair forms the lower lip (labium).

Complete metamorphosis:

Metamorphosis means 'any complete change in appearance, character, circumstances etc' in this case change of body and form and appearance.

The eggs hatch to produce larvae (caterpillars, grubs or maggots depending on species) that are quite unlike adult insects. The larvae grow and moult several times, finally producing a pupa (chrysalis). Inside the pupa the whole body is reorganized, and a winged adult emerges. Many larvae of plant feeding insects such as ladybirds have branched spines with pointed tips to make them unpleasant to birds and to deter parasites to lay eggs on them.

Incomplete metamorphosis:

Some insects such as cockroaches, termites and dragonflies go through a more gradual process. The young or nymphs developed from an egg look more like the small versions of the adults. Very young nymphs have no wings but older nymphs have buds on the thorax inside which the adult wings develop. At each moult these wing buds get longer, until finally a nymph moults and adult emerges. Dragonflies have a long life cycle and may take two to three years from egg to adult. The nymphs have complex gills inside the abdomen, through which water is pumped in and out, absorbing oxygen and getting rid of carbon dioxide like fish do.

INSECT SPECIES:

Each species of insect is a member of an order (large groupings) made up of other insects with the same physical features and outlined in the overview that follows with the numbers of species referring those with a presence in the Northern Territory (Reference of species numbers and scientific naming of orders, families and species as per Northern Territory Insects CD, Graham Brown 2009)

(1)	Hymenoptera	(Wasps, bees, ants)	661 species
(2)	Lepidoptera	(Butterflies, moths)	1101 species
(3)	Odonata	(Dragonflies, Damsel flies)	102 species
(4)	Orthoptera	(Crickets, Grasshoppers)	374 species
(5)	Hemiptera	(Aphids, Whiteflies, Cicadas, Scale insects)	1593 species
(6)	Diptera	(Flies, Mosquitos, midges)	877 species
(7)	Ephemeroptera	(Mayflies)	13 species
(8)	Dermaptera	(Earwigs)	60 species
(9)	Blattodea	(Cockroaches)	84 species
(10)	Coleoptera	(Beetles, Weevils)	2426 species
(11)	Phasmotodea	(Stickinsects)	32 species
(12)	Phithiraptera	(Lice)	157 species
(13)	Neuroptera	(Lacewings, antlions)	184 species
(14)	Thysanoptera	(Thrips)	124 species
(15)	Strepsiptera	(Strepids)	10 species
(16)	Mantodea	(Mantids)	58 species
(17)	Thysanura	(Silverfish)	9 species
(18)	Siphonaptera	(Fleas)	7 species
(19)	Trichoptera	(Caddisflies)	214 species
(20)	Embioptera	(Webspinners, embids)	1 species

(21)	Isoptera	(Termites)	111 species
(22)	Psocoptera	(Psocids, booklice)	7 species

What follows is an outline of every order and its typical relationships with the environment including with other animals. A knowledge of these relations may help you to appreciate and facilitate the function and management of such insects in your garden. The species listed as examples covers the most commonly encountered species in Darwins gardens in more detail (chart number of the example is given for quick reference in the animal chart under appendices) .

1. Hymenoptera (Wasps, bees, ants)

Biology: They undergo complete metamorphosis with eggs usually lasting a short period laid in or near food sources and larvae feeding on or mining in leaves or are predatory or parasitic on insects or spiders. The adults may live several weeks. The females of most groups can sting by using the ovipositor to inject toxins. The males are produced from unfertilized eggs.

Ecology: The sting of females may discourage many vertebrate and invertebrate predators. Some ants are an important food source for some vertebrates. Because of the predatory and parasitic habit of most species, this order of insects is beneficial in regulating the numbers of 'pest' species, while bees and other groups within the order are important flower pollinators with some being plant species specific. Apart from saw flies, wasps, bees and ants can be recognized by their narrow 'waist'. Several of this groupings are 'social' insects to live together in a nest they build themselves. Many species of wasps are useful to gardeners as they kill the grubs and caterpillars that attack their food crops or amenity plants, Together with bees they are also important pollinators of crops.

Bees:

Bees here are covered in greater detail than the other orders or groups because of their relative importance as pollinator and long association with humans to provide honey, wax and pollen. Also because I love bees and as an amateur beekeeper used to lookafter a few hives for a while. To me bees are they the most perfect creature, serving the web of life without destroying nor exploiting any other lifeforms be it plants or animals. They are an offshoot of the wasp clan that have become vegan while most wasp species remained as predators of spiders and insects. The flowering plants offer the bees nectar and pollen freely in return for pollination services. Since I'm a vegan and don't eat animal products, I never took their honey from them, just being happy to have them pollinate my plants. However from an ecological viewpoint we need not to introduce the European Honey Bee into natural areas where there is a potential for them to displace native bees one reason I finally gave beekeeping away. Sadly, where I live now I haven't spotted a single bee of any species in years. They seem to have completely disappeared from large sections of Darwin even from areas where I'd expected to see a few because I know they were there once.

Bees, in essence are wasps but have become specialized for a diet of pollen and honey in both adult and larval stages. Many wasps eat also nectar but not normally pollen and that is how you can separate them. If the specimen carries pollen on their legs it is almost certainly a female bee species. Bees have compound eyes each formed of thousands of tiny fixed lenses also called facets. The antennae of bees, often referred to as feeler, serve a tactile function but more importantly they provide bees with their sense of smell. Three pairs of legs and two pairs of wings attach to the thorax of the bee, The oldest known bee fossil is around 100 million years old from Myanmar (Burma), when dinosaur were at their peak concurring with the evolutionary path of flowering plants. It is thought that there are an approximately 2000 species of bees in Australia. Though currently of little apparent economic value, the Australian large bee fauna truly is vitally important in providing pollination services to a large percentage of Australian flora species, and thus, in the maintenance of natural ecosystems. Many plants are mainly pollinated by native bees and some only by native bees as seems to be the case for example for the Melastoma species in the Top End. Bees are much more efficient pollinators compared with many other flower visiting insects. What makes them so efficient is that females collect pollen and nectar in order to provision their brood cells and, in doing so, may visit hundreds of flowers. Moreover, even if the bees are generalists, they tend to work flowers of the same plant species on individual forays, increasing the likelihood that they will effect cross-pollination. Specialist bees, of course, are even more efficient in this regard.

Bees exhibit metamorphosis, that is every individual passes through four main stages: egg, larva, pupa and adult. Males take no part in nest construction and provisioning. The female has innate abilities to craft materials into the nest structure, find and exploit flowers for pollen and nectar, learn landmarks as they develop a 'mental map' of their local environment, and repeatedly navigate between their nests and resources. Many types of nests have evolved for different bee species from earth borrowing structures to wood boring structures, utilization of tree hollows and free-form aerial nests. Adults of both sexes take up nectar for carbohydrates and eat pollen the latter providing protein and fat but only females gather loads of pollen and nectar and transport them to their nests to be stored as larval food. The majority of bee-pollinated flowers are brightly colored, commonly blue and yellow but sometimes a also a duller brown. In the tropical monsoonal belt, the majority of species of bees may be active from May to August, the dry season. Usually bees visit flowers to obtain pollen and nectar but, in a relatively small number of specialized species, they also obtain oil in place of nectar. These floral rewards are offered up by plants in order to secure the pollination services rendered by their insect visitors.

Nectar is usually lapped from the nectaries of flowers using the hairy, flexible tongue and is drawn up through a channel in the proboscis by the pumping action of the muscular pharynx. It then travels via the oesophagus through the thorax into the abdomen where it collects in the crop or ‘honey stomach’, a clear, thin-walled, elastic sac formed from the most posterior part of the oesophagus. Nectar consists of a relatively dilute solution of sugars in water and, to thicken the nectar to honey, bees commonly regurgitate a drop of nectar onto their mouthparts, hold it there for some seconds allowing evaporation of water to occur, then re-swallow it. This process, which is repeated over and over, is performed by both sexes and usually takes place while the bees rest on stems or foliage.

Very few of Australian native bee species have been assessed on their conservation status. Processes to threaten Australian native bees are thought to be clearing of natural habitat for agriculture and human settlement, fire, broad-scale use of pesticide, introduced diseases, competition from introduced bees (particularly Apis mellifera or European Honeybee) and climate change. Habit requirements, the most critical factor for the survival of any species, vary widely for native bees, some being fairly adaptable and other having more specific needs. The more specific those needs, the more vulnerable the species will be to habitat changes. Floral preferences are one of the most important factors in determining the resilience of a species to change. Generalist foragers such as Blue-banded Bees do better at surviving habitat alteration and colonizing urban and suburban gardens than do specialized foragers. Similarly nesting site preferences are also important. Invasive weeds can also threaten native bee populations. They may out-compete native plants on which the bees depend for nectar and pollen, In the NT buffel grass poses the biggest problem. Where once fields of native ephemerals would appear and flower after heavy rains, supporting many kinds of native bees, other insects and birds, dense growth of buffalo grass now appear instead.

In recent years there has been growing interest in encouraging native bees in home gardens and there are many online articles providing advice on how to set up ‘bee posts’ and ‘bee hotels’, which provide nesting sites for the many species that use existing holes (‘lodger’ bees). These can be improvised using any readily available scrap wood. While cut sections of bamboo make durable nesting tubes, cardboard or paper tubes when protected from rain can be just as acceptable to the bees. How many species of bees will visit a garden depends on several factors, including the diversity of floral resources and nesting sites it provides and its proximity to natural bushland. The last of these factors is paramount, for without a ‘reservoir’ of bee species within flight range, the number of species that can colonize a garden will be severely restricted. However, even if your garden is far from bushland, there are numerous native bee species that survive in suburbia thanks to flowering shrubs and trees such as Eucalyptus, Callistemon and Melaleuca. There are also some generalist bees that survive quite well in the absence of native flora, obtaining their pollen and nectar from flowers of exotic ornamentals, herbs, shrubs and trees or even weeds. In order to make gardens more attractive to a wider variety of local native bees it is widely recommended to plant a variety of flowering plants and focus on those native to your area particularly members of the Myrtaceae and which, through observation, you may determine are attractive to the local native bees.

Examples of selected Hymenoptera species in the NT:

<u>Amegilla aeruginoses (Copper Rust Bee) 4.1</u>
Family Apidae

The family name comes from Apis (Latin for a bee). Subgenus Notomegilla includes just two species: the very common, widespread blue-banded bee, Amegilla chlorocyanea, and the very different A. aeruginosa which is covered in short, iridescent green or bronze hair and is distributed across the northern half of Australia, occurring also in Papua New Guinea.

Size: Head and body 1 cm, green eyes

Habits: Active during the day this bee visits flowers to feed on pollen. At night the males perch by gripping a twig in their jaws, sometimes many individuals together. Females are ground dwelling, digging a nest tunnel to deposit pollen, nectar and egg at the end chamber. Amegilla species burrow to make nests and, most often, nests are made in the ground.

Habitat: Not very well documented here it is probably any forest or shrubland where enough flowers occur.

<u>Amegilla chlorocyange (Blue Banded Bee) 4.2</u>
Family Apidae

Size: Head and body 1 cm, green eyes

Habits: Active by day feeding on pollen it has the potential to be cultivated commercially to perform as a pollinator on tomato crops. At night males perch together by gripping a twig. Females dig a nest tunnel in the ground, ending in a chamber where they deposit a mass of pollen and nectar and lay an egg.

Habitat: They are generally in forests, shrublands and grasslands where sufficient flowers are present.

Although all Amegilla species burrow to make nests and, most often, nests are made in the ground, whether level, sloping or vertical (as in clay cliffs cut by streams or rivers), Blue-banded bees, however, sometimes choose other nesting sites. They have been reported from decaying sandstone, adobe walls and soft mortar and also have been found in clayey soil held on the roots of fallen trees, termite nests (mud guts) built in tree hollows, and large mud-nests built.

Notes: Numerous native bee species particularly the Blue-banded Bee drive quite well on Eucalyptus, Callistemon, and Melaleuca but also on flowers of exotic ornamental herbs, shrubs and trees as well as weeds. Native bees can be of practical use, in that some of them pollinate flowers, that honey bees do not. For example Blue-banded Bees are able to buzz-pollinate flowers of tomato, capsicum, chilli and other solanaceous plants.

Apis melifera (European Honeybee) 4.3
Family Apidae

Size: Head and body 12 mm, black eyes and legs

Habits: First brought to Australia by settlers in 1822 and unlike other native bees, the European Honeybee will attack if aggravated. Flying workers maintain a preferred body temperature by shivering muscles to warm up or regurgitating fluid to cool down. This species builds a hive to contain a queen, male drones, workers and soldiers. Worker communicate the distance and direction of food sources to other workers with code motions of a 'dance'. Colonies can reach high densities and compete with native pollinators, both invertebrates and vertebrates for pollen. Feral European Honeybee can also displace a wide range of animals that also use hollows. After their arrival in Australia the honeybee soon began establishing feral colonies and spread into the bush. Feral honeybees are now found over most of Australia, wherever there is free water. This is the only bee in Australia that produces white, hexagonal wax comb in cavities in trees, caves, rocks or buildings or, occasionally, on the outsides of tree limbs or rock overhangs. It is also the only bee that visits freshwater sources to drink. Honeybees are often mistaken for native bees, especially when they are much lighter or darker in colour than is considered the norm.

Habitat: Any place where sufficient flowers and water exist.

Notes: Commercial beekeeping operations hire out large number of hives to farming corporations to pollinate a range of crops including Mangos and other horticultural crops particularly in the Katherine region.

Megachile aethiops (Northern Purple-winged Bee) 4.4
Family Megachilidae

Apart from members of the tribe Lithurgini which excavate burrows in rotting wood, most Australian megachilids are lodger bees that make their nests in existing holes. These may include vacated galleries of wood-boring beetles in dead, standing or fallen timber, naturally hollow stems, shafts of ground burrowing wasps and bees, crevices between rocks, vacated nests of muddauber and potter wasps, and man-made holes. These cavity-nesting megachilids collect and transport a variety of materials to the nest for use in its construction. All members of this family are solitary (although a few exhibit gregarious nesting habits).

Size: Head and body 16 mm in females and 13 mm in males, body black

Habits: This species feeds on pollen and nectar with females building cells in a natural or artificial cavity including making its nests in vacated mud-nests built by wasps. Each cell is stocked with pollen and an egg. Females use resin to line the internal walls of the mud cells and also to coat the whole exterior of the mud-nests. Males die soon after mating.

Habitat: Poorly known but thought to range from WA to Qld across Norhern Australia.

Trigona mellipes (Northern Sugarbag Bee) 4.5
Family Apidae

The tribe Meliponini is closely related to the honeybee tribe Apini and includes highly social bees commonly known as stingless bees or sugarbag bees. It is represented by many genera throughout tropical and subtropical regions of the world. In Australia it is represented by two genera, Austroplebei and Tetragonula, most species of which have previously been placed in the genus Trigona. These are the only native corbiculate bees in Australia. They range across northern Australia from the Pilbara and Kimberley divisions of WA, through the NT to Qld and south as far as southeastern NSW. The bees of this tribe are very much smaller than honeybees and closer to the size of bushflies (worker body length 2.9–4.9 mm). They are generally black to brown, the abdomen sometimes being reddish, and some species have whitish tomentum on the face or white to yellow integumental markings on the face and thorax. The sting is atrophied and non-functional.

Size: Head and body 4 mm, brown to black, queens are paler and up to 5 mm long.

Habits: Like other members of the genus they are unable to sting but sometimes landing on humans to lick sweat. Colonies comprise thousands of individuals in typically located nest in a tree cavity with usually one or more conspicuous tubes as entrances. They are a traditional source of honey for indigenous people. Like the honeybees (Apis species), stingless bees live in populous, highly eusocial colonies comprised of an egg-laying female (queen) and her sterile daughters that function as workers. The workers secrete wax from abdominal glands and use it in nest construction although, unlike Apis, they first mix it with varying amounts of resin to form a brown material called 'cerumen'. Nests are built in natural hollows in tree trunks and branches, in rock hollows or occasionally in man-made hollows. Typically, all that is seen externally is an entrance funnel or tube made of cerumen. The entrances of tree nests have been recorded at heights ranging from 0.7 to 15 m. Workers sometimes close off the entrances overnight with a latticework of sticky cerumen, evidently to deter the entry of ants or other predators. A major part of the internal nest space is devoted to the rearing of brood. The form of the nest is governed to some degree by the size and shape of the hollow in which it is built. Nests in hollow branches are usually quite linear and the greatest recorded nest length was 6 m. In broad hollows, nests may be more spherical. As in most native bees and unlike honeybees, stingless bees mass provision and seal their brood cells while honeybees build open brood comb and workers feed the larvae progressively. Cells always open upwards as the provision is fluid, consisting mostly of pollen but with an upper clear layer of honey mixed with secretions from the workers. The queen deposits a single egg in each cell, the egg standing upright in the surface of the provision, then workers close the cells. Once the larva has consumed all of its provision, it defecates and then spins a thin cocoon flush with the cell's inner walls (Apis larvae do not spin cocoons). Workers strip away the cerumen walls of cells containing cocoons and reuse it elsewhere. As in honeybees, workers of stingless bees communicate information about the quality and location of resources to their nest-mates and recruit foragers. New colonies are established by swarms consisting of a young, newly mated queen and several workers from an old colony. They fly to a site where workers have already established the basic structure of nest and where the queen can commence laying her eggs. Once a queen begins producing eggs, her abdomen swells and extends considerably. Queens begin life in specially constructed brood cells that are larger than those that produce workers. Numbers of females are produced in such enlarged cells and they are referred to as 'gynes' as not all of them go on to become queens. Males (or drones) are not too dissimilar from females and are reared in identical brood cells. They form flying swarms outside nests at times and young females fly from the nests into the swarm to be mated.

Habitat: Open woodland

Notes: The stingless sugarbag bee also swarms at times but is harmless to humans and plants while ecologically important as pollinator and to provide food to some birds. Traditionally, Aboriginal people seek the nests of these bees for their stores of honey.

The workers store the honey in cerumen pots that are then sealed, so the bees do not lend themselves to honey production as readily as the honeybees, which store honey in open cells of the brood comb. Nevertheless, keeping Australian stingless bees in artificial hives for ‘sugarbag honey’, for pollinating certain crops or just for interest’s sake is becoming increasingly common.

Xylocopa paryula (Large Carpenter Bee) 4.6
Family Apidae

Name: From the Greek ‘xyle’ (= wood) + ‘kopto’ (= to cut). Three tribes of carpenter bees are represented in Australia: the first (Xylocopini) contains large to very large bees of robust form while the other two (Ceratinini and Allodapini) contain quite small, rather slender bees.

Size: Head and body 7 mm for females and 5 mm for males, yellow on top of back.

Habits: Females bore into dead wood of standing trees and build up to 7 compartments within, each for one offspring.

Habitat: Open woodland, Carpenter bees are so called because they make their nests in dead wood and other dead plant tissue. Many excavate their own burrows, be it in soft pith, rotting wood or nearly sound wood, while others use the vacated burrows of woodland stem-boring insects. Often, too, they fashion wood or pith particles into structures within their nests.

Since rotting and punky wood is the preferred nesting medium for the Large Carpenter Bee(Xylocopa spp.), Lithurgus and several species of Colletidae and Halictidae, retaining any dead branches on garden trees or including a dead, rotten stump or log in garden landscaping could attract this bee to your garden.

Apart from bees, Hymenoptera also includes wasps and ants such as the very well known and often disliked Green Tree Ant. Who of Darwin's gardeners hasn't been on the receiving end of their bites?

Oecophylla smaragdina (Green Tree Ant) 6.2
Family Formicidae

Size: Head and body around 1 cm

Habits: They are very common with colonies building a number of nests in one or more leafy trees or shrubs, nests that are aggressively defended. A colony may contain half a million individuals. They consume insects and nectar. Themselves edible, the acid contained in their bodies produces a tangy flavor, Green Tree Ants eat a variety of insects, both those which they find dead and others which they kill. The nests are built around a clump of leaves and house their eggs, larvae, baby ants and dead insect parts. Individual nests are usually part of a larger colony, but only one nest houses the queen.

Habitat: Forests and shrublands, particularly the denser habitats of monsoon, riverine and mangrove forests

Practical notes on Hymenoptera:

'Bee posts' and 'bee hotels' can provide nesting sites for species that use existing holes (lodger bees). Use the cut sections of bamboo to make durable nesting tubes. By providing habitat and suitable forage plants for native bees, the home gardener may also be able to assist the conservation of some species. The success of such an endeavor will depend on several factors, including the diversity of your floral resources and nesting sites it provides and its proximity to natural bushland. The latter is particularly important for without a reservoir of bee species within flight range, the number of species that can colonize a garden is crucially restricted.

Retaining any dead branches on garden trees or including a rotten stump or log in a garden landscape could benefit the Large Carpenter Bee as their preferred nesting medium. The greater the diversity of plants in the garden, the more likely it is that the bees will obtain what they require.

In our garden I found that the lack of bee pollinators manifests a failure of Melastoma spp to produce fruit despite flowering beautifully. Melastoma is a very important pioneer shrub species in local monsoon rainforest and its flowers provide pollen but no nectar, hence the need for bee pollinators that are able to harvest pollen from within the pores of the flowers stamen that contains the pollen. I tried to pollinate by hand with a brush but that doesn't work, seemingly only bees can do the job.

Another example for the importance of attracting bees and wasps into a floristically diverse garden, is the pollination of Sandpaper Fig and other figs which requires a tiny wasp entering the synconium, that houses the tiny flowers inside, the wasp to bring about pollination, a process even further complicated by the dioecy of figs (male and female flowers on different trees).

2. Lepidoptera (Butterflies, moths)

Some people romantically regard butterflies as the 'birds' of the insect world. Apart from their beauty they act for humans also as flagship for the identification and preservation of critical habitats under threat, and as convenient indicators for monitoring climate change or pollution and so play an important role in conservation biology. Moths are not that well known since many are nocturnal and operate out of sight although they are just as important.

Butterflies are generally a tropical group of insects and often depend on rainforest plants for larval food. Nearly half of the butterflies (173 species) in Australia are associated with rainforest and of these 114 species are found only in this habitat. Not surprisingly North Queensland's extensive wet rainforests are the richest part of Australia for butterfly species where 68 % of total butterfly fauna is found.

Butterflies undergo a complete metamorphosis from egg through larva and pupa to adult. The egg is laid usually on the underside of the larval food plant (LFP), but sometimes on the trunk or branches. That larva also known as caterpillar feed on plant leaves and sometimes flowers or even seed and its main aim is to eat for growth.

All around the world, billions of caterpillars are munching away on plants, turning carbohydrates into protein, an added bonus for their predators and animals that can't digest plant tissue for themselves. Thus caterpillars are one of nature's major food sources and recycling agents. Those millions of caterpillar pellets falling on the ground are a useful manure.

Biology: They undergo complete metamorphosis with their eggs laid singly or in masses on or near the food plant mostly during the wet season when vegetation turns lush and juicy with new growth. Larvae are mostly phytophagous that is eating or mining in leaves or boring in trees by feeding on roots or bark. Butterflies produce one or more generations annually. Most species of moths are nocturnal and may be taken in large numbers at lights including ultra violet light.

Ecology: Larvae, pupae and adults are preyed on by large number of vertebrate and invertebrate animals. Larva play an essential role in the functioning of our ecosystems as they recycle nutrients from the plants back into the soil through their feces and also by serving as food for birds, spiders, insect predators and parasites such as certain species of flies and wasps. The pupa also known as the chrysalis, is the non-feeding stage in which all of the larvae organs are reorganized and transformed into those of the adult. Finally the adult, also known as the imago, is responsible for sexual reproduction and dispersal via egg laying. Adults drink fluids, primarily nectar from flowers but also water from puddles, sap flows and fermenting juices from rotting fruit or dead animals, especially so in the tropics. In hot tropical lowlands butterflies may begin to fly within an hour of sunrise to feed at flowers and this is the best time to find them. I have included references to the LFP (Larval Food Plant) for each of the common species described below.

Examples of Lepidoptera in the NT:

<u>Tirumala hamatus (Blue Tiger) 2.1</u>
Family Nymphalidae

Size: Wingspan 7 cm

Habits: They are relatively uncommon in the NT, sometimes seen drinking from wet sand and dispersing widely during the pre-wet season. They breed only during the wet and during dry aggregates in a shady humid place.

Habitat: Monsoon forest and rainforest (vine thicket)

LFP (Larval Food Plant): Feeding on the young leaves of the vines Secamone elliptica, Cynachum carnosum, Marsdenia velutina and M. glandulifera.

<u>Cethosia penthesilea (Orange Lacewing) 2.2</u>
Family Nymhalidae

Size: Wingspan 6.5 cm

Habits: Adults fly in sunlit gaps in the forest and settle on leaves, commonest in early dry season,

Habitat: Monsoon forest

LFP: Adenia heterophylla

<u>Hypolimnas bolina (Varied Eggfly) 2.3</u>
Family Nymphalidae

Size: Wingspan 6 cm

Habits: Common with males defending territories around areas of larval food plants, Larvae feed on a broad variety of herbaceous plants. This species is not breeding during the dry season but completes at least 2 generations per year

Habitat: A wide variety including parks and gardens.

LFP: Synedrella nodiflora, Alternanthera denticula, Sida rhombifolia

<u>Hypolimnas alimena (Blue-banded Eggfly) 2.4</u>
Family Nymphalidae

Size: Wingspan 7 cm

Habits: The males are territorial.

Habitat: Monsoon forest and rainforest

LFP: Pseuderanthmum variabile, Asystersia gomgetica

<u>Euploea corinna (Common Crow) 2.5</u>
Family Nymphalidae

Size: Wingspan 7 cm

Habits: Abundant with adults feeding on a range of flowers but this species does not breed in the dry , preferring to aggregate in sheltered positions during this time. Caterpillars consume the leaves of many types of plants in the family Apocynaceae, at least two generations are completed each year as well as the young leaves of the vine Cynanchum viminale. They have also been recorded to feed on the young leaves of the vines Gymnatherea oblonga, Ichnocarpus frutescens Marsdenia geminata nad Secamone elliptica. Another species of this butterfly family Euploea darchia feeds on the young leaves of the vine Trophis scandens.

Habitat: A wide variety including parks and gardens.

LFP: Apocynaceae, Asclepiadceae, Moraceae

Notes: I observe frequent visits of the large Common Crow butterfly in our garden which to my amusement, is like clockwork every day at 11 am especially during November, selective on 'baby leaves' of a whole range of plants including Kumquat, Micormelum and Diaspyros, to lay the tiny white eggs on. The birds don't touch the egg laying adult form of this species of butterfly nor the eggs or the caterpillars, so I assume it must be toxic to them. How do the birds know? Proably by trial and error. The Common Crow also feeds on the young shoots of Ficus virens (Banyon tree) and some other fig trees such as Ficus aculeata.

Mycalesis sirius (Cedar Bush-brown) 2.6
Family Nymphalidae

Size: Wingspan 4 cm

Habits: Common, most abundant early and mid day with two generation per year and larvae feeding on grasses such as Imperata cylindrica together with other butterflies Melanitis leda, Suniana lascivia and Telicota colon.

Habitat: Mostly paperbark and swamps and open woodland.

LFP: Ischaemum australe, Themeda triandra

Notes: Themada triandra or Kangaroo Grass is a native seeding grass beneficial to both birds (seeds) as well as for this species of butterfly and can provide a beautiful decorative feature for any garden when planted in dense clumps.

Danaus petilia (Lesser Wanderer) 2.7
Family Nymphalidae

Size: Wingspan 6 cm

Habits: Common. Flying slowly it possess unpalatable chemicals in the body to deter predation. Larvae feed on foliage of a wide variety of plants in the family Apocynaceae. It has at least two generations per year. Its larvae are recorded to feed on the vine Cynanchum carnosum, Tylophora flexuosa but also on Cynanchum pedunculatum together with other butterfly species of Danaus affinis and Tirumala hamata.

Habitat: Many, including forests, shrublands, grasslands, parks and gardens, prefers open habitat

LFP: Brachystelma, Cynanchum, Maisdenia, Rhynchairhena, Sarcostemma, Asclepias, Gomphocarpus, Calotropis

Junonia villida (Meadow Argus) 2.8
Family Nymhalidae

Size: Wingspan 4 cm

Habits: Common, it flies quickly with adults feeding on flowers. Ir does not breed in the dry season but has at least two generations annually completed. Larvae feed on a number of shrubs and herbs

Habitat: Wide variety, favoring open woodlands, parks and gardens

LFP: Many species including Hyptis, Portulaca, Verbena and Lantana

Acraea andromacha (Glasswing) 2.9
Family Nymphalidae

Size: Wingspan 5 cm

Habits: Common and flies leisurely. Its caterpillar stage feeds mostly on the leaves of vines of genus Passiflora and other forbes, but are only recorded on Adenia heterophylla and species of Hybanthus particularly leaves of Hybanthus enneaspermus in the NT together with another species of this family of butterfly Acraea tersicore.

Habitat: Open woodland and monsoon forest

LFP: Passiflora cinnabarina, P. herbertiana, Adenia heterophylla

Eurema hecabe (Large Grass-yellow) 2.10
Family Pieridae

Size: Wingspan 4 cm

Habits: Flies slowly and low to the ground, feeds from flowers and has a minimum of two generations with larvae found on a range of different plants.

Habitat: Open woodland, grassland, monsoon forest edges

LFP: Cassia, Senna, Breynia, Phyllanthus, Acacia, Albizzia, Leucaena and Sesbania cannabina

Notes: If you want them in your garden try planting the tree Albizzia lebbek and the shrub Breynia cernua both very beneficial to a variety of other wildlife including the Large Grass-yellow.

Catopsila pomona (Lemon Migrant) 2.11
Family Pieridae

Size: Wingspan 6 cm

Habits: Common, breeds in the wet, migratory, larvae feed on the foliage of various species of Cassia and Senna

Habitat: Many, breeding mostly in open woodland and suburban areas

LFP: Cassia, Senna

Delias argenthona (Scarlet Jezebel) 2.12
Family Pieridae

Size: Wingspan 6 cm

Habits: Common residing in the canopy with larvae feeding on leaves of mistletoes

Habitat: Open woodland, paperbark swamps and gardens

LFP: Amyema, Dendrophtheo, Decaisnina signata, Diplatia furcata, Muellerina celastroides, Santalum lanceolatum

3. Odonata (Dragonflies, Damselflies)

Biology: Odonata have incomplete metamorphosis with eggs are either laid into plant tissue or freely into water of puddles, lakes, streams etc, prior to emergence mature nymphs climbing out of the water up reeds, rocks, wooden piers etc where the adult emerges. Many species are territorial flying back and forth over the same area or returning to the same resting place, some occur in large numbers at the end of wet season. Nymphs are aquatic and may be found in swamps, ponds, streams and lakes where they cling to vegetation or on the underside of rocks while adults are often found near water especially while mating or egg laying and also in clearings

Ecology: Nymphs are predators on other aquatic insects with adults predating on flying insects. Both nymphs and adults in turn are attacked by fish, frogs, reptiles and birds as well as other arthropods.

Example of Odonata in the NT:

Rhyothemis graphiptera (Graphic Flutterer) 6.11
Family Libellulidae

Size: Head and body 3 cm, distinctive yellow and black stripes on wings

Habits: Feeds on invertebrates including nymphs, this species of dragonflies are some of the fastest flying insects, catching other insects on the wing and consumes large numbers of mosquitoes.

Habitat: They can be observed in numbers in the vicinity of slow moving and still water. However I have seen them in places quite distant from waterbodies wherever they can chase airborne prey.

Notes: Everyone in Darwin knows that the wide presence of dragonflies and damselflies in the air of which there are an incredible 102 species in the NT, announces the eagerly anticipated arrival of the dry season when temperatures and humidity drops to more pleasant levels. However there seem to be fewer and fewer dragonflies around and I wonder if that has to do with mosquito control chemical measures or climate change. Mosquito control spraying in particular seems to severe a whole range of insects. Ironically the symbol of the Darwin City Council incorporates a dragonfly. There is a stylized 'D' for Darwin, which looks like the flight path of the dragonfly which is zooming skywards. If you like the idea of having dragonflies breed in your garden you should install a natural pond with suitable aquatic vegetation. As Darwin urban development pushes further and further into mosquito habitat dragonflies will soon be locally extinct seemingly just as with bees. You can observe a great variety of dragonflies in natural reserves such as the Casuarina Coastal Reserve mostly in open areas close to wetter vine-thicket edges with a proliferation of mosquitoes. Take care, cover up and watch.

4. Orthoptera (Crickets, Grasshoppers, Locusts)

Biology: Just as with dragonflies and damselflies this order also manifest through incomplete metamorphosis however with eggs usually laid on soil but may be laid on vegetation. Both nymphs and adults are mainly plant feeders and some are carnivorous on other insects. Crickets are soil-dwellers and may also be found under logs and rocks while most other species are found on or near vegetation.

Ecology: Eggs are parasitised by small wasps and flies while adults are parasitised by nematodes and fungi and are preyed upon by many vertebrates especially birds and invertebrates including wasps. Some species are of considerable importance as pests on economic crops

Examples of Orthoptera in the Top End:

Calephorops viridis (Lesser Buzzer) 6.3
Family Acrididae

Size: Head and body 1.5 cm male, 2 cm female

Habits: Makes buzzing flights.

Habitat: Open woodland, grasslands, ovals and lawns

Froggattina australis (Froggat's Buzzer) 6.4
Family Acrididae

Size: Head and body 2 cm male, 3 cm female.

Habits: When taking flight makes a loud buzzing sound up to 5 seconds, this is used by the male to attract a female.

Habitat: Open woodland, grassland, ovals and lawns

Gastrimargus musicus (Yellow-winged Locust) 6.5
Family Acrididae

Size: Head and body 4 cm male, 5 cm female

Habits: Makes a clicking sound during flight, Eggs are deposited on bare soil and remain viable for up to 10 months, In the NT has multiple generations.

Habitat: Grassy areas, including pasture and lawns.

Valanga irregularis (Giant Grasshopper) 6.6
Family Acrididae

Size: Head and body 6.5 cm male, 9 cm female, Australia's biggest grasshopper

Habits: Active by day, with good eyesight moves behind a leaf when spotting a predator. They eat leaves of trees and shrubs including crops. At the approach of the warmer part of the year the female lays 150 eggs in a hole in the ground.

Habitat: Forest, shrubland Parks and Gardens

Notes: In our garden in Nightcliff we seem to get quite a few of small and medium sized green grasshoppers in the early wet season but inspected closely they often turn out to be nymphs of species such as Lesser Buzzer and Giant Grasshopper characterized by the lack of wings and smaller size. The green color of these nymphs differs from the color of the adult forms and blends in with the color of plants they choose to feed on. Nymphs also tend to behave differently compared to the adult form. For example they tend to move to the other side of the stem or leaf to hide out of sight of approaching predators rather then to hop or fly away. I let the birds take care of them and otherwise tolerate minor damage to plants.

5. Hemiptera (Aphids, Whiteflies, Cicadas, Scale insects)

Biology: They also display incomplete metamorphosis with eggs are laid in a variety of places such as the soil or leaf litter in or on plant tissue. Nymphs and adults of most species are sap suckers and all plants may be attacked,

Ecology: Nymphs and adults can be parasitised by a variety of wasps, flies, nematodes and preyed upon by invertebrates such as beetles, wasps, spiders, lacewings and some caterpillars. Some species produce honeydew which is eaten by some ants, some wasps and some birds. Aquatic species are preyed on by fish, amphibians and aquatic insects and spiders.

White flies, aphids and scale insects are common in irrigated gardens. A simple control method is to keep a watchful eye throughout the year and simply cut off heavily diseased parts of the plant to be composted.

Example of Hemiptera in the Top End:

Macrotristria doddi (Darwin Whiner) 6.10
Family Cicadidae

Size: Head and body 5 cm with distinctive markings.

Habits: Whilst perched on a tree trunk it produces a droning sound. Adults can be observed just before and during the wet season. Larvae are similar to other cicadas living underground for a number of years and feeding on the sap of roots.

Habitat: Forest, parks and gardens

Notes: Out of the 200 or more Australian cicada species, there are at least 5 living in and around Darwin. They lay eggs into slits in tree branches. When the nymphs hatch out, they drop to the ground and burrow down into the rootzone to make a cell in which they live, sucking sap from young plant roots. They can be in the cell for about nine months to several years, growing and shedding their skins several times. When fully grown they emerge from the ground. Then they shed their skins for the last time and then fly around and live on plant stems and trunks. Two days after emerging, the males make their distinctive sound to attract females. After mating, cicadas live for only two to four weeks.

6. Diptera (Flies, Mosquitoes, Midges)

Everyone gets annoyed by Diptera, a fact of life in Darwin. If you are out in natural areas during the wet season in particular you are well advised to wear long trousers, long sleeved shirts, a mosquito net over the head and a hat. That is not just to feel more comfortable but also to avoid catching infectious diseases.

Biology: Undergoing complete metamorphosis, starting with eggs usually hatching within a few days, then onto larvae present in soil, vegetable matter, rotting plant or animal matter or water, the adults feed on liquid food including various plant and animal secretions or other fluids an are general pollinators, some species are blood feeders.

Ecology: They are preyed upon by a large variety of vertebrate and invertebrate animals but some species are significant pests as disease transmitters and may cause significant damage to plants and as leaf miners. However many species are important pollinators whilst others are important predators which control the numbers of some insects.

Notes: A fly is an insect with two wings instead of hind wings. Instead they have a pair of small structures called halterers, which helps them balance in flight. All flies undergo complete metamorphosis, with grubs or maggots living mainly in water or in a moist rotting plant and animal tissue. Maggots can carry the bacteria that causes botulism and when eaten by birds, even just one maggot, can cause fatal toxic nerve poisoning. Always remove and bury carcass of dead animals. Many flies, like mosquitoes spread diseases such as malaria and carry germs. Note that the two species in the example given together with other mosquito species can transmit Ross River Virus and a whole range of other viruses during the peak period during the Wet Season. If you work in your garden or visit conservation reserves and other natural areas, wear protective clothing or use a repellent. Suburbs within 1.5 km of the mangroves are in the range of biting midges, Culincoides ornatus, which are blood-sucking and inflict a mosquito-like sting. Female mosquitoes sting and suck blood because they need it for egg production. Male mosquitoes to the contrary eat flower nectar and plant sap. Monitor water collection items such as bowls, old tyres and containers in your garden for evidence on mosquitoes breeding. If you have a natural pond you may to consider populating it with fish to eat mosquito larvae.

Examples of Diptera in the NT:

<u>Culex annulirostris (Common Banded Mosquito) 6.12</u>
Family Culicidae

Size: Head and body 4 mm

Habits: The females feed on blood of mammals and birds with eggs laid on surface of freshwater while biting mainly at night. It transmits a range of diseases to human including Ross River Virus.

Habitat: Anywhere with water.

<u>Ochlerotatus vigilax (Saltmarsh Mosquito) 6.13</u>
Family Culicidae

Size: Head and body 4 mm

Habits: Eggs are laid on damp ground and hatch when inundated, Females bite day and night and prefer animals or birds.

Habitat: Coastal areas, primarily in saltwater marshes particularly high in pre-wet

7. Ephemeroptera (Mayflies)

Biology: Incomplete metamorphosis. Eggs are laid in the water of streams and less frequently in ponds. Nymphs are aquatic and take up to one year to mature feeding on plant detritus or microscopic aquatic organisms. Their adult life is short lasting only up to one day.

Ecology: Adults and nymphs are important food sources for fish as well as aquatic insects and spiders.

8. Dermaptera (Earwigs)

Biology: Incomplete metamorphosis. Eggs laid in soil. Both nymphs and adults are nocturnal and feed on a range of plant material or on other insects and can be found under logs or rocks and in leaf litter.

Ecology: Preyed on mostly by birds

Example of Dermaptera in the Top End:

<u>Nala lividipes (Black Field Earwig) 6.14</u>
Family Labiduridae

Size: Head and body 11 mm

Habits: Inhabits loose soil and can be a pest to crops.

Habitat: Fields and other vegetated areas.

9. Blattodea (Cockroaches)

Biology: They undergo incomplete metamorphosis and inhabit diverse habitats. Native species are not considered pests, although they may be attracted into houses by lights. They can easily be kept in captivity on a varied diet of vegetable scraps, paper toweling, dry cereal and fish food as well as a source of moisture. In the garden or wild they are mostly found on trees and shrubs, under bark, in rotting logs, on the ground or in leaf litter with many being nocturnal.

Ecology: Nymphs and adults are preyed upon by frogs, reptiles, birds, and insectivorous mammals as well as many other arthropods including spiders, ants, mantids, beetles and wasps.

Examples of Blattodea in the NT:

Periplaneta australasiae (Australian cockroach) 6.7
Family Blattidae

Size: Head and body 5 cm with yellow markings on the wing.

Habits: Active mostly at night as a common household pest it scavenges for any organic matter.

Habitat: Virtually any environment in Darwin mostly associated with humans

Periplaneta americana (American Cockroach) 6.8
Family Blattodea

Size: Head and body 5.5 cm

Habits: They are mostly active at night while scavenging organic matter.

Habitat: Prefers warm humid environments mostly associated with human habitation.

Notes:

If you desire to feed insectivorous birds, reptiles or mammals in your garden, you can easily farm cockroaches like they do industrially in China (there for human consumption) by placing corrugated iron sheets an inch apart in a shady corner of the garden perhaps next to the compost bin and spill food waste into the gap from the top. The device needs to be sealed along the edges with a piece of timber ro similar material. Open the device at the bottom and rattle it a bit to allow cockroaches to escape into a jar or into the garden, ready for feeding. Would you believe, a cockroach can survive for up to 3 months without its head. Apparently so.

10. Coleoptera (Beetles, Weevils)

Beetles make up 40 % of all the insects known to science out of the estimated total existing thought to be about 5 – 6 million species. Some estimate that there are at least about 300 million insects for every living human. Insect also outnumber humans 12 : 1 by combined weight.

Coleoptera means 'sheath wings' and characteristically this order has a first pair of leathery or hardened wings that form a kind of sheath, when folded covering the membranous hind wings. Beetles undergo a complete metamorphosis consisting of four stages: egg, larva, pupa and adult. The body of most beetles is covered with an 'armor' to give it protection and serves as a skeleton in the absence of a vertebra. All beetles have antennae with the primary function to smell and probe but also perceive electromagnetic waves, infrared radiation and to gauge the humidity of the air. Beetles can smell the tiniest trace of odors such as from a mate or food. As insects, beetles don't have lungs but inhale air through spiracles, a complicated system of tubes known as the trachea, its pipework delivering oxygen directly to each cell. Air travels through this labyrinth of branched, chitin-lined and narrowing pipes in order to reach the cells directly. The spiracles can open and close to regulate airflow and limit water loss. Most beetles that can fly need to take in a lot of air prior to flight. Their abdomen literally pumps up in order to hold the larger quantity of air required to inflate their second pair of wings and to supply the body with an increased amount of oxygen during the flight.

The huge number of species occupies many niches in nature and is conveniently grouped according to the food they eat. They may be carnivorous (meat eaters), phytophagous (plant eaters) or omnivorous (meat and plant eaters). Other more specialist groups can also feed on decaying organic matter ranging from excrement to carrion (dead animals) among other substances. Beetles and their larvae eat anything from wild and garden plants, to pollen, leaves, fruits, nuts, stems, roots, dung, carrion, rotten wood, construction timber, harvested grain, stored food, other invertebrates, and each other. The plant-eating beetles are fussier than most – they often specialize on certain plants, sometimes even only on specific parts of the plants. Beetles in decaying tree trunks often depend on microscopic fungi in the timber, while others prefer very dry, thin branches of fallen trees. The majority of herbivores eat fresh, green foliage but many live on dried plant matter, including the many kinds of stored products of humans. Some plants that are otherwise poisonous are the most favored foods for certain beetles – such as dry tobacco for the Cigarette Beetle, Lasioderma serricorne (Anobiidae).

Beetles live in water, up trees, in the soil, in ant nests, in bee burrows, in our homes; they visit flowers, they patrol leaves, they fly and bump at the lighted window of a late summer evening. They indicate freshwater quality, ecological continuity of threatened habitats like ancient woodlands; they are an excellent measure of local conservation effort and regional biodiversity.

Biology: Undergoing a complete metamorphosis they are found in a wide range of habitat depending on group. All species can be found in the substrate they feed on such as soil, rotten logs, stems of plants, leaves and flowers, boring in trees, under bark and in ponds and streams. Typically the eggs of beetles grow into grubs, some which feed and grow for several years before becoming adults, the most heavily armored of all insects. A typical beetle has two large compound eyes. These are made up of lots of individual, six-sided eyes, called ommatidia. The complexity of a beetle eye depends on its use. Species that depend a lot on their sight have large compound eyes, consisting of many ommatidia, while those that have little use for keen eyesight developed simpler eyes. Beetles living in the permanent darkness of caves for instance are blind, with eyes absent or having just vestiges of them, perhaps with some light sensitivity, but no sight. Despite its complexity, the beetle eye sees the world as a somewhat blurred image. However, it detects movement readily and it perceives certain colours too. Yellow seems to be a very attractive colour to many insects, not just beetles. Entomologists use plastic plates of this colour, filled with water to attract and trap a whole host of insects, but especially flies, wasps and bees.

Beetles – like all other insects – have an open circulatory system, which means that their ‘blood’, the haemolymph, is not circulating in a closed network of arteries and veins, like our blood does, but instead it fills most of the interior of the body and surrounds all cells. Haemolymph bathes the organs directly, supplying them with oxygen. Circulation is at low pressure, created by the pumping action of a simple heart, located in the dorsal area of the thorax. Body movements also assist circulation. Haemolymph is composed of water, inorganic salts, carbohydrates, proteins, lipids and some other organic compounds. It is not red like the blood of vertebrate animals, but rather colourless, or sometimes yellowish or greenish. Haemolymph also ‘rinses out’ wastes, particles of dead cells and bacteria. Their excretory organs, known as Malpighian tubes, remove salts and nitrogenous waste from the haemolymph and transport it to the digestive tract. There are four to six Malpighian tubes in a beetle. Toward the end of the tract, at the rectum, salt is pumped back into the haemolymph, followed by water through osmosis. The nitrogenous wastes are eliminated as almost dry matter, along with the faeces.

Ecology: While eggs are parasitised by wasps, larvae are preyed upon by spiders and wasps and adults are attacked by birds, reptiles and mammals. Aquatic species are attacked by fish. Many species are also of economic important with a potential to cause damage to pastures, crops and stored products. There are 2426 known species of beetles in the NT

Examples of Coleoptera in the NT:

<u>Gnathaphanus philippensis (Common Black Ground Beetle) 3.1</u>
Family Carabidae

The ground beetles form one of the largest families of beetles. They are classified in 1500 genera and about 30 000 described species distributed worldwide. At present the Australian fauna consists of 295 genera and about 2575 described species and subspecies. The genus Gnathaphanus is widely spread all over Australia as well as in Japan, the Philippines, Indonesia, New Guinea and a number of Pacific islands. Members of this genus are granivores (grain eaters) and omnivores. Some species have traveled around the world as 'hitchhikers' with shipments of grain and other stored products. About 15 described species live in Australia.

Size: Head and body 7 mm

Habits: Feeds on seeds, attracted to light at night at times.

Habitat: Shelters under debris in the ground, often around margins of waterbodies.

Notes: I have noticed some or perhaps a similar species under my large pots plants if the plant saucer rest on uneven ground or on spacers. Every so often a bird or lizard checks the edges and catches one. They come out at night to feed on remains of spilled seeds.

<u>Cicindela semicincta (Emerald Tiger Beetle) 3.2</u>
Family Carabidae

One of Australia's most commonest Tiger beetle species.

Size: Head and body 1 cm

Habits: Active by day and night. Sometimes hunts insects around lights. Known as a voracious predator of smaller insects thus its name tiger beetle. Prey includes tadpoles of the Canetoad. Some tiger beetles hunt by stealth, patiently waiting until potential prey comes near. Others attack with a sudden rush. Larvae inhabit burrows in the ground and waiting at the entrance to ambush smaller invertebrates.

Habitat: Various, especially near water. This small beetle is an alert, fast-moving predator of small insects. Its favored habitat is near flowing water, where it can be seen on tree trunks, but also on the ground. It occurs almost everywhere in Australia, except the arid interior of the Northern Territory.

<u>Lasioderma serricorne (Cigarette Beetle) 3.3</u>
Family Anobiidae (Furniture and Spider beetles)

Many species of anobiids are woodborers, while others are polyphagous, feeding on dry vegetable matter, leather, textiles and various other stored products. In nature anobiids prefer dry habitats also – they can be found in or under the bark of dead or diseased trees and in leaf litter. Occasionally they are attracted to artificial light at night, but never in large numbers. In Australia there are about 189 named species in 38 genera, including a number of introduced foreign species

Size: Head and body 3 mm

Habits: Despite the fact that nicotine is a deadly poison to almost all insects it has a liking for feeding on dry tobacco. It doesn't eat the entire cigarette (or cigar) but drills countless holes and passages into it, rendering it useless. Larvae will also bore tunnels in grains and seeds, dried fruit, wood and other dry substances.

Habitat: Wherever suitable foodstuffs are found and mostly associated with human habitation persisting inside the shelter of buildings also. They can bore into and breed in compressed woodchip panels (despite their formaldehyde content) and can damage preserved museum specimens of insects, birds and mammals, even those which have been treated with arsenic. Because they are small and avoid daylight, Cigarette Beetles are often not detected before they cause widespread damage.

<u>Bostrychopsis jesuita (Large Auger Beetle) 3.4</u>
Family Bostrichidae

Bostrichidae do not have cellulase, a digestive enzyme which breaks up cellulose in their food. They utilize starch and sugars in the sapwood they consume with the help of endosymbiotic bacteria that lives in their alimentary canal. In their natural habitat adult and immature bostrichids can be found in damaged or dead trees in many parts of Australia, although they are most numerous in the tropics. Adults readily fly to artificial light at night.

Size: Head and body 2 cm

Habits: Adults bore into the wood of eucalyptus, acacias and other trees including fruit trees. It can cause some damage to fruit and other cultivated trees but is not considered a serious pest as it favors already injured or unhealthy trees. It occurs in most parts of Australia, except the arid, tree-less environments. Eggs are laid within the bored tunnels of mainly sick or dying trees where after hatching the larvae begin to chew their own tunnels.

Habitat: Any treed area

Prosopocoilus bison (Bison Stag Beetle) 3.5
Family Lucanidae (Stag beetles)

The name ‘stag beetles’ reflects the appearance of the males of many species, as they usually show prominent, antler-like mandibles. These ‘antlers’ are often strongly toothed or lined with pubescence. Opinions differ as to their purpose – more than likely, different stag beetles employ their mandibles for different purposes. Some use them as weapons in self-defence and in battles between rivaling males. Others use them to pin down the female during courtship.

Size: Head and body 6.5 cm

Habits: Eggs are deposited in cracks of dead wood. Stag Beetle typically spend 3 – 8 years as larvae, feeding inside a tree trunk and as adults only live for a few months.

Habitat: Although they bore into timber, they pose no serious threat to forestry or the timber industry, as the larvae live only in decaying wood. Some species prefer mouldy, fungus-ridden, fallen logs, while others sometimes live in sick, but still standing trees in forests,

Dilochrosis brownii (Brown's Fruit Chafer) 3.6
Family Scarabaeidae (Scarab beetles)

Scarab beetles are so diverse and their appearance so variable that it is almost pointless to give a general description of this family. Their most obvious characteristic is their lamellate antennae.
The habits of scarabs are just as varied as their appearance. Many are coprophagous, others feed on carrion, on decaying wood, on many parts of live plants, some are ant and termite-loving. The adults of quite a few species don’t eat at all. Well over 2200 species in approximately 270 genera are known from Australia.

Size: Head and body up to 2.5 cm

Habits: Active by day, feeds on nectar of flowers

Habitat: Treed areas

Xylotrupes ulysses (Rhinoceros Beetle) 3.7
Family Scarabaeidae (Scarab beetles)

Size: Head and body up to 6 cm, One of the largest and most spectacular Australian beetles is the rhinoceros beetle, also known as the elephant beetle, *Xylotrupes ulysses australicus.* This heavily built, chestnut coloured scarab is found all year around in the northern parts of Australia,

Habits: Adults seen year-round in NT and eat bark, fruit and flowers, larvae live under rotting logs or other decomposed organic matter that they consume and are also common in the nests of the Orange-footed Scrubfowl. Mating takes place from late December to the end of January or even into February. The males frequently congregate in large numbers on tree trunks and branches, especially those of the poinciana trees (Delonix regia). They move about vigorously while making noises to dislodge each other from the tree. The sound they produce is created by rubbing part of their abdomen against the ends of the elytra.

Habitat: Generally in forests and recognized as a minor forestry and horticultural pest. The adults feed on bark of various ornamental and forest trees and are known to damage pineapples, banana stems and coconut palms.

<u>Merimna atrata (Fire Beetle) 3.8</u>
Family Buprestidae (Jewel or metalic wood-boring beetles)

Nearly all jewel beetles are active and diurnal. Most are especially very active and alert on hot, sunny days when they readily take to the wing if disturbed, or feign death and fall (thanatosis), or fall then fly. They are phytophagous, the adults feeding on foliage, bark or the nectar or petals of flowers. Some species are important pollinators.

Size: Head and body up to 2 cm

Habits: Larvae bore in the wood of recently dead hardwood trees such as eucalyptus, acacia and grevillea. Can locate fire with special infrared receptors on his abdomen and will mate soon after the trees are burnt with the female depositing the eggs under the burnt bark

Habitat: Any treed area,

<u>Coccinella transversalis (Transverse Ladybird) 3.9</u>
Family Coccinellidae (Lady or Ladybird beetles)

Ladybird beetles are very distinctive in shape and therefore most of them are quite easy to recognize. Some ladybird species are considered as pests because they damage the foliage of plants, including some cultivated ones. However, the adults and larvae of most species are predators of aphids (Hemiptera: Aphidoidea), coccids (Hemiptera: Coccoidea) and other small insects and mites (Arachnida: Acarina), and are therefore important in the control of some unwanted insects, especially scale insects (Hemiptera: Coccoidea). Two species of Coccinella occur in Australia: Coccinella transversalis is our most common. All Coccinella species are predaceous; their main prey animals are aphids. They also hunt other small invertebrates and occasionally feed on pollen. In the Coccinellidae, 57 genera and 306 valid species are currently listed for Australia.

Size: Head and body around 5 mm

Habits: Commonest ladybird in Australia, Active by day, eats mostly aphids but also eggs of others of the same species and pollen.

Habitat: Any vegetated area supporting appropriate prey.

Poneridia semipullata (Figleaf Beetle) 3.10
Family Chrysomelidae

The leaf beetles form one of the largest families of beetles. Worldwide it has about 33 000 named species divided into 11 subfamilies, but it is estimated that a further 10 000 species still await discovery and description. Chrysomelids occur throughout Australia, including Tasmania, Norfolk and Christmas islands, with approximately 2250 described species, 188 genera and 10 subfamilies. The adults of most Australian species feed on the foliage of angiosperms, mainly *Eucalyptus* and *Acacia*.

Size: Head and body 1 cm

Habits: Adults feed on fig leaves, larvae also feed on the leaves of figs.

Habitat: Forests, parks and gardens

11. Phasmotodea (Stickinsects)

Biology: Incomplete metamorphosis, eggs may survive several years before hatching, nymphs last up to several months. Nymphs and adults are foliage feeders especially on eucalyptus and myrtaceae, acacia or grasses. They have one generation per year

Ecology: Nymphs and adults are preyed upon by birds and mammals.

Example of Phgasmotodea in the NT:

Eurycnema osiris (Darwin Stick Insect) 6.1
Family Phasmatidae

Size: Head and body up to 14 cm for males and 26 cm for females

Habits: Inhabits and feeds on foliage of trees and shrubs. Females lay hundreds of grey to brown eggs and hatch withing 4 to 25 months.

Habitat: Forests, shrublands, parks and gardens.

Notes: They are amazingly camouflaged amongst the similarly colored foliage of most trees. On occasion I spot one in vegetation along the Nightcliff coastline.

12. Phithiraptera (Lice)

Biology: Incomplete metamorphosis, eggs are laid in groups of up to several hundred, nymphs and adults feed on skin or blood of birds and mammals, very host specific.

Ecology: Main threat to lice is from the host itself through scratching and grooming. They can transmit diseases such as typhus, myxomatosis and tapeworms with severe infestations potentially debilitating to the host.

13. Neuroptera (Lacewings, antlions)

Biology: Complete metamorphosis, eggs laid on the ground or attached to plants, adults and larvae are predaceous, found near or in water, on vegetation and in leaf litter.

Ecology: All stages are attacked by a wide variety of insects especially ants and wasps, adults are mostly nocturnal and are preyed upon by bats. Lacewings are economically important in the control of sap-sucking insects and feed on a variety of pests including aphids, psyllids and scale insects.

14. Thysanoptera (Thrips)

Biology: Incomplete metamorphosis, eggs are laid into slits cut into or attached onto the host plant, nymphs and adults are phytophagous, fungal-feeding, gall-forming or predaceous on other invertebrates. Some are important plant pests and can be found on plants especially flowers and young shoots, leaf litter and in plant galls, or host plants of prey.

Ecology: Attacked by fungi and predaceous arthropods such as bugs and spiders.

15. Strepsiptera (Strepids)

Biology: Complete metamorphosis, parasitic.

Ecology: Parasitic on other insects

16. Mantodea (Mantids)

Biology: Incomplete metamorphosis, nymphs and adults are predaceous on insects and other arthropods, because they are cannibalistic their numbers are never very high

Ecology: Nymphs and adults are cannibalistic as well as predatory and are attacked by lizards, birds and insectivorous mammals.

17. Thysanura (Silverfish)

Biology: Feed on plant products especially paper and glues, several species are domestic pests,

Ecology: Largely unkown, spiders are their most important predator.

18. Siphonaptera (Fleas)

Biology: Complete metamorphosis, parasites of mammals or birds, adults free-living blood-suckers, host specific, cat flea attacks a wider variety of mammals including cat, dogs and humans and is the most likely species to be found on these hosts.

Ecology: Larvae may be preyed upon by general predators, can be serious economic pests because of their biting habit and as a vectors for disease.

19. Trichoptera (Caddisflies)

Biology: Complete metamorphosis, eggs laid in or near water, adults live up to several weeks and may feed on water or nectar, several generations a year may occur, adults can be found near water and may be swept from vegetation.

Ecology: Larvae are an important art of the diet of some fishes, attacked by predatory aquatic insects, adults are attacked by other insects and spiders, and by birds, bats, frogs and fish.

20. Embioptera (Webspinners, Embids)

Biology: Incomplete metamorphosis, eggs are guarded by the female, feed on living and dead plant material including moss, lichen, leaves and bark adjacent to their silk galleries

Ecology: Eggs are parasitised by wasps, nymphs are parasitised by wasps and flies

21. Isoptera (Termites)

Biology: They undergo incomplete metamorphosis are social and live in colonies founded by a king and queen together with a caste system of workers, soldiers and reproductives. The first offspring are tended by the queen and king until mature after which the workers take over the feeding of the young, nest construction and food. The soldiers guard the nest against intruders. Many termite species harvest and feed on dead grass with some feeding on decaying matter in the soil and relatively few are considered timber pests.

Ecology: Termite colonies (nests and galleries) are attacked by frogs, snakes and mammals including echidnas and numbats. Damaged nests are also susceptible to invasion by ants. Flying termites are slow fliers and are eaten in large numbers by frogs, reptiles, birds and predatory insects and spiders, most species feed on dead timber but may damage other subterranean materials such as pipes and cables.

Notes: You may spot little conical mud structures in your yard. These are termite mounds made by the Tumolitermes sp.. They eat mostly dried grass and other decomposing matter. Out of the 350 or so species of termites in Australia only about 20 are considered pests including the well known large Mastodermes darwiniensis. About once a year you will witness flying termites. Whilst flying around males and females pair off to start a new nest together. The wings drop off soon after landing and the female becomes a very large queen while the male king stays close by. They firstly breed sterile workers which build the nest and gather food through a vast network of underground tunnels. As the colony grows soldiers are also produced. More aggressive than the workers they protect the nest from unwanted visitors. After a year when the nest is fully established a batch of fertile termites is produced which sprout wings and fly away to start the process all over. Interestingly termites also commonly referred to as 'white ants' are not closely related to ants but more to cockroaches. Termites are one of natures most important recycling agents, returning nutrients to the soil from digestion of cellulose in dead wood, roots and leaves. While in a wet environment the recycling is done mostly by microscopic protozoans, bacteria, fungi and worms, in dry substrates this job falls on to termites which can cope better with hot and dry conditions. Their mounds become rich storehouses of carbon, nitrogen, phosphorus, potassium and other nutrients. The excavation of termites also alter the structure of trees and create hollows which are utilized by many animals such as bats, birds, reptiles and mammals. When the mounds break down, the fertilizer contained in it is returned to the soil.

When flying termites emerge, birds, lizards, snakes, frogs, microbat ants and other insect feast on them. Ants predate termites and often invade termite nests. Frilled lizards as well as geckos, legless lizards, skinks and blind snakes also feed on termites. There is no doubt that termites are incredibly benefical for the ecology of the Top End savannah as they are for gardens, for without them there would be no viable self-sustaining healthy soil. Rather than to fight them, we should focus to build our structures to be termite proof and not spend huge amounts of money on useless chemical termite treatments that also kill microbial life and other organisms that rely on a prescence of termites.

Examples of Isoptera in the Top End:

Coptotermes acinaciformis (Tree-piping Termite) 6.9
Family Rhinotermitidae

Size: Head and body 6.5 mm for workers and soldiers.

Habits: This species colonizes living trees by eating the wood and hollowing out the core, often filling the cavity with earth. As it grows the colony will build a mound at the base of the tree from which many underground tunnels lead to other trees. Their activities usually don't kill the host tree and food trees but weaken them and so make them susceptible to damage by fire and storms.

Habitat: Forest, shrublands and grasslands

Notes: We tend to come down on all termites within developed urban areas through the uses of dangerous toxins that not only can cause damage to the targeted colony of termites but also to many other insects such as ants the latter which are the natural antagonist to termites in the connected web of life. We need termites as they are vitally important for top soil creation and also help create the tree hollows and cavities that are important nesting sites for other animals. Have a walk in any public park and observe a proliferation of Tree-piping Termites hardly any of which kills the tree. We need to live with nature rather than outside of it.

22. Psocoptera (Psocids, Booklice)

Biology: Incomplete metamorphosis, nymphs and adults feed on a variety of plants as well as algae and some feed on insect fragments, under bark and leaves, in leaf litter, old fences and under rocks, not usually common.

Ecology: Attacked by nematodes, fungi, spiders and a wide range of insects, lacewings, ants and wasps.

A final word on insects:

This concludes the quick tour of orders of insects and you may have now an inkling on how this world is interwoven with anything else. In general most people view insects as harmful but are they really or is it just in our skewed homo-centric perception of the world? Insects are held responsible for the destruction of between 10 – 15 % of the world's human food despite the wide spread use of pesticides in pursuit for profits on gigantic fields of mostly mono-cultured crops. The use of pesticides in many cases does not discriminate between pest species and useful insect species. It kills them all, good and bad insects, often including mammals, reptiles, birds and other creatures that depend on such insects. Application of pesticides is also forcing the adaption of the insect's genetic immune-resistance against those chemicals. The response of the farmer has been the use of ever stronger doses of chemicals or alternatively applying newer more lethal and worse the application of multiple chemicals. Since insects are largely responsible for top-soil formation and with insects reportedly declining by 9 % annually, our farming systems are increasingly challenged by the degradation of soils on which crops grow. On top of this we continue to clear forests for urban development, agriculture and industrial development and so lethally diminish the last refuge of the biodiversity of life. To make things worse our scientists and technocrats have begun meddling directly with creation itself through the introduction of genetically modified cropping plants. These and many other problems such as climate change has forced us into a corner without an escape. As many scientists are warning, we now know we head towards extinction, it's no longer a question of if but a question of when on current trajectories.

We need to understand and fully appreciate that insects are fundamental to the food chain. Why is it then that we are trying so hard to eliminate them? Bees, flies and butterflies help pollinate our food plants, wasps and ladybirds destroy the caterpillars and aphids that attack plants, beetles and flies clean up rotting plants and other wastes. Insects provide food for lizards, birds and many other animals.

Spraying insecticides, be on industrial scale or on a smaller scale in our parks and gardens we kill all of these creatures and ultimately undermine the basis of our own existence.

Is there a solution to the problem? Of course there is. We now know we have to convert at least 30 % of developed land back to natural forest or 'wildlands' in order to halt the decline of biodiversity and accelerating species extinctions, the latter running at a thousand fold pace compared to natural. We need to decentralize crop production and grow our food locally in mixed cropping systems and preferably firmly based on permaculture principles. Food is the most fundamental need of any organism including the human to persist. Growing organic food under permaculture systems will be more expensive because it requires more labor but is this so bad? All we really need is to change our priorities in life and promote the quality of naturally grown local food over the purchase of the latest iphone, a bigger car and mansion. Growing and consuming natural foods locally will also reduce green house gas emission by substantially reducing the need to haul food over long distances. Consider that the food that you grow yourself especially grown the bio-organic way, tastes better, is healthier, is free of harmful chemicals and most importantly has less negative consequences for the environment. In the Top End we have the opportunity to grow a huge variety of vegetables and fruits either in shadehouses or in the garden year round. In addition to the satisfaction of growing your own food, the physical activity of gardening will be beneficial to your fitness and health.

What is not an insect but is commonly thought off as an insect? The following groups are invertebrates just as insects and likewise have a big role to play in natural systems.

Spiders (have eight legs)
Centipedes (have one pair of legs on each segment)
Millipedes (two pairs of legs on each segment)
Earthworms (no legs)
Scorpions (have eight legs)

SPIDERS

The total number of Australian spider species is probably around 15,000 to 20,000. So far only 4000 of them have been described. Spiders have four pairs of legs and two body segments, the cophalothorax (head and chest together) and the abdomen at the rear. The body segments are connected by a tube called the pedicel. The front section has most of the muscles, brainpower, eyes and legs. The rear section has the lungs, genitalia, gut, and spinnerets, with some muscles supporting these. Males have external secondary sex organs, on the ends of each of their pedipalps. The female has a receiver for the male’s organ on the underside of her abdomen near the lungs called the epigyne. Eyes (usually eight) are important and often distinctive.

Many people seem to have a natural aversion of spiders which in some people even just in thought, escalates to panic and fear. Yet spiders are great to have in the garden not only because of their habit of controlling flying insects such as mosquitoes but also many providing birds on a supply of spider webs to reinforce their nests by helping to hold other structural components together. Spiders can be fournd everywhere in natural bushland but when I look around in my neighborhood there are very few spider webs in sight. Council and body corporate garden crews tend to remove them as do backyard gardeners. The fear of spiders is ungrounded. I once lived in an open shed on a bushland block near Katherine infested with redback spiders, invaded by snakes and many other creepy crawlies yet I was never bitten once. Sure there may have been a small risk, but so is just driving to work or holding a mobile to your head, living near a G5 tower or getting vaccinated. I don't mind spiders and wish other people would likewise. Just think of them as your personal flying insect control particularly for mosquitos. Leave their nets untouched in the quiet vegetated corners of your garden. Here are some of the most commonly encountered in Darwin gardens.

1. Daddy Long Legs (Pholcus phalangioides) 5.1
   Family Pholcidae

Pholcids are well known because of their tendency to travel with humans and live in houses, garages, outhouses, sheds and other buildings. As well as the nine introduced species there are around 60 Australian pholcid species in 16 genera. The number of species is expected to double as a result of more research work. The common Daddy Long-legs Spider Pholcus phalangioides (so named because the abdomen is finger-shaped) is one of the most noticed house spiders because of its enormously long legs, and because it lives where humans have built dwellings.

Size: Head and body 6 – 8 mm

Habits: Active day or night and builds a messy web in quiet dark places, such as hollow log and cavities amongst rocks. It traps invertebrates in the web but will also enter the web of other spiders to prey upon them or to eat their eggs. This species breeds any time of the year. Their venom is mild to humans.

Habitat: Open woodland, houses and other structures.

Notes: A myth developed around its venom, suggesting it would easily kill a person if only its fangs were big enough to penetrate skin. This is simply false. It probably arose because of its ability to kill the Redback Spider Latrodectus hasseltii but its success at capturing, killing and eating Redback Spiders is due to technique, not venom. Daddy Long-legs Spiders can tangle up and wrap Redback Spiders from a safe distance by means of their long legs, which they use to apply silk. Once the Redback is fully trussed, the Daddy Long-legs Spider can deliver bites at will and simply wait for the bigger spider to die so it can feed.

2. St Andrews Cross Spider (Argiope aetherea) 5.2
   Family Araneidae

When most people imagine a spider they probably have in mind an orb-weaver of some kind, usually in a fairly large web and with a spider waiting at the centre. Araneidae is one of those spider families. Its spiders are the archetypal Orb-weavers. Because of the huge range of species in Araneidae, they can be organized into subfamilies (large groups of related genera) such as:

• Araneinae	Classic Orb-weavers
• Argiopinae	St Andrew's Cross Spiders
• Cyrtarachninae	Shiny Orb-weavers
• Cyrtophorinae	Tent-web Orb-weavers
• Gasteracanthinae	Spiny Orb-weavers
• Mastophorinae	Bolas Spiders & allies
• Nephilinae	Golden Orb-weavers
• Zygiellinae	Leaf-curling Orb-weavers.

The webs of Orb-weavers are often vertical or nearly so. Some are horizontal. Sticky silk spirals are utilised to trap prey. When the spider senses movement of its prey struggling in the web it rushes to bite its victim, or wrap it in silk, or both.

Size: Head and body 5 mm male, up to 18 mm female

Habits: This species builds a large X shape into their webs and sits head down in its center. If a male enters the web to mate and the female is not receptive the male may be eaten. Females construct egg sacs at the end of her web, each sac containing up to 300 eggs.

Habitat: Forests, heathland, parks and gardens

Notes: St Andrew's Cross Spider webs like other Orb-weaver webs are often in the open, and easily damaged or destroyed by larger animals, as humans who have walked around their yards or in the bush at night will know. The huge number of webs made at night can be surprising. Common in parks and gardens as well as bushland, most St Andrew's Cross Spiders have characteristic web decorations in the form of a full or partial X shape, with thick white silk along the radials of the web. This web ornamentation is known as a stabilimentum.

3. Garden Orbweaving Spider (Eriophora biapicata) 5.3
   Family Araneidae

Size: Head and body male 17 mm, female 25 mm, both hairy including on the legs

Habits: Creates a large web at dusk in the open space between trees and shrubs. The spiders sits in the web center during the night to wait for flying invertebrates. By day hides in nearby vegetation. Bites are reportedly not too serious.

Habitat: Open woodland, parks and gardens

4. Edible Golden Orbweaving Spider (Nephila edulis) 5.4
   Family Nephilidae

There are only three nephiline genera in Australia. The best known is Nephila whose spiders construct large webs made from strong golden silk, hence the family name. Nephila sp are well known and highly visible, especially Nephila plumipes the Eastern Golden Orb-weaver, Nephila edulis the Australian Golden Orb-weaver and Nephila pilipes the Northern or Tropical Golden Orb-weaver. The name Nephila is derived from Greek, meaning fond of spinning. The species name edulis means edible in Latin.

Size: Head and body male 5 mm, females 40 mm

Habits: They create a huge permanent web across a space between vegetation. The females sit in the web day and night. When abundant, prey may be wrapped in silk and cached in the web for later consumption. Males are occasionally eaten after mating.

Habitat: Open woodland, shrublands, parks and gardens

Notes: Nephilines are timid spiders and bites are rare. The effects of bites of even the giant Nephila pilipes are minor, resulting only in redness, swelling and perhaps blisters which soon disappear.

However Nephila edulis and Nephila pilipes are reportedly capable of eating large prey including birds and even snakes. The golden-yellow silk of Nephila sp is incredibly strong and versatile. It has been woven into impressive garments including a famous cape from Madagascar utilizing the silk from 1.2 million spiders.

5. Giant Golden Orbweaving Spider (Nephila pilipes) 5.5
   Family Nephilidae

Refer notes edible Golden Orbweaving Spider

Size: Head and body male up to 4 mm, females up to 50 mm

Habits: This species also creates a huge web across space between vegetation. Females sits in the web day and night. Prey is mostly flying insects, but also occasionally small vertebrates. It breeds in the wet season when males can often be seen in the web. Their courtship is elaborate.

Habitat: Monsoon and riverine forest, parks and gardens, rainforest

6. Australian Hermit Spider (Nephilengys papuana) 5.6
   Family Nephilidae

Size: Head and body male up to 5 mm, female up to 18 mm

Habits: Active at night, the female builds a large web across a surface such as a tree trunk, boulder or wall with a tubular retreat in the middle where she hides by day or if disturbed. If the web is damaged it will be repaired. Nephilengys spp have retreats attached to the hub of the orb webs, and also to the nearby surface against which the web is built. They are occupying the retreat by day, then emerging at night to wait for prey to get trapped in the web which is large and persistent. Males lose their palps during mating. The detached palp forms a plug which prevents other males from achieving insemination.

Habitat: Forests, parks and gardens

7. Redback Spider (Latradectus hasselli) 5.7
   Family Theridiidae

Theridiids are called Comb-footed Spiders because nearly all species have a comb of stiff bristles on the outermost segment of leg 4 which is used for drawing silk from the spinnerets. In various places they have also been called Tangle-web Spiders or Cobweb Spiders because some species have messy space webs, but the family as a whole has many web architectures. The family is one of the least studied, despite the attention given to the Redback Spider (the best known member of the family in Australia). There are nearly a hundred species in around 25 known genera. It is estimated there may be well over 500 Australian species in more than 100 genera when more studies are done. The Redback Spider is thought to have originated in the South Australian or Western Australian deserts. From this remote origin it has invaded the rest of Australia and several places overseas.

Size: Head and body male up to 3 mm females up to 15 mm.

Habit: Redbacks build a messy web including a funnel-shaped structure which is the spiders retreat during the day. Their webs are often located in dark and quiet places. They feeds on invertebrates and sometimes small vertebrates. Males survive about ten months without food. Females often eat the male after copulating, The Redback has a dangerous venom and a bite may cause acute pain, weakness, nausea, convulsion, paralysis and eventually death without administration of an antivenom.

Habitat: Open woodland, gardens and often in areas around human habitation.

Notes: You may not want these in your garden. The larger female is capable of inflicting extremely painful bites. If bitten call an ambulance.

8. <u>White Crab Spider (Thomisus spectabilis) 5.8</u>
   Family Thomisidae

Crab Spiders, some also known as flower spiders, are daytime ambush hunters, common throughout Australia in most habitats but more common in tropical and subtropical areas. They are nearly always camouflaged. They have crab-like legs, allowing them to move sideways. Some can change colour to match flowers. Their spinnerets are short and conical in a tight cluster. They have a sac-like retreat, often in a folded leaf, where females lay eggs.

Size: Head and body male 3 mm, female 12 mm

Habits: Active by day they do not build a web but sit on a flower waiting for nectar feeding insects to arrive. Against a white flower, the UV-reflecting spider creates a pattern which attracts flying pollinators. A bite can cause pain, swelling, nausea, headaches and dizziness. Crab Spiders are renowned for capturing prey many times their size. Insects and even other spiders foraging among flowers are ambushed and bitten in the head or neck, resulting in a quick death.

Habitat: Open woodland, heathland, parks and gardens

Notes: Crab Spiders are perhaps the easiest daytime spiders to photograph. Because they rely on camouflage to avoid detection, their main defense strategy is staying still. Other groups like Jumping Spiders and Lynx Spiders leap about and run away. If you put a crab spider on a leaf, it's likely to freeze in place, even if not invisible against the background.

9. <u>Green Ant Scent-mimicking Spider (Cosmophasis bitaeriata) 5.9</u>
   Family Salticidae

Jumping Spiders are members of the family Salticidae, the world's most diverse and abundant spider family, with over 500 described genera and more than 5,000 described species, making up more than 13 per cent of all described spiders. In Australia, these small predators are particularly abundant and diverse.

Size: Head and body up to 1 cm

Habits: By emitting ant odors it mimics the smell of green ants which allows the spider to enter the nest without causing aggression. It then preys on the larvae of the Green Tree Ant Oecophylla smaragdina. It does not look much like a Green Tree Ant and therefore avoids adult ants during daylight. Males and females, unlike most Cosmophasis, look very much alike. Retreats of this species occur on the same vegetation as their hosts. The more Green Tree Ants there are, the more spider retreats there will be. It also eats other invertebrates. Females lay their eggs on the outside or inside of Green Ants nests. The spider is non-lethal to humans.

Habitat: Forests, parks and gardens

Notes: For the photographer Jumping Spiders are ideal, inquisitive and cheeky, relatively easy to find and often will turn to look at the camera, sometimes jumping onto the lens. Their ability to track and ambush prey is amazing. They can calculate distances while watching their prey, then move to a vantage point out of line of sight and with a prodigious leap, fly through the air to grab their victim and immobilize it with a bite. Jumping spiders are so widespread and abundant it is inevitable they sometimes bite people. No one has suffered any serious, long-lasting health problems as a result, the worst being strong pain and sweating lasting a day or so when bitten by some of the larger northern species.

10. Green Jumping Spider (Mopsus mormon) 5.10
    Family Salticidae

Size: Head and body males up to 12 mm, female 15 mm

Habits: Active both day and night it hunts invertebrates and spiders while juveniles also drink nectar. Both males and females may construct a flattish home of silk in foliage. This is a big, obvious spider, inquisitive and fearless and a ready biter but not seriously harmful, causing only mild to sharp pain and swelling is not considered dangerous to humans.

Habitat: Forests, parks and homes, mainly found in rainforest and other well-vegetated coastal areas often in gardens.

SCORPIONS

The word "scorpion" is thought to have derived from the Latin 'scorpius', which is the romanization of the Greek 'skorpíos'. They are predatory arthropods as arachnids placed in the order of Scorpiones and have eight legs just as spiders but are easily recognized by their pair of grasping pincers and a narrow, segmented tail the latter which is often carried in a characteristic forward curve over the back and ending with a stinger. They are an ancient organism going back 435 million years and now cover over 2,500 described species. There are 29 Australian species of which 16 – 17 occur in the NT.

A common scorpion found in the Darwin area is Lychas variatus (Northern Marbled Scorpion). Its head and body including tail reach 55 mm. Commonly hiding by day under debris or in holes or crevices, it is generally found in forests and grasslands. A sting results in pain that last for a few hours but is not lethal.

Altough primarily preying on insects and other invertebrates some scorpion species also take vertebrates. They kill prey after restraining it with their pincers. Themselves they are preyed on by larger animals and the venomous sting can be used both for killing prey and for defense against predators.

During courtship, the male and female scorpion grasp each other's pincers and move around in a "dance" where the male tries to maneuver the female onto his deposited sperm packet. All known species give live birth and the female cares for the young as their exoskeletons harden, transporting them on her back. The exoskeleton contains fluorescent chemicals and glows under ultraviolet light. The young scorpions may take up to five years to reach maturity.

The vast majority of species do not represent a serious threat to humans, and healthy adults usually do not need medical treatment after being stung. Australian scorpions are not considered dangerous. Since most scorpion species are nocturnal, finding shelter during the day in burrows, cracks in rocks and tree bark they don't easily interfere with humans. Many species dig a shelter underneath stones a few centimeters long. Some may use burrows made by other animals including spiders, reptiles and small mammals.

Scorpions may be attacked by other arthropods like ants, spiders, solifugids and centipedes. Major predators include frogs, lizards, snakes, birds, and mammals. Scorpions generally prey on insects, particularly grasshoppers, crickets, termites, beetles and wasps. Other prey include spiders, woodlice and even small vertebrates including lizards, snakes and mammals. Species with large claws may prey on earthworms and mollusks. The majority of species are opportunistic and consume a variety of prey and they can also display cannibalistic behavior. Prey size depends on the size of the species. Several scorpion species are wait and ambush predators near the entrance to their burrow. Others actively seek out prey actively using their mechanoreceptive and chemoreceptive hairs on the bodies to capture it with their claws. Small animals are merely killed with the claws, particularly by large-clawed species. Larger and more aggressive prey is given a sting.

Scorpions, like other arachnids, digest their food externally. The chelicerae, which are very sharp, are used to pull small amounts of food off the prey item into a pre-oral cavity below the chelicerae and carapace. The digestive juices from the gut are egested onto the food, and the digested food is then sucked into the gut in liquid form. Any solid indigestible matter is trapped by setae in the pre-oral cavity and ejected. The sucked-in food is pumped into the midgut by the pharynx, where it is further digested.

Being an integral part of the food chain in a healthy environment they contribute by increase diversity and to maintaining balance. If you are inclined to respect their ancient heritage and curious to observe them then provide a habitat by mixing loose debris with a patch of placed rock under which the scorpions can hide during the day.

MILLIPEDES

Millipedes are a group of arthropods that are characterised by having two pairs of jointed legs on most body segments. Each double-legged segment is a result of two single segments fused together.

Although the name "millipede" derives from the Latin for "thousand feet", no known species has 1,000. There are approximately 12,000 named species classified into 16 orders and around 140 families, making the class of Diplopoda the largest class of myriapods, an arthropod group which also includes centipedes and other multi-legged creatures. Millipedes can be distinguished from the somewhat similar but only distantly related centipedes (class Chilopoda), which move rapidly, are venomous, carnivorous, and have only a single pair of legs on each body segment rather than two as with millipedes. There are at least 4 locally described species of millipedes in the Northern Territory.

The majority of millipedes are slow-moving detritivores, eating decaying leaves and other dead plant matter. Some eat fungi or suck plant fluids, and a small minority are predatory. Millipedes are generally harmless to humans, although some can become household or garden pests. Most millipedes defend themselves with a variety of chemicals secreted from pores along the body. However its primary defence mechanism is to curl into a tight coil, thereby protecting its legs and other vital delicate areas on the body behind a hard exoskeleton. Millipedes do not bite, and their defensive secretions are mostly harmless to humans, usually causing only minor discolouration on the skin. However the secretions of some tropical species may cause pain, itching, local erythema, edema, blisters, eczema, and occasionally cracked skin. Eye exposures to these secretions causes general irritation and potentially more severe effects such as conjunctivitis and keratitis. This is called millipede burn. First aid consists of flushing the area thoroughly with water; further treatment is aimed at relieving the local effects.

First appearing in the Silurian period some 428 million years ago, millipedes are some of the oldest known land animals. Early forms probably ate mosses and primitive vascular plants. Millipedes, centipedes, and other terrestrial arthropods attained very large sizes in comparison to modern species in the oxygen-rich environments of the Devonian and Carboniferous periods, and some could grow larger than one metre. As oxygen levels lowered through time, arthropods became smaller. Millipedes and centipedes are both groups of myriapods and thus share similarities, such as long, multi-segmented bodies, many legs, a single pair of antennae, and the presence of postanntennal organs, but also display many differences and distinct evolutionary histories, as the most recent common ancestor of centipedes and millipedes lived around 450 to 475 million years ago in the Silurian.

The head alone exemplifies the differences with millipedes having short, geniculate (elbowed) antennae for probing the substrate, a pair of robust mandibles and a single pair of maxillae fused into a lip while centipedes have long, threadlike antennae, a pair of small mandibles, two pairs of maxillae and a pair of large poison claws.

Millipedes come in a variety of body shapes and sizes, ranging from 2 mm to around 35 cm in length, and can have as few as eleven to over a hundred segments. They are generally black or brown in colour, although there are a few brightly coloured species, and some have aposematic colouring to warn that they are toxic.

Millipedes breathe through two pairs of spiracles located ventrally on each segment near the base of the legs. Each opens into an internal pouch, and connects to a system of tracheae. The heart runs the entire length of the body, with an aorta stretching into the head. The excretory organs are two pairs of malpighian tubules, located near the mid-part of the gut. The digestive tract is a simple tube with two pairs of salivary glands to help digest the food.

The genital openings (gonopores) of both sexes are located on the underside of the third body segment (near the second pair of legs) and may be accompanied in the male by one or two penes which deposit the sperm packets onto the gonopods. In the female, In all except the bristle millipedes, copulation occurs with the two individuals facing one another. Copulation may be preceded by male behaviours such as tapping with antennae, running along the back of the female, offering edible glandular secretions, or in the case of some pill-millipedes, stridulation or "chirping".

Females lay from ten to three hundred eggs at a time, depending on species, fertilising them with the stored sperm as they do so. Many species deposit the eggs on moist soil or organic detritus, but some construct nests lined with dried faeces, and may protect the eggs within silk cocoons. In most species, the female abandons the eggs after they are laid, The young hatch after a few weeks, and typically have only three pairs of legs, followed by up to four legless segments. As they grow, they continually moult, adding further segments and legs as they do so. Some species moult within specially prepared chambers of soil or silk, and may also shelter in these during wet weather, and most species eat the discarded exoskeleton after moulting.

Typically forest floor dwellers, millipedes live in leaf litter, dead wood, or soil, with a preference for humid conditions The diplosegments of millipedes have evolved in conjunction with their burrowing habits, and nearly all millipedes adopt a mainly subterranean lifestyle. They use three main methods of burrowing; bulldozing, wedging and boring.

Being detrivores millipedes generally play a significant and important role in the breakdown and decomposition of plant litter. Estimates of consumption even consider that millipedes may collectively consume nearly all the leaf litter in a region. The leaf litter is fragmented in the millipede gut and excreted as pellets of leaf fragments, which facilitates decomposition by other microorganisms. Where earthworm populations are low in tropical forests, millipedes play an important role in facilitating microbial decomposition of the leaf litter. Some millipedes are herbivorous, feeding on living plants, and some species can become serious pests of crops.

Millipedes also provide an important source of food in as they are preyed on by a wide range of animals, including various reptiles, amphibians, birds, mammals, and insects.

Asiomorpha coarctata, Paradoxosomatidae or also taxed as Orthomorpha coarctata (Long-Flange Millipede) is one of the common local Darwin species and grows to about 21 mm. living in loose humid soil while feeding mostly on decomposting leaf matter. They can be found readily in large numbers in fresh plant potting mixes and in a humid, sheltered locations with fallen vegetation and loose soil.

CENTIPEDES

The name derives from the New Latin prefix centi-, 'hundred', and the Latin word pes, pedis, 'foot'. Centipedes are elongated segmented predatory arthropods. with one pair of legs per body segment distinguished from Milllipedes who have two legs per segment. Most Centipedes are generally venomous and can inflict painful bites, injecting their venom through pincer-like appendages known as forcipules. Despite the name, centipedes can have a varying number of legs, ranging from 30 to 354. Like spiders and scorpions, centipedes are predominantly carnivorous.

Worldwide, an estimated 8,000 species of centipedes are thought to exist, of which 3,000 have been described. Of these at least 10 – 21 centipede species occur in the Northern Territory.

Centipedes can be found in a wide variety of environments. Lacking the waxy cuticle of insects and arachnids and therefore causing them to rapidly lose water they generally require a moist microhabitat. Accordingly, they are found in soil and leaf litter, under stones and dead wood, and inside logs. Centipedes are among the largest terrestrial invertebrate predators, and often contribute significantly to the invertebrate predatory biomass in terrestrial ecosystems.

Many species of centipedes lack eyes, but some possess a variable number of ocelli, which are sometimes clustered together to form true compound eyes. However, these eyes are only capable of discerning light and dark, and have no true vision.

Forcipules are a unique feature found only in centipedes and in no other arthropods. The forcipules are modifications of the first pair of legs, forming a pincer-like appendage always found just behind the head. Forcipules are not true mouthparts, although they are used in the capture of prey items, injecting venom and holding onto captured prey. Venom glands run through a tube almost to the tip of each forcipule.

As predators, centipedes mainly use their antennae to seek out their prey. The digestive tract forms a simple tube, with digestive glands attached to the mouthparts. Like insects, centipedes breathe through a tracheal system, typically with a single opening, or spiracle, on each body segment. They excrete waste through a single pair of malpighian tubules.

The head differs from that of millipedes which have short, geniculate (elbowed) antennae for probing the substrate, a pair of robust mandibles and a single pair of maxillae fused into a lip while centipedes have long, threadlike antennae, a pair of small mandibles, two pairs of maxillae and a pair of large poison claws.

Centipede reproduction does not involve copulation. Males deposit a spermatophore for the female to take up. In one clade, this spermatophore is deposited in a web, and the male undertakes a courtship dance to encourage the female to engulf his sperm. In other cases, the males just leave them for the females to find. In some species they lay their eggs singly in holes in the soil, and the female fills the holes with soil and leaves them. The number of eggs the females lay ranges from about 10 to 50. Time of development of the embryo to hatching is highly variable and may take from one to a few months. Females of some species show a higher degree od parental care. In this case the eggs, 15 to 60 in number, are laid in a nest in the soil or in rotten wood. The female stays with the eggs, guarding and cleaning them to protect them from fungi. The female in some species stays with the young after they have hatched, guarding them until they are ready to leave. If disturbed, the female either abandons the eggs or eats them; abandoned eggs tend to fall prey to fungi rapidly.

Although being predators centipedes have been observed to eat vegetable matter when starving. Centipedes are mostly nocturnal and what they eat is not well known because of their cryptic lifestyles and thorough mastication of food but is thought to be mostly earthworms for some species. The bigger centipede species due to their size, are able to feed on vertebrates, in addition to invertebrates. In this case springtails may provide a large proportion of their diets. Many larger animals prey upon centipedes, such as rodents, lizards, beetles and snakes. They form an important item of diet for many species and the staple diet of some.

Some species of centipedes can be harzardous to humans because of their bite. While a bite to an adult human is usually very painful and may cause severe swelling, chills, fever, and weakness, it is unlikely to be fatal. Bites can be dangerous to small children and those with allergies to bee stings. The venomous bite of larger centipedes can induce anaphylactic shock in such people. Smaller centipedes are generally incapable of piercing human skin. In any case always wear protective gloves when working in the garden and be cautious when spotting a centipede. Respect their ecological role in the food web and let them carry on.

<u>LIZARDS, MAMMALS, REPTILES AND AMPHIBIANS</u>

Apart from birds and insects there are also a number of other animals that can make their home in some of our Darwin gardens and that means mammals including bats, but also lizards, frogs and snakes. An absence of frogs and lizards is amongst the best indicators of an environment gone wrong because it could indicate that pollutants are high in your environment as these creatures respond sharply with their highly tuned physiologies. Like spiders, frogs and lizards help to keep flies and mosquitoes under natural control. If you have frogs in your garden you may also get predatory birds, snakes and lizards that feed on frogs.

Just like birds, depending on species, bats live of fruits, blossoms and insects and their presence depends on the relative abundance of each food source. Bats have received more of our attention recently as a suspected source of the origin of coronavirus in China. We have a few bat species in our gardens in Darwin of our own and they are either insectivorous or frugivorous. The frugivorous flying foxes (Black Flying Fox and Little Red Flying Fox) produce one baby each year. Pregnancy lasts for about six months and birth taking place in October or November, just after the Mangoes are ripening, The mother carries the infant around with her for three months, until it becomes too heavy. Bats live up to 20 years but can fly after only three months and become fully independent after about a year. Unlike insectivorous microbats, frugivorous flying foxes navigate primarily by sight, and in the dark their visual prowess exceeds that of humans. Parts of the eye structure are similar to primates, suggesting an evolutionary link. Like many large mammals, fruit bats carry viruses which can affect humans, including Lyssavirus, Japanese Encephalitis, Ross River and Hendra virus. Direct transmission to humans (except in the case of Lyssavirus) does not occur, and bats like other mammals, are reservoirs for these diseases, which then require another carrier to reach people, similar as the mosquito carry Ross River Virus from wallabies to humans. Northern fruit bat populations establish more permanent camps than those in southern regions, reflecting the more predictable nature of flowers and fruit in areas receiving heavy rain annually. Flying foxes are of pivotal importance to the maintenance of native forests. Seeds pass rapidly through their relatively short digestive tract, leaving the seeds almost always viable. The huge numbers of bats disperse these seeds great distances between isolated clumps and to new areas thereby enriching genetic diversity. The fruit bats are also major pollinators to native forests. In some cases fruit bats are the only known pollinators or seed dispersers of certain plant species. The smaller micro bats tend to roost in dark places such as caves, mines, tree hollows and under bark while the flying-foxes roost among the branches of tall tree or in palmtops.

Snakes are very common in Darwin Gardens covering about 20 species with about 700 a year on record to be removed from urban habitation by the Parks and Wildlife Service on average. Of these only 2 percent are considered dangerous. mostly the Northern Brown Snake. However the majority of snakes is quite harmless, the most common of them being the Northern Carpet Python and the Golden Tree Snake.

Lizards are common in Darwin gardens and are a prolific predator of insects and other smaller creatures. They come in a huge range of size up to 1.5 m long.

I have selected the most commonly occurring species of mammals, lizards and amphibians for inclusion into this book and they are described in random order as follows. The number behind the name of the species refers to the number in the animal species charts at the back of the book.

<u>Northern Water Dragon (Lophognathus temporalis) 7.1</u>

Lizards, such as the common Northern Water Dragon are not reptiles unlike crocodiles.

Size: Snout-vent length 10 cm to 40 cm, the males are larger and can reach 60 cm including its tail.

Habits: Abundant in suburbia they are ground-dwelling as well as arboreal and sleep perched in vegetation. The mainly feed on invertebrates which they mostly catch on grassed surfaces.

Habitat: Forest, shrublands, parks and gardens often near the edge of waterways.

Notes: I see quite a few of them in our garden, they can dart very fast to catch an insect, then stop, head raised high, on the lookout of more. The birds don't take any notice of them, obviously for them the Northern Water Dragon poses no danger nor does it in any way for humans. They are lovely to watch and very useful in containing insect populations. Their numbers seem to fluctuate with seasons and insect populations and when inactive tend to lower their metabolic rate and hibernate late in the Dry.

<u>Northern Dwarf Tree Frog (Litoria bicolor) 7.2</u>

Size: Total length 3 cm

Habits: Common at night, they perch on grass or other plants especially near water, During the day it rest with limbs tucked closely, in shaded or hidden positions, such as within crowns of Pandanus. The female lays clumps of eggs below the surface. They eat tiny invertebrates.

Habitat: Vicinity of waterways and open woodland.

Notes: If you install a natural pond you'll see lots of them.

<u>Green Tree Frog (Litoria caerulea) 7.3</u>

Size: Total length up to 10 cm

Habits: They are very common and inhabit buildings, holes, crevices, soil cracks and tree hollows. Breeding in ponds, pots and other receptables that fill with water in the wet, they find refuge in cavities and hiding places in moist gardens during the dry. When rains arrive the male starts croaking loudly from the edge of perches near unmoving water to attract a female with the female then laying up to 4000 eggs on the surface. They eat invertebrates and sometimes small vertebrates.

Habitat: Tropical forests and swamps

Notes: I find them anywhere in odd places for example dislodged in the neck of my watering can. They are a cute looking frog in its bright green color and a favorite subject of photography. The Green Tree Frog reaches very high densities in the suburbs of Darwin possibly the highest anywhere in Australia for this species. However they are not that common in the bush and rarely call there. If you establish a wet or boggy area in your garden they will have a place to live. This year in 2021 I have them living in an arrangement of pots where several of them stay happily during the Dry Season.

<u>Cane Toad (Rhinella marina) 7.4</u>

Size: Rotal length 14 cm, max 24 cm females are larger

Habits: Active at night with adults eating mostly invertebrates but also small vertebrates and often congregate around artificial water and light sources, In the NT the Cane Toad breeds mostly in the wet season and depositing up to 20,000 eggs. When disturbed it oozes a sticky white toxin from the skin that when ingested by predators can cause death of many species including the Northern Quoll and Yellow-spotted Monitor.

Habitat: Forests, shrublands, grasslands and gardens.

Notes: They were introduced from Hawaii into Queensland as a supposed biological control agent for the cane beetle in sugar cane crops. The Cane Toads failed to eliminate the beetle but are now quite successful in severely impacting the local wildlife across Northern Australia including insects, lizards, small animals, birds and other frogs and toads that is largely due to their voracious appetite combined with their toxicity of both their forms of adult, eggs and tadpoles. The toxin can kill a dog within 15 minutes of eating a toad. However they seem to have completely disappeared from our area in Nightcliff about two years ago perhaps partly due to the action of Straw-necked Ibises and a couple of relatively dry wet seasons. As a result the larger monitors in our location have made a comeback.

<u>Northern Bluetongued Lizard (Tiliqua scincoides) 7.5</u>

Size: Snout-vent length 30 cm, total 50 cm

Habits: They are active during the day, twilight or after dark while avoiding the hottest times. This lizard shelters in holes, burrows, hollow logs or other suitably sized cavities and feeds on invertebrates, other small animals, carrion and soft plant matter. It becomes inactive during low food supply in the late dry season and then remains in a burrow. They are live-bearing. The Northern Bluetongued Lizards don't seem to be bothered by anything other than finding their preferred food, dead insects. Mating season for them is in July or August while later in November to December they give birth to up to 25 young, which are born independent. Since they are so timid and slow and not overly reactive to threats, dogs and cats are one big danger to them in backyards and elsewhere.

Habitat: Open woodland, shrublands and gardens

Notes: If you suspect there might be some in your garden or if you had a sighting of them, you can entice them to come closer by putting out a bait of small pieces of chicken heart and watch them approach for a photo opportunity within a few minutes. They must have an incredible sense of smell.

<u>Brushtail Possum (Trichosurus vulpecula) 7.6</u>

Size: Head and body 40 cm, total length 80 cm with males the larger than the females.

Habits:The Brushtail Possum forages by night for leaves, fruits and flowers with eucalypt leaves being the primary food source. They shelter in a tree hollow, dense foliage or inside roofs of buildings and are breeding year-round. Possums are marsupials, that is females have pouches. Pregnancy lasts 17 days after which the baby continues in the pouch and gaining nutrition from a teat for three to four months. They are gradually weaned and departing the den when about a year old, with a life expectancy of six years.

Habitat: Open woodlands.

Notes; In decline in the NT like most mammals, although urban Darwin and rural outskirts support higher densities of possums perhaps due to the relative abundance of food sources in the irrigated lush vegetation particularly where eucalypts have been retained.

<u>Pygmy Long-eared Bat (Nyctophilus walkeri) 7.7</u>

Size: Head and body 4 cm

Habits: Insectivorous. In suitable habitat hunting by flying low to the ground and slowly but may also may harvest food on the ground itself. They roost in dense vegetation and tree hollows and raise 1 - 2 young born at the beginning of the wet season.

Habitat: Although commonest in forests bordering waterways they also inhibit monsoon forest and open woodland.

<u>Northern Blossom Bat (Macroglossus minimus) 7.8</u>

Size: Head and body 5 – 7 cm

Habits: Feeds in darkness on blossom and to a lesser extent on fruit and will defend a food source from other individuals. An important pollinator of many woodland and rainforest plants. It roosts by day alone in dense vegetation, in the mouths of caves and hollows, or under the eaves of quiet buildings.

Habitat: Forests and coastal areas

<u>Black Flying Fox (Pteropus alecto) 7.9</u>

Size: Head and body 23 – 28 cm

Habits: By night it searches for a wide variety of flowers and fruit, sometimes traveling far but normally less than 20 km. During daylight the Black Flying Fox rests in semi-permanent communal camps typically in mangroves or riverine forest and often mixing with other fruit bat species. A single young is born in the wet season and clings tightly to its mother whilst she flies out to forage. After a month the female leaves the young in camp and by three months the young fly out to forage by themselves.

Habitat: Forests, common in gardens with large fruiting trees such as mangoes

<u>Little Red Flying Fox (Pteropus scapulatus) 7.10</u>

Size: Head and body 20 – 24 cm

Habits: By night this species searches for a wide variety of flowers and fruit, especially blossoms of eucalypts and makes long journeys following food sources. After good seasons huge camps of over a million individuals can establish in favoured sites such as mangroves or riverside forest. Mating occurs in Nov - Dec and a single offspring is born during Apr to May.

Habitat: Forests

<u>Pale Field Rat (Rattus tunneyi) 7.11</u>

Size: Head and body 12 – 20 cm, tail 8 - 15 cm

Habits: Active by night it is searching on the ground for plant matter while by day it shelters in a burrow,

Status: Formerly common, now rare

Breeding: Mainly in the late wet season with an average litter of 5 young after a 3 week pregnancy.

Habitat: Forests and grasslands, favoring areas of loose soil especially near water.

Notes: In the tropical monsoon zone of Northern Australia, mammals, particularly smaller than 5 kg such as the Pale Field Rat as well as small insectivorous or carnivorous mammal species, have declined at a very fast rate, increasingly becoming rarer or are locally gone. Some scientists mention a figure of a 90 % general decline across the Top End for some species but nobody seems to know for sure. The decline is speculated to be caused by the interplay of a variety of changes to the landscape such as pastoral and other land development, weed invasions, change to fire regimes, Cane Toad invasion and increased predation such as by feral cats. Let us call this list of changes to landscape simply the human disease, ironically happening in a state with the lowest human population density of Australia. Perhaps in Top End urban areas in the case of the Pale Field Rat a factor may also be the more aggressive introduced Black Rat which hasn't suffered the same rate of decline as mammals in natural areas.

<u>Black Rat (Rattus rattus) 7.12</u>

Size: Measuring 16 – 22 cm overall with a tail of 18 – 25 cm and weight of 150 – 230 g, it differs from similar rodents by its proportionally long hairless tail. Its coat is gray almost black towards the tail and grey, yellow or white on the underside and the tail is covered in scales that form rings. This rat has a relatively short lifespan of 3 – 5 years.

Habits: Omnivorous, a generalist feeder with a great flexibility in foraging behavior and active in low light and darkness with the diet including plant material such as seeds, fruits, stems, rhizomes and leaves, fungi, arthopods, snails, worms, birds, eggs, invertebrates, carrion and scraps however preferring food with high protein and nutrient content. They live in a small family groups in a burrow or cavity in tree or roof. These rats are very agile with a keen sense of hearing and danger.

Breeding: They have up to 6 litters of 5 -10 young in a year under favorable conditions, the offspring then invading and often displacing other species in the area they invade.

Status: They are abundant in Darwin and spreading to adjacent woodlands. An introduced species to Australia that has originated in India they have the potential to alter vegetation communities, hasting local extinction of some bird species and displacing of similar sized rodents.

Habitat: In monsoon, riverine and open woodland.

Notes: Importantly this species is a significant vector for disease, they can carry bacteria and viruses in their body including Salmonella and Leptospiralis and with some of the pathogens incurable and fatal in humans. They have caused both pandemics and epidemics worldwide. To discourage Black Rats in your garden, locate and remove any burrows and if feeding other animals place only very small amounts of food early in the morning and then only into open areas which the rats tend to avoid. Their natural enemies in Darwin are cats, birds of prey, snakes and large monitors. Monitors access their burrows and birds of prey such as owls and goshawks can hunt them any time on the day. A cat can effectively wipe them out locally but only at a collateral cost to other native wildlife which the cat also preys on. Another fabulous predator of the Black Rat is the Northern Carpet Phyton capable of eating one rat a week.

Frilled Necked Lizard (Chlamydosaurus kingii) 7.13

Size: Snout-vent length 26 cm, total length up to 90 cm

Habits: Affectionally known as 'Frilli' they are a predator of insects but also taking vertebrates infrequently and is not considered at risk from Cane Toads. They often ambush from a low position on a tree trunk typically in the morning and afternoon and is not really much active in the Dry Season. The 'frillies' start mating just before the wet season. In November females excavate a shallow burrow in which to deposit 4 – 23 eggs which hatch after 60 – 80 days. The gender of hatchlings is determined by temperature with around 30 degrees Celsius producing roughly equal male and females and temperatures. Above or below this temperature mark only males are hatched. They maintain a home range and can be fatally affected by fires especially by hot late season fires as their strategy is to climb high when a fire is approaching.

Habitat: Open woodland dominated by rough barked eucalyptus, abundant in parks.

Notes: They seem to be in severe decline in urban areas, perhaps due to the rise in average temperatures that favors male gender only and pest control measures that reduce their food sources. I used to enjoy the fabulous 'frillies' at the Nightcliff Swimming Pool. Sadly, they are gone there, perhaps forever.

Northern Carpet Python (Morelia spilota) 7.14

Size: Usually 2 m long but can reach up to 3 m, pale tan coloring with brown, orange and yellow jagged-edged bands.

Habits: This is a nocturnal non-venomous constrictor preying on mammals, birds and lizards. By day it shelters in hollows and also building roofs.

Breeding: They can live for decades and lay up to 33 eggs in the late dry season.

Status: They are second most common snake encountered in Darwin backyard gardens.

Habitat: Very common in the suburbs of Darwin particularly those close to tall mangrove forests such as Rapid Creek and Nightcliff, they are particularly fond of the Black Rat their favorite prey and find the shady, cool, irrigated Darwin backyards to their liking.

Notes: Consider their potential to consume about one rat a week which makes them a very effective pest control agent. They tend to stay resident if there is enough food. Since they are usually quiet and secretive during the night and resting in a hide-out during the day you may only rarely encounter them.

<u>Golden Tree Snake (Dendrelaphis punctulatus) 7.15</u>

Size: Usually about 1.2 m and up to 2 m long. Golden brown color with a blue-black head whitish below is easily recognizable,

Habits: Being a harmless non-venomous snake and preying mostly on frogs and lizards, it sleeps coiled in high tree foliage.

Breeding: Egg laying

Status: Reportedly the most commonly encountered snake in suburban Darwin

Habitat: Forests particularly near waterways and in mangroves.

Notes; I remember well, a Golden Tree Snake unexpectedly encountered shortly after arriving in Darwin whilst pruning a tree. Since then for over forty years, I have come across numerous snakes in the bush in the Top End, in the Alice and WA. I nearly stepped on death adders, had the highly venomous King Brown Snake slip from under my swag and stirred up other venomous snakes while crawling about the bush but have never been bitten once. My advice is to move slowly and pay attention at all times when outdoors. The snakes try their best to get away from you if you allow them.

<u>Yellow Spotted Monitor (Varanus panoptes) 7.16</u>

Size: Total length 1.4 m, a lot bigger than the Spotted Tree Monitor that also occurs in Darwin gardens.

Habits: Feeds on smaller animals, carrion and eggs dug up. Inactive during the late dry season when there is a scarcity of food.

Breeding: It lays up to 13 eggs in the wet season which take 7 month to hatch.

Status: Thought to be vulnerable and now rare because of the Cane Toad. Simply biting a toad will kill the monitor.

Notes: Occasionally I encounter a very large specimen of these monitors in our garden. Parading around like it owns the place it appears seemingly unafraid of humans. Our pair of resident Bush Thick-knees birds are then getting hyper exited and fearlessly fighting off the monitor, worried about their chicks or eggs. Once I witnessed the monitor digging up the hiding spot of the last surviving Black Rat in our garden and triumphantly holding it up in the air then swallowing it alive. This monitor goes in and out of the stormwater drainage system presumably finding its way to Nightcliff beach.

This concludes the section of a few of the most common animal species encountered in Darwin gardens. I recommend that you purchase the book 'A guide to Wildlife and protected areas of the Top End' by Lindley McKay and published by the Environment Centre NT for a comprehensive description of both vertebrates and invertebrates, the guide which provides detailed information of 700 species with over 2000 color images and with most species illustrated by two or more images to help identify a species.

PLANTS

A plant is defined as a member of the vegetable group of organisms belonging to the 'Kingdom of Plantae' as distinct from the kingdoms of animalia, bacteria, archaea, protists and fungi. In this book within the kingdom of plantae we are mainly concerned with flowering plants and particularly the relationships of such plants with animals as well as organisms of the other kingdoms. To understand which plants are important for wildlife we also need to think in terms of plant habitats the latter term defined as the native environment of a plant or animal. This is because animals and other organisms usually have relationships to many plants or floristic groupings within a habitat rather than with a single species of plant. Plants do not grow in isolation and need specific growing conditions and in addition often depend on synergistic relationships with bacteria and fungi and in the case of flowering plants but also often on pollinators all of which is tied into the concept of habitat.

PLANT HABITATS IN THE TOP END

Most gardens in Darwin's residential areas are helped by irrigation and resemble the image of wet lush tropical forests. When we try to create a garden for wildlife we can also take inspiration from the Top End natural wet habitats. The 'monsoon vine-forest' seems to be the most desirable 'archetype' of garden and here I point out some of their distinguishing features before describing the other types of habitats of which there are ten in this text as adopted from John Brooks book 'Top End Native Plants'.

Monsoon forest here is the term applied to the moistest, most close-canopied forest, although in the Top End they don't receive rainfall throughout the year like true tropical rainforests. There are three broader natural types of monsoon vine-forest in the NT most of which have in common small size and a more or less discrete and often widely separated patch network within the coastal belt. However some patches are located further inland and corresponding somewhat with the distribution of rainfall. Many monsoon vine-forest species have the capacity to disperse far from parent plants with birds being the major dispersal agent. A large number of plants possessing in the Top End monsoon forest have small fleshy fruits and other types of reproductive structures that are attractive for birds, features that include colored seeds, bicoloured seeds and fruit-seed combinations and glistening dark seeds. There are only 19 fruit-eating bird species on report to visit monsoon vine-forest patches in the Top End. Of these only three, all fruit-pigeons, are likely to be major dispersal agents. These three are exclusive frugivores without a muscular gizzard and so seeds pass through their digestive intact. The three species are the Torres Strait Pigeon, the Australian Banded Fruit Dove and the Red-Crowned Pigeon. The Torres Strait Pigeon is the most important of these because of its migratory habit and occurrence in large numbers during the fruiting period. The 'torries', pictured on the title page of this book, are of comparatively large size, enabling it to eat all but a few of the larger fruits. The Red-Crowned Pigeon in contrast has a broader dietary spectrum helped by it's residency throughout the year. The Australian Banded Fruit Dove in a more easterly location plays an important role in linking sandstone fine forests in the Alligator River Region. Similar to the three pigeons, fruit bats are also important dispersal agents especially of small seeded fruits such as figs and passionfruits. However they are not likely to be significant dispersers of large seeded fruits since they typically digest only juice and pulp.

Within the ten habitats described below there can be considerable differences in the species composition associated with subtle variations of moisture availability and development of the forest on a given site. Within a habitat some species may only be present in certain stages of the development of a patch of rainforest for example pioneer species or colonizers following disturbance. Many plant species have the potential to occur in several habitats because of their capacity to adapt to different soil types and environmental conditions. When we determine what type of garden we want we should consider our garden to be created in terms of a single or at the most two natural habitats in order to have enough scope to assemble a characteristic floristic assembly of the chosen type(s). A larger parcel of land may give you more options than a typical 600 square meter block. Habitats can also be thought of as wet or dry zones and variations of moisture pattern within one of the ten types.

<u>Habitat 1: Eucalypt Woodland in sandstone habitat</u>

This habitat developed a response to nutrient deficient soils that is displayed in features such as hard stiff foliage as in grevilleas, phylodes as in acacias and reduced foliage as in calytrix.

Sandstone plant and animal communities are unique in the Top End with open woodlands on sandstone dominated by eucalypts such as E. miniata and E. tetradonta and also Corymbia bleeseri, E. phoenicia, E. kombolgiensis and E. arnhemensis.

The rocky sandstone pavements which are low in soils support unique vegetation communities dominated by spinifex and wattles like A. gonocarpa and many genera of heath shrubs such as Boronia, Calytrix, Grevillea and Hibiscus. This habitat is generally seasonally dry with plants adopted to drought. Species of this habitat are very much suited to dry rock gardens.

Habitat 2: Monsoon vine-forests in sandstone habitat

There are usually two variations, those associated with sites of year-round water availability and those occurring in seasonally dry situations.

Those with perennial moisture occur typically along streamlines in protected gorges, at seepage on steep slopes or at the base of cliffs and at headwater springs.

The canopy in this habitat is high and dominated by evergreen trees (e.g. Calophyllum sil, Calophyllum soulatri, Elaeocarpus grandis, Horsfieldia australiana, Myristica insipida and the endemic palm Carpentaria acuminata), Typically there is a dense understorey of smaller trees as well as ground ferns and sedges.

In contrast sandstone vine-forests on seasonally dry substrates especially in the western Arnhem Land are often dominated by just one evergreen tree species, Allosyncarpia ternata.

Habitat 3: Open Forest in lowland habitat

This habitat is commonly known as savannah, dominated by E. tetradonta and E. miniata either singly or in combination and is the most distinctive and wide ranging Eucalyptus community in Northern Australia mainly occurring on deep well drained sites.

Adaption in the Eucalypt Savannah is driven by a species ability to survive a long dry season and then respond quickly and compete effectively during the short wet season.

These adaptations include:

- Obtaining moisture from the lower layers of the soil to remain active or alternatively go into dormancy
- All evergreen species or those which are leafless for only a brief period or shed just part of their leaves are dependent on a deep root system (ie Eucalypts)
- Ability to recover from the impacts of drought and fire by dormant buds in the stems and lignotubers and or rhizomes.

Upper strata species generally have Eucalyptus. miniata and E. tetradonta, however this strata is then varied on gravelly ground to Corymbia dichromophloia, Eucalyptus bleeseri and E. tintinans while on low lying and seasonally wet areas turning to Corymbia bella, C. confertifolia, C. grandifolia and on plains to Corymbia polycarpa and E. tectifica.

The Midstorey generally includes Acacias, Grevillea heliosperma, G. pteridifolia, Terminalia carpentariae (Wild Peach) and Terminalia ferdinandiana (Billy Goat Plum).

The groundlayer features many grasses but most commonly speargrass (Sorghum species) and other grasses such as Heteropogon triticeus, Chrysopogon fallax, Eriachne, Sehima nervosum and Themeda triandra.

<u>Habitat 4: Open Woodland in lowland habit</u>

Common trees in Open Woodland area are Eucalypt spp, Erythrophloeum chlorostachys (ironwood), Owenia vernicosa, Bracychiton diversifolius (Kurrajon) and Xanthostemon paradoxus and in drainage lines there also is Lophostemon lactifluus while in seasonally waterlogged areas we find Melaleuca communities.

In contrast to the similar habitat Open Forest in lowland habitat (habitat 3), in woodland there is a higher presence of smaller trees as the understorey to sparser Eucalypts and a more patchily distribution of trees including Erythrophleom chlorostachys, Terminalia ferdinandiana, T. grandiflora, Acacia spp., Planchonia careya, Buchanania obovata, Xanthostemon paradoxus and Syzygium suborbiculare.

Woodlands are also dominated by tall annual and perennial Sorghums, Whitegrass, Golden Beard

Grass (Ribbon Grass), Kangaroo Grass and Native Millet communities in areas over 800 mm annual rainfall.

Habitat 5: Freshwater Streams in lowland habitat

The plant assemblage verging streams and rivers is one of the most species rich ecosystems in the NT. This habitat mainly takes the form of a narrow riparian strip that is dominated by Melaleuca spp (paperbarks) and Pandanus spp and often also include Melaleuca leucadendra, M. argentea, M. cajuputi, Pandanus aquaticus, Eucalyptus camaldulensis, Barringtonia acutangula, Casuarina cunninghamiana, Leptospermum madidum, Acacia auriculitformis, Lophostemon grandiflorus and Lophostemum lactifluus,

Species from lowland Monsoon vine-forest also occur here often with both habitats overlapping. We find Bambusa arnhemica, Nauclea orientalis, Syzygium armstrongii, S. forte, Ficus racemosa and Xanthostemon eucalyptoides but also a diverse range of Lilly-pillys (Genus Syzygium) many with fleshy fruits including the Red Bush Apple Syzygium suborbiculare. Eucalytus include Corymbia bella, C. polycarpa, E. bigalerita. Other trees in this habitat include Leichardts Plum Nauclea orientalis, Lophostemon lactifluus, Cordia brachiata, Xanthostemon eucalyptoides and Darwin Black Wattle Acacia auriculiformis.

The lower storey of this habitat includes Pandanus spiralis, Ficus corunolata, Ficus racemosa, Terminalia platyphylla and shrubs such as Melastoma malabathricum, Antidesma ghasembilla, Flueggia virosa, Clerodendrum floribundum and ferns such as Blechnum orientalis all highly beneficial for wildlife.

Habitat 6: Vine-forests on rock outcrop in wetland floodplains

The vegetation of rock outcrops in the wetlands is typically dense and thicket like, with a low canopy often only a few meters in height, while vines are often abundant especially those with thorns such as Capparis spp and Smilax australis. The canopy comprises mainly deciduous trees and shrubs including Allophyllus cobbe, Canarium australianum, Croton spp, Ficus spp., Grewia breviflora, Helicteres spp, Miliusa spp, , Sterculia quadrifida, Strynchnos lucida, Vitex acuminata and Wrightia pubesens with a small component of evergreen species such as Celtis philippinensis and Drypetes lasiogyna.

In contrast to these rock outcrops in the wetlands the floodplains of major Top End rivers themselves which surround those outcrops are largely treeless areas and which are inundated annually by the expansion of the rivers during the wet season. The typical clay soils of the floodplains support sedges of the genus Eleocharis and grasses such as Hymenachne acutigluma, Leersia rexandra, Pseudoraphis spinescens and native rice (Oryza) species. The seasonal flooding that brings new layers of silt turns the plains into a highly fertile habitat. In such areas specialized small seed eating grassland birds can be found locally next to extensive congregations of waterbirds, particularly Magpie Geese, Plumed Whistling duck and Wandering Whistling Duck but also Jacanas and Herons.

<u>Habitat 7: Lowland vine-forest in wetland</u>

As with vine-forest in sandstone terrain, those in lowlands are also associated with both perennially moist sites as well as seasonally dry substrates.

Evergreen vine-forest are associated with rare perennial spring and seepage habitats, as well as along the margins of some perennial streams (ie. Holmes Jungle, Berry Springs, Howard Springs and Black Jungle). In these situations soils are typically waterlogged with relatively deep organic loams overlaying gleyed clays. The upper canopy there is dominated by evergreen trees such as Acacia auriculiformis, Buchanania arborescens, Calophyllum soulattri, Ficus racemosa, Horsefieldia australiana, Sterculia holtzei and Syzygium nervosum but also palms (Carpentaria acuminata and Livistonia benthamii) with a small number of decidious elements (eg. Nauclea orientalis and Terminalia microcarpa). Understorey comprises Alphitonia exelsa, Hibiscus tiliaceus, Denhamia obscura while groundcover is usually sparse apart from local groundferns that include Blechnum indicum and B. orientale.

Seasonally dry lowland vine-forests where water tables are in reach of rootsystems can more easily be dominated by evergreen trees such as Buchania arborescens, Cathormium umbellatum, Ficus racemosa, Maranthes corymbosa, Myristica insipida and Pongamia pinnata.

However with diminishing water availability the canopy height also decreases and then gets replaced by deciduous species that include Bombax ceiba, Ficus virens, Peltophorum pterocarpum, Sterculia quadrifida and Terminalia microcarpa.

<u>Habitat 8: Sand dunes and beaches</u>

Common creepers and small shrubs that help to colonise and help stabilise the dunes include Canavalia rosea, Ipomea pes-caprae, Vitex rotundifolia, Vitex trifolia, Sesuvium portulacstrum and a grass Vetiveria elongata,

Some feature the ability to root at nodes along prostrate stems which helps to form stabilizing mats on the sand.

Other taller species include Cordia subcordata, Casuarina equisetifolia, and Scaevola sericea and Hibiscus tiliaceus.

Habitat 9: Coastal vine-forests

This habitat occurs on a variety of mainly seasonally dry substrates, especially sandy or shell beach ridges (eg. Casuarina beach) and lateritic landforms (eg Eastpoint Reserve).

The canopy of coastal vine-forests is typically less than 10 m in height and mainly made up by both deciduous trees (Bombax ceiba, Canarium australianum, Grewia brevifolia, Sterculia quadrifida) and evergreen trees (Alstonia actinophyllam Celtis philippinensis, Diospyros compacta, D. maritima, Dyrpetes lasiogyna, Mimusops elengi and the tall Tamarind tree, Tamarindus indica).

Such smaller canopy trees often lend themselves to the landscaping of small suburban blocks.

Habitat 10: Mangrove communities

The Top End is rich in Mangroves with over 30 species present and it has been speculated that mangroves may have originated in Northern Australia. Mangroves are subject to periodic tidal inundation and are vital in helping to stabilise coasts and estuaries , retard tidal and current erosion and allow suspended sediment to settle. They also provide an important habitat for crustaceans, molluscs and fish, a rich resource of feeding grounds and nursery beds, while accommodating food and home for a range of birds at the same time.

Typically mangrove grows in zones forming distinct bands parallel to the contour of coast and coastal river banks. Mangrove forest grow along the edges of the coast and coastal rivers, on mud or sand substrates flooded at high tide and exposed during low tide. They are the most dense of the NT forests, but also simple, with few tree species, and mostly no understorey plants.

Typically species include Sonneratia alba and Avicenna marina at the seaward edge, followed by an area dominated by Rhizophora stylosa, Bruguiera exaristata and Ceriops australis. Lumnitzera racemosa often forms the landward fringe. The grey mangrove Acicennia marina is the most widespread mangrove and is a particularly important tree for mammals, reptiles and birds such as the Collared Kingfisher as it forms large hollows. The White-breasted Whistler and Mangrove Fantail are among the exclusive mangrove specialists and you are unlikely to see them in gardens.

Broad consideration of modeling gardens after habitat.

Your garden for wildlife should ideally be modelled on floristic references associated with any of the ten habitats. Within the irrigated Darwin urban residential areas, the habitats people most readily appreciate are habitats 5, 7 and 9 since these tend provide a lot of shade, deliver a lush look and provide protection from the elements without the fire hazards assciated with dryer habitats. In contrast rural properties in a savannah setting may benefit to model their gardens on habitat 1, 3 and 4 in order to seamlessly extend into the natural environment, minimize maintenance and provide for local wildlife. Properties with coastal frontage should consider incorporating elements of habitat 8, 9 and 10. The choice of habitat of course may also be influenced by you desire to retain existing residential local wildlife as well as your preference for desired wildlife and be linked to potentials considering the current condition of your garden, the condition of the garden of your neighbors and proximity to parks and natural remnant vegetated areas if applicable.

BENEFITS OF PLANTS

For humans many benefits arise out of interaction with plants, including inspiration, reduction of mental fatigue, reduction of sick days and patient recovery. A lack of interaction with vegetation and the outdoors has been linked to increased obesity and a wide range of behavioral problems, particularly in children. Such benefits are very plausible considering that the human species evolved for many hundred of thousands of years somewhere in the deep tropical forests of Africa living on mainly fruits, greens, nuts and roots. This heritage is still deeply ingrained into our genetic makeup and functioning just as it is in a similar way with many of our closest relatives, the apes. We entirely depended on food providing plants for at least 95 % of our history before deviating to a more carnivorous behavior.

In cities vegetation directly reduces the local heat island effect and stormwater runoff. It improves water and air quality. Plants produce oxygen and facilitate carbon sequestration that is carbon fixed by plants in their tissue can be locked up for hundreds of years or into the soil via sloughing of roots and leaves for thousands of years. Plants are an agent of air pollutant removal, which are absorbed and broken down. Likewise they remove soil and water pollutants particularly heavy metals. Storm water runoff is reduced by transpiration. Plants also effect a reduction of air temperature by means of direct shading as well as by transpiration of water through their stomata. Last but not least they provide habitat, foods and cover for many species of organisms including the human and are a major source of pharmaceuticals for humans. The number and quality of all of these services that vegetation provides is often directly correlated with the amount of living biomass.

Photosynthesis of plants is the foundation of all current lifeforms bar some anaerobic organisms. The magic formula is: 6 CO_2 (carbondioxide) + 5 H_2O (water) + light = $C_6H_{12}O_6$ (carbohydrate) + 6O_2 (oxygen). While we need plants they don't need us. To prove this just leave a small patch of fertile soil to itself and watch it for a few years. Birds, wind and other animals drop seeds and as a consequence pioneer plant species germinate, grow and provide cover for secondary species and before you know you have a small self-sustaining ecosystem full of life powered by the sun. The magic of life unfolds by itself. Since we depend on nutrition that plants or animals that eat plants provide to us, humans cannot exist without, unless in the distant future we supposedly genetically engineer our body to utilize photosynthesis ourselves or grow food in a labaratory or factory.

We ordinarily judge plants by what we see, that is the part above ground and forget that the roots of a plant are often just as extensive and important as the above ground portion not just for the plant but also for everything that lives in the soil. Roots form an extensive and complex network that pumps carbon from the leaves to feed soil organisms and contributes to soil organic matter. Roots are storage organs and chemical factories that may change soil pH (soil acidity/alkalinity), poison competitors, filter out toxins and concentrate rare elements. Roots have an inbuilt sensor network that helps regulate plant growth and an absorptive network for limiting soil resources of water and nutrients. The roots mechanical structures support plants, build soil porosity and provide channels for the movement of organisms while its hydraulic conduits redistribute soil water and nutrients. And last but not least roots provide in most cases a habitat for mycorrhizal fungi, rhizosphere and rhizoplane organisms. The roots achieve all these tasks in a variety of forms that include the seminal root originating from the seed, adventuous roots from the stem, first, second and so on order lateral roots and finally feeder roots. Plants produce new roots to grow larger and explore new volumes of soil to increase their acquisition of nutrients and replace old roots with the young roots mainly taking up the bulk of nutrients. Mycorrhizal formation also requires the younger roots. An entire library of books has been written on the ecology and science of of plant species yet many people are just now appreciating the vital importance of plants, now that we have destroyed well over 50 % of the worlds natural vegetation in turn unleashing repercussions that already starting to hit us together with climate change and a thousand fold exctinction rate of species, species that depend on the remaining natural vegetation.

RECOMMENDED PLANTS

While the following plant species cover just a limited palette for your native garden in the Top End environment there are enough to help you design a sensible floristic assembly to mimic some of the ten habitats described. This selection represents native plants that are likely to be available in nurseries, have many benefits for wildlife and have been used in gardens and public landscapes many times before. You may start your garden off with just a few specimens, keeping in mind that a garden is a changing dynamic entity as a whole. A good strategy is to establish a framework first, then add and refine as the years go by. For example if you don't have large shade trees and intend to plant shade tolerant midstorey plants you may have to plant fast growing shade trees first and wait to follow up with shade tolerant plants.

The descriptors of recommended plants are structured in the following order:

Botanical name
Common name
Plant type (TR = tree. SH = shrub, G=grass, V=vine),
F = Flowering period,
Ft = Fruiting period
Habitat [any of the ten types as described on page 158 to 164]
Chart reference (referring to the plant chart number in the appendices)
Botanical Family
Notes (size, seasonal growth, flower color, fruit type, local occurrence, connection to organisms etc)
Cultivation (Propagation, adaptability, usage, animal references, indigenous use etc)

I have not included a detailed botanical description of the plants since there are better and widely available information sources such as John Brooks book 'Native Plants of the Top End' and online resources including by various government agencies (refer recommended reading). The information here rather aims to provide a quick and succinct reference for selection of suitable species in the planning of your garden. This first edition of the book includes only a few photos but the second edition will be fully photo referenced including at least one photo of each plant species or organism. A chart of the species is attached in appendices to have core information at once glance.

1. Acacia auriculiformis (Black Wattle)

TR F: Apr - Jun Ft: Jul - Oct
Habitat [2, 5, 7, 9] Chart: Monsoon 1.1
Family: *Mimosaceae*

Notes: Reaching 10 - 20 m height, Black Wattles are evergreen with yellow flowers and are commonly the first plants to grow in a disturbed area. They are therefore considered a pioneer species. Their seeds are tough and can survive fire, floods, and droughts. Their roots are capable to absorb nitrogen from the air. Black Wattles are extremely fast growing and their roots protect the soil from erosion. They also provide shade for other shade tolerant trees to grow underneath them. They tend to be short-lived to less than 25 years. As is common with Mimosaceae, acacias have a symbiotic relationship with either arbuscular mycorrhizas (VAM) and ectomycorrhizas (ECM) or both, that is they exchange carbohydrates with the fungi's minerals and other substances. The butterflies Prosatus dubiosea and Theclinesthes miskini (Wattle Blue) feed on the tree's flowerbuds, flowers and leaves.

Cultivation: Readily germinating from treated seed (hot water treatment), they adapt to a wide variety of well-drained soils, including infertile sites. The tree is hardy and very fast growing and is suitable for larger properties as shade and shelter tree but not so near infrastructure because of its invasive root system and size. They are not recommended for home gardens unless you intend to grow them as a temporary protective pioneer cover and remove them later on but before they get too big and costly to remove. They are useful to wildlife as the ripe Black Wattle seeds hang out of the seed pod attached by a fleshy yellow-orange 'hanging bits' which birds and ants love to eat and in doing so spread the seed.

A general feature of wattles is their ability to coexist with Rhizobium bacteria which take nitrogen from the air and add it to the soil in a form plants can use. The dense prickly stands of certain wattles species are also a favorite of the Double-barred Finch as nesting sites. Possums eat the flowers of wattles while the seeds are eaten by galahs and cockatoos.

Like many wattles, they don't like pruning and do not recover easily from the base of the trunk. If your garden has poor top soil to start with, it would make sense to plant a number of Black Wattles as a temporary measure and as protective cover for both your final shade tolerant monsoonal vine thicket shrubs or other slower growing permanent canopy plants. After a few years you can cut the Black Wattles at the base of the trunk and use the green bulk as chipped mulch and nitrogen fertilizer.

2. <u>Allosyncarpia ternata</u>

TR F: Oct - Dec Ft: Jan - Feb
Habitat [2] Chart: Monsoon 1.2
Myrtaceae

Notes: Growing to 10 - 30, this large evergreen tree has cream-white flowers. Allosyncarpia, like other Myrtaceae has a mutual beneficial relationship with dual ectomycorrhiza (ECM) / arbuscular mycorrhizas (VAM) but mainly with ECM

Cultivation: Propagated from fresh seed it grows in well drained soils albeit slowly. It is suitable for large properties to provide shade and shelter.

3. Alphitonia exelsa (Red Ash or Soap Tree)

TR F: Jan - Apr Ft: Jun - Oct
Habitat [2, 3, 4, 7, 9] Chart: Monsoon 1.3
Rhamnaceae

Notes: 5 - 10 m high this tree is evergreen with cream colored, scented flowers that develop into a black fruit in form of drupes. It can be found in Holmes Jungle, East Point and Casuarina Coastal Reserve as well as along the freshwater reaches of Rapid Creek. The tree is considered both a pioneer and climax canopy species. Like other Rhamnaceae, Alphitonia exelsa has a mutually beneficial relationship with arbuscular mycorrhizas (VAM). The butterfly Hypochrysops ignitus feeds on the trees leaves.

Cultivation: The tree grows on a wide variety of well drained sites and is very hardy and fast growing. It regenerates after disturbance from seed in the soil and displays an attractive layered branching and distinct leaves, wood, bark and roots. Propagate Alphitonia exelsa from fresh seed that is collected during September and October, with the seed to be treated by immersion in hot water (88 – 92 Celsius) for five minutes to induce germination. The tree is used for various medical purposes in indigenous medicine and flowers provide a good source of nectar for bees. The fruit is especially attractive to most fruit eating birds. As a pioneer species it grows in full sun and provides cover for more shade tolerant monsoonal species to grow underneath or in its cast shadow.

4. Alstonia actinophylla (Milkwood)

TR F: Aug - Sep Ft: Oct - Nov
Habitat [3,4,7,9] Chart: Monsoon 1.4
Apocynaceae

Notes: A 15 - 20 m high evergreen tree with cream-green scented flowers turning to fruits that are papery follicles containing thin silky hairy seeds, The milky sap can cause blindness if it comes in contact with the eye. The tree is very common and can be found at East Point, Casuarina Coastal Reserve and many other areas. Like other Apocynaceae, Alstonia actinophylla may have a relationship with arbuscular mycorrhizas (VAM) although this has not been researched to my knowledge.

Cultivation: It grows in a range of sites in well drained soils and is propagated from both, fresh seed and cuttings. Although slow growing it is adaptable and suitable for larger properties as a stable hardy shade tree but generally thought as unsuitable for home gardens on smaller blocks. An important pioneer species it is able to withstand fairly intense fires regenerating from root suckers but like many other pioneer species does not grow well in shade. Often mistletoes grow well on this tree. Mistletoe fruit will attract frugivores while the flowers appeal to a range of pollinators.

5. <u>Antidesma ghaesembilla (Bush Current)</u>

SH F: Sep - Dec Ft: Dec - Apr
Habitat [2, 3, 4, 5, 7, 9] Chart: Monsoon 1.5
Euphoribiaceae

Notes: Grows to 5 - 10 m tall as a semi-deciduous shrub with creme-yellow flowers. Male and female flowers are on different plants and develop into purple-black current like fruit with a single seed, A similar species in the Top End is the related Antidesma parvifolium which has much smaller leaves and and growth form, albeit a similar fruit and like habitat and growing requirements. Antidesma's have a mutual relationship with arbuscular mycoorhizas (VAM). Flowers appear with new foliage.

Cultivation: Readily striking roots from 5 – 10 mm diameter hardwood cuttings with leaves removed and planted directly into the final position, they grow quickly and are extremely hardy and adaptable. Figbirds, friarbirds, the beautiful mistletoe birds and many others such as wide gaped honeyeaters eat the small sweet fruit and spread the seeds in the garden elsewhere. To my surprise I even observed Bar-shouldered Doves feeding on the fruit. I think the small size of the fruit and sweetness makes it attractive to a very wide range of birds. Beware of dioecy, that is the male and female flowers are on separate plants. The term comes from Greek meaning 'two households'. You are advised to plant several of them if you want fruit but with cuttings from a fruitbearing plant you are assured fruit. They are excellent filler plants and respond positively to pruning. Early pioneers in the NT used the fruit to prepare jam and indigenous people seek out the fruit and eat it raw when ripe turning purple-black fruit. In contrast to A. ghaesembilla the similar A. parvifolium don't seem to get attacked by leaf eating insects as much and grows faster, staying evergreen throughout the year on a modest watering regime. Fruit is available for a long period on irrigated plants. I love this plant in the garden and so does wildlife, making it a 'must have' and highly recommended for a garden with wildlife.

6. <u>Breynia cernua (Bird Apple)</u>

SH F: all year Ft: all year
Habitat [1, 2, 3, 4, 7, 9] Chart: Monsoon 1.6
Euphorbiaceae

Notes: Growing to 2 - 5 m high, this alternate leaved evergreen mid-storey pioneer shrub has pale-cream small flowers with both male and female flowers carried in leaf axils on the same plant. It develops small fleshy berries that turn from pink to black with age. Breynia cernua is dependent on leaf-flower moths (Epicephala spp) for its pollination and like other species of tree or shrub in the genus Breynia is also a food plant for the larval stages of butterflies such as Eurema hecabe (Large Grass Yellow) and Hypolyaena phorbas (Blackspotted Flash) both feeding leaves particularly young leaves. Relationships with fungi is not known.

Cultivation: Grown from seed or cuttings this species is a useful screening or infill shrub for its bushy growth form. The seed will not require scarification treatment but tends to be slow growing. I love this little shrub in a garden because it provides flowers and fruit year-round to help fill the gaps in fruit supply to frugivores. Even honeyeaters such as the White-gaped Honeyeater seek out the small fruit just like other animals. It's a must have in a garden for wildlife, yet difficult to obtain from Darwin's commercial nurseries. There is also an attractive interstate cultivar with deep claret colored foliage and is called Breynia 'Ironstone Range' which is more readily available in garden centers but its soft leaves tend to be demolished by a variety of insects particularly larvae of the large grass yellow butterfly at least in our garden. Breynias grow in full sun as well as part shade and have a very dense rooting system that responds well to watering. There is a beautiful specimen at the start of the East Point Mangrove Walk but you can find them on most walks in Darwin conservation reserves. Because the young fragile leaves are favorites of insects you may need to monitor and pick any infestations manually to give young plants a chance to establish.

7. Cupaniopsis anacardioides (Tuckeroo)

TR F: Aug - Sep Ft: Oct - Jan
Habitat [2, 4, 7, 9] Chart: Monsoon 1.7
Sapindaceae

Notes: This is a very hardy evergreen tree growing to 5 -10 m tall that has small white flowers turning into yellow-orange fruit with 3 shiny black seeds. A number of butterfly/diurnal moth species feed on flowerbuds, flowers and young leave shoots of the tree and include Prosatas dubiosa, Anthene lycaenoides, Anthene seltutius, Arhopala eupolis and Arhopala micale.

Cultivation: From fresh seed it grows into a useful shade tree and can be found at Casuarina Coastal Reserve, Channel Island, Howard Springs Nature Reserve, East Point Reserve. Like some other Sapindaceae, Cupaniopsis anacadiodes may have a relationship with arbuscular mycorrhizas or be nonmycorrhizal. This tree performs in harsh exposed conditions such as poor soils and salt laden winds.

8. Diospyros maritima (Australian Ebony)

TR F: Jan - Mar Ft: Jan - Nov
Habitat [8, 9] Chart: Monsoon 1.8
Ebenaceae

"Diospyros" literally means fruit of the gods,

Notes: A beautiful 5 - 8 m high climax evergreen small canopy tree, it has white flowers with male and female flowers on separate trees and red-orange berries. They are a preferred larvae plant for the Common Crow butterfly in my own observation. Like other Ebenaceae, Diospyros maritima may be symbiotic with arbuscular mycorrhizas (VAM).

Cultivation: It features a dense rounded crown with large, glossy dark green leaves and can be propagated from fresh seed without scarification treatment but in that case may take a few month to germinate. The tree grows just above high tide and is somewhat tolerant to salinity. The seedlings of this species are very slow growing and one should grow several of them in pots until they start fruiting to find which ones are male and female. The young seedling leaves are susceptible to sun burn. Diospyrus are magnesium hungry according to one local nursery. They are one of the most beautiful and useful understorey plants for a monsoonal vine garden as is the similar species Diospyros compacta. Brown Honeyeaters and moths visit the tiny white flowers for nectar facilitating pollination. Figbirds are also quick to take to ripe fruit and swallow them whole. I have a few Diospyros maritima in our garden and found that they prefer a partly shaded position and perform magnificently with a little watering. They seem to flower sporadically throughout the year under irrigation.

9. Diospyros compacta (Australian Ebony)

TR F: Oct - Dec Ft: Jan - Apr
Habitat [4, 7, 9] Chart: Monsoon 1.9
Ebenaceae

Notes: 4 - 6 m high, evergreen, dense, with white female flowers and yellowish male flowers both on separate trees and yellow berries turning red when ripe. Like other Ebenaceae, Diospyros maritima may be symbiotic with arbuscular mycorrhizas (VAM).

Cultivation: Propagated from seed the edible fruit is attractive to birds especially pigeons and also figbirds. If you intend to grow any of the Australian Ebony it is best to grow only one species since the two D. maritima and D, compacta as well as other Diospyros apparently hybridize. Most of these species are all very similar and very beautiful little trees especially when sufficiently watered and have proven useful to a variety of wildlife including frugivorous bird species such as figbirds. The requirements are similar for most of the Diospyros species.

10. Albizzia lebbeck (Albizzia)

TR F: Sep - Oct Ft: May - Jul
Habitat [4, 9] Chart: Monsoon 1.10
Mimosaceae

Notes: A tall deciduous canopy tree growing to 10 - 15 m, it produces cream flowers in globular heads and fruit as stiff woody pods containing several brown seeds. Its roots, like other Mimosaceae, work in synergy with bacteria to obtain nitrogen directly from the atmosphere. When leaves drop during the dry season the nitrogen contained in the leaves enriches the soils. They are a pioneer species and grow in full sun. They may have a mutual relationship with fungi like other Mimosaceae,

Cultivation: Propagation is readily from seed. The tree adapts to a wide variety of well drained soils, is very hardy and very fast growing making it an excellent shade and shelter tree for larger properties but less suitable for home gardens because of its spreading crown and size. Wood is suitable for fuel and construction, foliage may be lobbed for fodder and makes good green manure. There is a old neglected specimen next to the busy Nightcliff roundabout that when flowering attracts a plethora of pollinating insects including bees. They seem to be evergreen when lightly watered during the dry season as by the way are many local 'decidiuous' species also often displaying modified flowering and fruiting periods compared to growing in the natural situation.

11. Ficus scobina (Sandpaper Fig)

SH F: all year Ft: all year but mainly Oct - Jun
Habitat [2, 4. 7. 9] Chart: Monsoon 1.11
Moraceae

Notes: Growing to 3 - 8 m this species is evergreen with inconspicuous male and female flowers on separate trees in form of fleshy green-brown receptacles turning black. Some members of the genus

Ficus have a mutual relationship with arbuscular mycorrhizas (VAM) while others are nonmycorrhizal, the status of Ficus scobina as with other Top End Ficus species is unclear.

Cultivation: Rather untried with edible fruit and smooth grey bark compared to the similar F opposita and F. acuelata also called Sandpaper Fig. All three Sandpaper Fig species are relatively slow growing and need both male and female to produce fruit to be attractive to fruit eating birds especially figbirds. There are a few specimen of F. scobina along the East Point Mangrove walk. A good way to obtain plants is to transplant natural seedlings which can often be found in the late wet season under existing trees along Darwin's coastlines or in gardens.

12. Flueggea virosa (White Current)

SH F: Oct - Feb Ft: Oct - Apr
Habitat [2, 3, 4, 8] Chart: Monsoon 1.12
Euphorbiaceae

Notes: Growing to a shrub of 3 m height and often deciduous in the dry it displays tiny cream male and female flowers on separate plants that bear a profusion of roundish fleshy white berries. The plant is commonly found on the margins of vine forest patches or in areas of disturbance. It is capable of regenerating readily following fire which makes it a pioneer plant thus growing well in full sun. Like many other Australian Euphorbiaceae, Flueggea virosa may have a symbiotic relationship with fungi although this is apparently not yet established.

Cultivation: Propagation is reportedly from seed, although I managed to root some cuttings in January after stripping berries and leaves. It is a hardy shrub for screening and has edible globular white fruit which are often produced in large quantities and eaten by indigenous people but only when perfectly ripe. Look for it at the Casuarina Coastal Reserve, Holmes Jungle, East Point, Howard Springs and Berry Springs Reserves. Unfortunately it is only rarely on offer in any of the nurseries in Darwin. I think it's an excellent little shrub, largely beneficial to wildlife and goes well together with Breynia cernua as understorey plant because of their like growing requirements and both doing quite well when watered.

13. Leea rubra (Leea)

SH F: Oct - Mar Ft: Nov - Jun
Habitat [2, 4, 7, 9] Chart: Monsoon 1.13
Leeaceae

Notes: Growing to 3 m with small pink to red flowers and bright red berries turning black when ripe, this shrub is evergreen and features large deep green leaves loosely arranged in a compact bushy growth form. Leea grows naturally in disturbed areas of lowland, upland rainforest and monsoon forest. They may be nonmycorrhizal since they develop a dense rootsystem. Relationships with fungi are unknown. The young leaves of Leea are a food plant for the butterfly Agarista agricola.

Cultivation: Propagation is from seed and cuttings. The plant is hardy and adaptable with an edible fruit though quite bitter tasting. Suitable as pot plant, fast growing and responding positively to irrigation, this species also has known medicinal properties. Leea flowers are visited by a variety of potential insect pollinators, including flies, wasps, butterflies and beetles and the fruit is consumed by some fruit eating birds. The plant is a must have for any garden with wildlife and can tolerate a high level of shading. In fact most plants that I have seen grow best in partial shade rather than in the full sun and therefore make an excellent understorey plant in a garden.

14. Leea novoguinensis (Leea)

SH F: May - Jul Ft: Aug - Sep
Habitat [2, 4, 7, 9] Chart: Monsoon 1.14
Leeaceae

Notes and Cultivation: Very similar to Leea rubra but with a complimentary flowering and fruiting time. You can grow both of them in our garden next to each other as they probably don't cross pollinate because of their different flowering periods.

15. Maranthes corymbosa (White Cloud)

TR F: May - Sep Ft: Sep - Nov
Habitat [2, 5, 7, 9] Monsoon 1.15
Chrysobalanaceae

Notes: A large tree reaching a height of 10 - 25 m depending on soils. The plant is evergreen with cream flowers in terminal clusters and the green fruit turning black with single woody shelled seed. The profuse clusters of flowers provide a good source of nectar for honeyeaters and insects. Maranthes corymbosa, like others in this genus may have a mutual relationship with arbuscular mycorrhizas (VAM). The butterfly Arphopala eupolis feeds on the young leaves of this tree.

Cultivation: Propagation is from fresh seed or cuttings, The tree adapts to a wide range of well-drained soils, but grows better on deeper soils with ample moisture. It is a good stable shade tree for larger properties. Find it at Casuarina Coastal Reserve and East Point Reserve and planted in several of Darwin's road verges such as Dick Ward Drive.

16. Micromelum minutum (Lime Berry)

SH F: all year Ft: all year
Habitat [2, 4, 7, 9] Chart: Monsoon 1.16
Rutaceae

Notes: “Micromelum” literally means small apple and refers to the fruit. The shrub grows to 3 - 10 m, usually in pioneer understorey to about 3 – 5 m and is generally multi-stemmed with greenish-cream fragrant flowers, fleshy bright red fruit that enclose a single seed. Flowers and ripe fruit may be present on one plant at the same time throughout the year. A number of species in the Rutaceae family are symbiotic with arbuscular mycorrhizas although it is not know if this is also the case for Micromelum minutum. The leaves of M. minutum are food for the larvae of the butterfly Papilin fuscus (Fuscous Swallowtail) easily recognizable by its distinctive hindwing tail.

Cultivation: It grows from fresh ripe seed that has been collected during November to March, the seed requires no scarification treatment and generally grows well on well-drained soils. This species is relatively hardy and quick growing and provides a good source of nectar for bees and both flowers and fruit also attract birds into the garden. You can find it locally at Holmes Jungle, Channel Island and Casuarina Coastal Reserve and also along the East Point forest walk closer to the city. A much under-utilized large shrub or small tree it prefers a semi shaded position under a high canopy and responds well to watering. It is advisable to check the establishing juvenile plant for butterfly eggs to avoid having the young plant foliage stripped.

17. Milletia pinnata (Pongamia)

TR F: Sep - Nov Ft: Jun - Sep
Habitat [5, 7, 8, 9] Chart: Monsoon 1.17
Fabaceae

Notes: Growing usually 5 - 10 m, this tree is somewhat deciduous with a very dense umbrella-shaped spreading crown featuring pale-cream pea flowers and woody pods containing 1 - 2 seeds. Many of the Fabaceae family have relationships with fungi although I could not find any reference to Milletia pinnata in this regard. A range of butterflies/diurnal moth species feed on the flowerbuds, flowers and young leaves of this tree and include Anthen lycaenoides, A. seltuttus, Hasora chromus, Jamides phaseli and Prosotas dubiosa.

Cultivation: From fresh seed and fast growing it is suited to coastal exposure. All parts of the plant are toxic and cause vomiting and thus are not recommended for gardens with small children and pets.

18. Mimusops elengi (Red Condoo)

TR F: Nov - Jan Ft: Apr - Jun
Habitat [8, 9] Chart: Monsoon 1.18
Sapotaceae

Notes: Evergreen, this tree grows to 10 - 14 m high and develops a tall trunk and dense crown while displaying cream flowers in clusters, oval red orange berries and shiny green foliage. Some of the Sapotaceae are known to have relationships with arbuscular mycorrhizas (VAM) however if Mimusops elengi has is unknown.

Cultivation: Cultivated from seed the tree is adaptable to most well drained soils but slow growing. It makes a good shade tree and its edible fruit can be eaten raw.

19. Morinda citrifolia (Rotten Cheesefruit or Noni)

TR F: all year Ft: all year
Habitat [7, 9] Chart: Monsoon 1.19
Rubiaceae

Notes: A small evergreen pioneer mid-storey tree that grows to a height of 3-10 m with distinct dense foliage and large glossy leaves also displaying small white scented flowers and fleshy pear shaped fruit the latter turning creamy-white when ripe. Like many Rubiaceae may have a relationship with fungi although it is unknown.

Cultivation: Cultivated from seed it is readily germinating even quicker if scarified with acid treatment and generally grows well on most well drained soils even with exposure to salt laden coastal winds. The fruits are eaten raw by indigenous people as a treatment for colds, influenza and diarrhea but is also applied externally to treat fever and pains. Fruits turn smelly when fallen to the ground and the leaves may be eaten when young or used to wrap and cook food particularly rice. A variety of honeyeaters visit the flowers for nectar and some frugivores may feed on the fruit. Young leaves are edible and are sometimes targeted by grasshoppers. The fruits can be fermented to produce a health drink commonly traded as Noni juice, renown for its rejuvenating effects. There a few Morinda trees in our garden mostly grown self seeded and responding well to hard pruning in order to keep them small. Daily, I pick a nearly ripened soft fruit, let it ripen on the bench top and mix with a cup of water or rice milk into a blender, remove the seeds with a small sieve, sweeten with honey and enjoy as a healthy drink. Note that according to scientific literature, Morinda citrifolia is used for more than 40 types of ailments worldwide. It has been proven that 'Noni' is pharmacologically active and is successfully used in different forms of cancer such as colon, esophageal, breast, colorectal cancers; cardiovascular diseases, diabetes, arthritis and hypertension, benefits substantiated by clinical investigations. (Health Benefits of Morinda citrifolia (Noni): A Review by Mohammad Ali, Mruthunjaya Kenganora, Santhepete Nanjundaiah Manjula, 2016). You will be able to harvest more fruit if you irrigate this tree during the Dry Season. M. citrifolia is one of the few species that can be grown successfully under and next to Carpentaria Palms seemingly tolerant to the dense rootsystem that these palms develop.

20. <u>Murraya paniculata (Orange Jasmine)</u>

SH F: Nov - Dec Ft: Mar - Jul
Habitat [4, 9] Chart: Monsoon 1.20
Rutaceae

Notes: This species grows to 1 - 5 m high as a dense shrub with white, highly fragrant flowers and red fruit. It is often found as an understorey plant in vine thickets, including behind beaches. Like some Rutaceae it may have a mutual beneficial relationship with arbuscular mycorrhizas (VAM).

Cultivation: It is cultivated from fresh seed or softwood cuttings and has become widely popular in Darwin for ornamental purposes as a small tree or hedge because of its hardiness and wide range of soil tolerance. The plant often flowers sporadically and produces small fragrant clusters which attract bees, while the fruit attracts small frugivorous birds. Its a must have in any garden and can be shaped and trimmed to function as a hedge.

21. <u>Myristica insipida (Native Nutmeg)</u>

TR F: Feb - Mar Ft: Sep - Dec
Habitat [2, 7, 9] Chart: Monsoon 1.21
Myristicaceae

Notes: “Myristica' means fit for anointing because nutmeg butter from the closely related species has been used to treat rheumatism. A dense evergreen tree growing to 10 - 20 m it has male and female small cream flowers on separate trees and fruiting trees display large thick leathery drupes with single large brown seed wrapped in bright red aril. There are no known relationships with fungi.

Cultivation: It grows best from fresh seed on a range of well-drained soils but requires ample moisture even then it is slow growing. Aboriginals ground the kernel and use it as spice, The red aril is edible.`Find it at Holmes Jungle, Casuarina Coastal Reserve, Berry Springs and Howard Springs. Nutmegs are quite a beautiful dense shade trees but are more suitable for larger properties. If your garden gets visits from frugivorous birds you may discover a few nutmeg seedling popping out of the ground. While developing into a large tree, under suitable conditions in the home garden it can be kept compact by pruning.

22. <u>Peltophorum pterocarpum (Yellow Flame Tree)</u>

TR F: Aug - Jan Ft: Dec - Mar
Habitat [6, 9] Chart: Monsoon 1.22
Caesalpiniaceae

Notes: This deciduous tree grows to 10 - 15 m with dense-crown spreading tree and spectacular yellow flowers on branching terminal inflorescences producing grey-black woody pods. It may have relationships with mycorrhizas as some of the Caesalpiniaceae family have.

Cultivation: Propagated from treated seed the tree adapts to a wide variety of soils and prefers ample moisture. It makes a fast growing shade tree for larger properties but is seen as weak to withstand cyclonic wind impacts. Widely planted in the Darwin area and proven to require little maintenance its beauty outweighs potential drawbacks. The profusion of clusters of yellow flowers contrasts vividly against its dark foliage with flowers attracting nectar eating birds such as Lorikeets in large numbers.

23. <u>Pleomele angustifolia (Native Dracaena) formerly Dracaena angustifolia</u>

SH F: Jul - Oct Ft: Aug - Dec
Habitat [2, 7, 9] Chart: 1.23
Agavaceae

Notes: “Pleo” meaning full and “mele” meaning honey, refer to the abundant nectar produced by one species of the genus. This species grows to 1 - 5 m with strongly scented greenish-cream flowers developing into smooth globular succulent berries on large terminal pannicles orange to red when ripe. It is perhaps nonmycorrhizal.

Cultivation: Propagated from seed or cuttings it grows in shady sites on well drained sandy soils and is also widely grown as pot plant. Find it at Holmes Jungle, Casuarina Coastal Reserve and Berry Springs Nature Reserve. Different and distinct in appearance this plant provides pleasing visual effects when planted against a wall or building and is generally very low maintenance.

24. <u>Sterculia quadrifida (Peanut Tree)</u>

TR F: Feb - Nov Ft: Apr - Dec
Habitat [2, 4, 5, 7, 9] Chart: Monsoon 1.24
Sterculiaceae

Notes: “Sterculius” was the Roman god of dung and privies, a reference to the offensive smell of some of the species. S. quadrifida grows to 10 m high or larger on favorable sites and is considered a deciduous pioneer canopy tree. It has small greenish-yellow flowers, scarlet-red leathery capsules open when ripe and contains 2 - 4 shiny black seeds. Several species of the Sterculiaceae family are reported to have relationships with arbuscular mycorrhizas (VAM) although I did not find any references to this particular species. Arhopala micale feed on the young leaves of this tree.

Cultivation: Easily propagated from fresh seed that is collected in October with no treatment and germinating within a week, the tree grows on a variety of well drained soils and is hardy and fast growing. The raw black seeds are edible with a subtle peanut like taste eaten after peeling the black seed skin, when the container fruit capsule is red and is splitting. Find it at Holmes Jungle, East Point, Casuarina Coastal Reserve, Howard Springs and Berry Springs Nature Reserves. It is useful as a small shelter tree for more shade tolerant monsoon vine thicket shrubs and perhaps as a host for climbers.

25. <u>Syzygium fibrosum (Red Bush Apple)</u>

TR F: Apr - Oct Ft: Jul - Dec
Habitat [7, 9] Chart: Monsoon 1.25
Myrtaceae

Notes: Growing to 5 - 10 m the tree features smooth shiny leathery leaves and cream flowers with numerous stamens. The fleshy pink-red fruit has a single seed. It is likely that Syzygium fibrosum like many other Syzygium species has dual associations arbuscular mycorrhizas (VAM) , ectomycorrhizas

(ECM) although some have only a relationship to one or the other.

Cultivation: Propagated from seed it prefers deeper well drained soils and ample moisture. The edible fruit is suitable for making jam. They are slow growing at the seedling stage. Like with most myrtaceae the flowers appeal to nectarfeeders while the fruit is sought after by frugivores.

26. Syzygium nervosum (River Apple)

TR F: Sep - Nov Ft: Dec - Jan
Habitat [2, 7] Chart: Monsoon 1.26
Myrtaceae

Notes: The Greek “syzygos” means joining and refers to the fused outer flower segments. This tree grows to 15 - 25 m, has scented cream flowers with numerous stamens in branching clusters, shiny and fleshy black fruit with single seed. It is likely that Syzygium nervosum like many other Syzygium species has dual associations arbuscular mycorrhizas (VAM) , ectomycorrhizas (ECM) although some have only a relationship to one or the other.

Cultivation: Grown from fresh seed it prefers deeper well-drained soils with ample moisture and is more suited as shade tree in larger properties rather than in small gardens. It has edible fruit that when ripe turn black. The timber is suitable for structural applications. Find the plant at Casuarina Coastal Reserve, Holmes Jungle, and Howard Springs Nature Reserve.

27. Tabernaemonlana orientalis (Iodine Plant)

SH F: Oct - May Ft: Feb - Aug
Habitat [2, 3, 4, 9] Chart: Monsoon 1.27
Apocynaceae

Notes: A shrub growing to 2 - 3 m with white tubular flowers is more readily recognizable for its fruit which has pairs of banana shaped orange segments. The stems contain a milky white sap. It may have a relationship with fungi like other species from the Apocynaceae family although this is unknown for Iodine plant. You can find a few good specimens on the East Point Reserve monsoon walk and it also grows in vine-thickets on rock outcrops.

Cultivation: It is propagated from fresh seed. Indigenous people occasionally eat the ripe fruit.

28. Terminalia microcarpa (Damson Plum)

TR F: Sep - Dec Ft: Dec - May
Habitat [2, 4, 5, 7, 9] Monsoon 1.28
Combretaceae

Notes: “Terminalia” refers to leaves clustered toward the end of the branchlets. This species grows to a stately 15 - 30 m height, is deciduous and features strongly scented cream flowers and flattish fleshy drupes turning red or purple when ripe that enclose a single seed. Like most plants of the genus Terminalia is likely to have a relationship with arbuscular mycorrhizas (VAM). The skipper butterfly Badamia exlamationis (Brown Awl) feeds on the young leaves.

Cultivation: Propagated from fresh seed it adapts to a range of well-drained soils but requires ample moisture. It is very fast growing and suitable as a shade tree for large properties. It tends to self seed being dispersed by fruit eating birds and is not suitable for home gardens because of its size and invasive roots. Indigenous people occasionally eat the thinly fleshed purple fruit. Find it at Howard Springs, Holmes Jungle, Casuarina Coastal Reserve and Berry Springs Nature Reserve.

29. Vitex glabrata (Black Plum)

TR F: Sep - Jan Ft: Nov - Feb
Habitat [1, 3, 4, 7, 9] Chart: Monsoon 1.29
Verbenaceae

Notes: This deciduous tree has opposite trifoliate leaves and is growing to 7 - 12 m with scented white-purple flowers and small purple-black edible fruits showing as fleshy drupes. Some of the Verbenaceae have an association with arbuscular mycorrhizas.

Cultivation: Propagation is from seed or cutting. It grows on most well drained soils as a relatively hardy shade tree. The popular edible shiny fleshy black fruit is very sweet to taste can either be eaten raw or cooked or sun-dried and stored. Find it at Holmes Jungle, Channel Islandm Berry Springs and Howard Springs Nature Reserves.

30. Wrightia pubescens

TR F: Nov - Mar Ft: Jun - Aug
Habitat [2, 4, 7, 9] Chart: Monsoon 1.30

Apocynaceae

Notes: A small semi-deciduous tree growing to 3 - 7 m with white scented flowers and fruit in form of long wooden follicle with numerous winged seeds. It is likely to have a mutual beneficial relationship with arbuscular mycorrhizas (VAM).

Cultivation: Propagated from seed it is relatively fast growing and prefers a semi-shaded position. The plant attracts a variety of nectare feeding organisms and lends itself for planting as understorey.

31. <u>Lophostemon lactifluus (Swamp box, Water gum or Swamp Mahagony)</u>

TR F: Sep - Dec Ft: Nov - Jan
Habitat [3, 4, 5, 6] Chart: Wetland 2.1
Myrtaceae

Notes: A small tree growing to 7 - 10 m, multi-stemmed at times, it has cream flowers on branched inflorescences and cup-shaped capsules with numerous seeds. It is a close relative to eucalyptus but with a slightly different flower. Like most Myrtaceae this species has a mutual beneficial relationship with dual ectomycorrhizas (ECM) / arbuscular mycorrhizas.

Cultivation: Grown either from seed or hardwood cuttings it makes a good shade tree and firewood. I'm not sure why it is not more utilized in the urban landscape in Darwin as it displays quite a beautiful bark and an interesting often multi-stemmed growth form. It does require watering on most soils unless a high water table is present and is a good plant to grow near the edge of natural ponds or bogs as a high canopy companion to other wetland species. Like most myrtaceae the flowers are very beneficial to native bees and birds. If you plant myrtaceae for this purpose it is best to plant a range of species covering local syzygiums, melaleucas, corymbias, eucalypts, asteromyrtus and swamp mahagony with complementary flowering times in a habitat compatible floristic arrangement in order to offer nectar throughout the year.

32. <u>Asteromyrtus symphyocarpa (Liniment Tree)</u>

TR F: Jan - Dec Ft: Jul - Dec
Habitat [4, 5, 6] Chart: Wetland 2.2
Myrtaceae

Notes: A small tree growing to 4 - 10 m with yellow to pale orange flowers and numerous stamens in globular heads that turn to cone-like capsules containing numerous seeds. Like other Myrtaceae probably has a mutually beneficial relationship with dual ectomycorrhizas (ECM) / arbuscular mycorrhizas (VAM). You can find thickets of this plant at Knuckey Lagoon near the highway.

Cultivation: Propagated from seed the tree displays weeping habit and adapts to a wide range of soils, while tolerating seasonal inundation. Useful as a decorative small screening tree with medicinal application, its crushed leaves can be applied as a chest decongestant and liniment to treat aches, sprains and for other medicinal conditions. It is a good source of nectar.

33. Banksia dentata (Banksia)

TR F: Dec - Apr Ft: Jul - Sep
Habitat [3, 4, 6] Chart: Wetland 2.3
Protaceae

Notes: Banksias are named after the famous English botanist Sir Joseph Banks who accompanied Captain James Cook on his voyage in 1770. There is only this species of banksia in the NT which grows to 5 - 7 m height as a straggly spreading tree with twisted and curling branches, numerous yellow flowers in large dense cylindrical spikes and fruits as woody wedge-like follicles with waver-like winged seeds. Its leaves are glossy green above, white below and have a beautiful earthy red-orange tinge when unfolding from the growth buds. This banksia grows naturally on margins of freshwater swamps or in moist seasonally flooded or wet sandy soils. Like all other Protaceae, banksias are generally strictly nonmycorrhizal.

Cultivation: Banksias are propagated from seed and tolerate poor soils and waterlogging. It is an excellent source of nectar for birds, bees and insects. I love this tree for its crookedness as an artistic embellishment to gardens while also attracting wildlife. Indigenous children love to suck on the sweet flowerheads. It should grow well as a companion to Swamp Mahagony and Liniment Tree.

34. Corymbia bella (Ghost Gum)

TR F: Sep - Dec Ft: Oct - Dec
Habitat [4, 5, 6] Chart: Wetland 2.4
Myrtaceae

Notes: Ghost Gum grows to 8 - 15 m height with small creamy-white flowers on short stalked clusters and cup-like capsules that are present on the tree most time of the year. The trunk and branches have a smooth white bark. 'Bella' comes from the Latin words 'bellus' meaning beautiful, referring to the tree as a whole. The tree prefers alluvial soils along low lying seasonally wet areas such as flood plains, along creek levees and at the edge of swamps amongst the melaleucas. It starts forming seeds after 11 years, a rather long wait. Like other Myrtaceae and in common with Eucalyptus it likely has a mutually beneficial relationship with dual ectomycorrhizas (ECM) / arbuscular mycorrhizas (VAM). The butterfly Arhopala eupolis feeds on young leaves of the tree.

Cultivation: Propagated from seed it adapts to a wide variety of soils in a sunny position and prefers ample moisture making it a good shade tree for large properties.

35. Grevillea pteridifolia (Fern Grevillea)

TR F: May - Sep Ft: Jul - Oct
Habitat [3, 4, 5, 6] Chart: Wetland 2.5
Proteaceae

Notes: Fern Grevillea grows to 5 - 8 m displaying silvery foliage and a bright showy display of nectar rich orange flowers that are numerous on dense racemens. Belonging to the Protaceae, grevilleas are generally nonmycorrhizal.

Cultivation: Best propagated by seed, tt is commonly found on seasonally inundated soils but also on blacksoil plains although being adaptable to a range of substrates. The tree tolerates periodic water logging and is highly attractive to birds and insects including bees. Reportedly susceptible to termite attack it is generally regarded as short lived (less than 10 years). However this is a not good enough reason to strike them of my favorite list of plants as it makes up with beauty and fast growth. Indigenous people are known to lick the flower heads for the sweet nectar or alternatively soak them in water to make a sweet energizing drink.

36. Nymphaea violacea (Water Lily)

AQ F: Jan - Jul Ft: Jan - Jul
Habitat [6] Chart: Wetland 2.6
Nymphaeaceae

Notes: Water lilies grow to less than 1m height as a perennial floating herb with their rhizomes buried in mud below the water. They have large white, blue or pink petals and numerous yellow stamens and a spongy roundish fruit with many seed berries carried under water. Water lilies are widely recognized as one of most beautiful plants. They have a relationship with arbuscular mycorrhizas.

Cultivation: Propagation is by seeds or rhizome. Roots, stalks and seeds are edible. This plant is a must have for a large natural pond a garden. You can find an examples at Knuckey Lagoon and many other local billabongs. Tubers and seeds are a staple food to indigenous people near the wetlands, large lagoons or swamps where the waterlily grows in abundance. Stems are also occasionally eaten. The yams are dug from mud and stripped of roots and stems and cooked gently. When the flower has fallen under the water and seed heads form they are harvested and peeled with the small seeds either eaten raw or ground to process into a damper. Even the flower pedals are edible. The flowers attract bees and other pollinators by providing a source of nectar and pollen.

37. <u>Nymphoides indica (White Snowflake)</u>

AQ F: Apr - Jul
Habitat [6] Chart: Wetland 2.7
Menyanthaceae

Notes: This lily grows to less than 1 m height as an aquatic herb with new stems rising from below floating leaves. It has white flowers with fringed pedals and yellow throat and small fruit capsule containing many tiny seeds. Most waterlilies have a relationship with arbuscular mycorrhizas.

Cultivation: It is common in freshwater lagoons, billabongs and swampy fringes on the floodplain, and best propagated from seed.

38. <u>Carallia brachiata (Bush Current)</u>

TR F: Jul - Sep Ft: Sep - Nov
Habitat [2, 4, 5, 7, 9] Chart: Riverine 3.1
Rhizophoraceae

Notes: Bush Current tree grows to 5 - 10 m, higher in favorable sites and features small cream clustered flowers and small pink to red berry fruits. The genus Carallia has a symbiotic relationship with arbuscular mycorrhizas (VAM). The butterfly Dysphania numana feeds on the leaves of the tree.

Cultivation: Propagated from fresh seed the tree is moderately fast growing and adaptable to a range of soils although generally favoring moister sites. It bears edible fruit and its wood is believed to be insect resistant. The fruit are highly favored by fruit eating birds. Indigenous people also eat the fruit including the soft seeds embedded in the fruit. Find the tree in Holmes Jungle, Casuarina Coastal Reserve and East Point Reserve.

39. Carpentaria acuminata (Carpentaria Palm)

PA F: Sep - Dec Ft: Dec - Mar
Habitat [2, 7, 9] Chart: Riverine 3.2
Arecaceae

Notes: This feather palm grows to 15 - 30 m height and develops small cream male and female flowers on impressively large compound inflorescences that turn to fleshy red fruit enclosing single seed. Carpentarias have a mutually beneficial relationship with arbuscular mycorrhizas (VAM). Butterfly Cephrenes augiades (Orange Palm-dart) feed on the palms leaves.

Cultivation: They generally grow in moist organic soils often subject to seasonal flooding and are propagated from fresh seed. Although this palm tree adapts to a wide variety of soils and grows in both full sun and shade it needs ample moisture. Very fast growing it is recommended for any Darwin garden. The immense clusters of orange-red berries attract the peaceful white Torresian Imperial Pigeons, affectionately known as 'Torries' together with a range of other birds. However if you plant any of them in number you should consider how to safely remove them when they grow old and tall or be weakened by termites as they sometimes do. When dropped from height large falling palm fronds are a hazard and can easily snap establishing plants below and pose a risk of injuring people walking below. Indigenous people utilize the apical pith or soft flesh at the growing tip as a favorable crisp and tasty raw or slightly roasted snack. Not many other plant species can grow under this palm being not able to compete with the densely matted rootsystem of the palm. It is advisable to grow the palm in clusters in a thickly mulched gardenbed and allow them to regenerate from seedlings.

40. Chrysopogon elongatus (Tamil Grass)

GR F: Apr - Dec
Habitat [5] Chart: Riverine 3.3

Notes: A pendulous grass to 1 m with seed bearing stalks up to 2 m.

Cultivation: From seed or rhizome division, they seem to grow well in large pots where I keep them for some seed eating birds. It fascinating to watch flocks of Double-bar Finches to work collectively in bending the long and strong stalks with the still green seed heads until the stalks reach right down to the ground achieved by using the combined and coordinated weight of a dozen or more birds. Once on the ground other birds can feed more easily on the seeds. They make a good feature plant on a terrace or near a water installation or a natural pond.

41. Corymbia ptychocarpa (Swamp Bloodwood)

TR F: Oct - Jun Ft: Oct - Dec
Habitat [5] Chart: Riverine 3.4
Myrtaceae

Notes: A beautiful medium sized tree growing to 8 - 12 m with a dense spreading crown of very long leaves and spectacular large pink or deep red flowers on prominent terminal inflorescences that in the wet season turn into thick woody capsules. Like other Myrtaceae and in common with related eucalyptus it likely has a mutually beneficial relationship with dual ectomycorrhizas (ECM) / arbuscular mycorrhizas (VAM). Corymba ptychocarpa used to be known as Eucalyptus ptychocarpa.

Cultivation: From seeds they adapt to a wide range of soils and require ample moisture. A fast growing, outstanding showy ornamental tree it provides large seed capsules and good source of nectar, Many birds are attracted to this plant in large numbers and variety.

42. Cyclophyllum schultzii (Canthium)

TR F: Sep - Nov Ft: Dec - Mar
Habitat [2, 5, 7] Chart: Riverine 3.5
Rubiaceae

Notes: A small multi stemmed tree growing to 2 - 8 m it displays scented small white flowers in clusters turning to edible red two-lobed fruit that ripe on pedicels. It grows naturally as an understorey plant at the edge of rainforest. Canthium have a mutually beneficial relationship with arbuscular mycorrhizas (VAM)/

Cultivation: Grown from seed with 3 to 10 weeks to germination, they prefer well-drained sandy loams under ample moisture. Fruit is edible and can be eaten raw. The tree sometimes flowers and fruits throughout the year particularly when irrigated.

43. Fragraea racemosa (Woodland Coffee)

TR F: Jan - Dec Ft: Jan - Dec
Habitat [2, 7] Chart: Riverine 3.6
Loganiaceae

Notes: Small to 4 -10 m with large white scented flowers on pendulous terminal racemes, the plant bears fleshy berries fruit with numerous small seeds embedded in pulp on a pendulous growth form. Some species in the family of Loganiaceae have a known association with arbuscular mycorrhizas but it is unknown for this species.

Cultivation: Propagation is from fresh seeds or cuttings with the plant grown best in light shade on well-drained soils with ample moisture. It makes a decorative ornamental tree and attracts a variety of birds.

44. Helicia australasica (Helicia)

TR F: Aug - Nov Ft: Jan - Apr
Habitat [2, 7, 9] Chart; Riverine 3.7
Proteaceae

Notes: Helicia grows to 5 - 10 m with long alternate elliptic leaves and creme-white scented flowers on slender pendulous racemens turning to fleshy fruit black when ripe with thin flesh enclosing two seeds. It is likely to be nonmycorrhizal like most plants in the Proteaceae family.

Cultivation: Propagate from fresh seed it grows in deeper soils on shady sites and requires ample moisture. The raw fruit is eaten by indigenous people.

45. Hydriastele wendlandiana (Wendland's Palm)

PA F: Jul - Nov Ft: Oct - Dec
Habitat [2,7] Chart: Riverine 3.8
Arecaceae

Notes: A palm tree growing to 10 - 15 m with small cream flowers numerous on slender drooping inflorescences, smooth fruits in clusters turning to bright red when ripe with thin flesh enclosing single seeds. It possibly has an association with arbuscular mycorrhizas like some others in the Arecaceae family.

Cultivation: From fresh seed, germinates slowly after 3 - 12 months and grows best in deep soils with ample moisture. It is a decorative clumping palm and suited also as a potted plant.

46. Leptospermum madidum (Weeping Tea Tree)

TR F: Jul - Nov Ft: Dec - Feb
Habitat [5] Chart: Riverine 3.9
Myrtaceae

Notes: The generic name is derived from the Greek word leptos (meaning slender) and sperma (meaning seed). The Latin word 'madidum' means moist or wet referring to the species growing on the banks of freshwater creeks and rivers to a height of 3 - 5 m with small cream flowers and very small cup shaped capsules containing numerous fine seeds. This small tree has creamy white shredding bark, weeping branches and foliage. This species has aromatic leaves which were used by the first European settlers as a substitute for tea. Like most Myrtaceae is likely to have a dual association with arbuscular and ectomycorrhizas although it is not known which type is dominant for this species.

Cultivation: Propagated either from seed (germinates easily) or cuttings it adapts to a wide range of well drained soils with ample moisture and is generally fast growing and fine leafed making it an excellent tree for small nesting birds by providing shelter and protection.

47. Livistonia benthamii (Fan or cabbage palm)

PA F: May - Aug Ft: Sep - Nov
Habitat [6, 7] Chart: Riverine 3.10
Arecaceae

Notes: A tall single stem fan-leaved palm to 10 - 15 m height it features cream to pale yellow flowers on inflorescences and fleshy purple-black fruits, containing single seed. This palm usually grows in colonies in moist substrates often in association with paperbarks. Like other Arecaceae is likely to grow in symbiosis with arborescal mycorrhizas (VAM). The butterfly Cephrenes trichopepla (Yellow Palm-dart) feed on the palms leaves.

Cultivation: From fresh seed germination takes 3 - 4 months for this relatively slow growing palm. It does better in heavier soils and requires ample moisture however slow growing. It is recommended to clump a few specimens into groupings to enhance the visual appeal. The appices or cabbage is eaten raw or roasted by indigenous people as is the pith of the young stems cooked on the fire.

48. Melastoma malabathricum (Native Lasiandra)

SH F: All year Ft: All year
Habitat [2, 5, 7] Chart: Riverine 3.11
Melastomataceae

Notes: A shrub growing to 2 m tall the species features large purple flowers on short hairy stalks turning to purple pulpy fruit with numerous tiny seeds. Melastoma usually grow along roads or in disturbed areas in rainforest, monsoon forest or wet areas in open forest. They are an ecologically important pioneer species that colonizes disturbed wet-sclerophyll and rainforest habitats. It produces no nectar, but giving pollinators large amounts of pollen instead, which must be extracted through pores on the anthers of the flowers by native bees. Melastoma's have an association with arborescular mycorrhizas (VAM).

Cultivation: From seed or cuttings, they grow well in well-drained soils in semi-shaded areas and with ample moisture are fast growing. If you want fruit you must have a presence of bees, preferably native species. They seemingly cannot be pollinated in any other way. However they do grow quickly and are great as a filler in a group of monsoonal vine thicket plants. They respond well to pruning with fresh growth from below. While the edible black fruit are very sweet and have numerous tiny pale seeds embedded in the pulp they do cause temporary blackening of the tongue when eaten. The fruit is very attractive to the range of frugivorous birds.

49. Nauclea orientalis (Leichardt Tree)

TR F: Sep - Dec Ft: Feb - May
Habitat [2, 5, 6, 7, 9] Chart: Riverine 3.12
Rubiaceae

Notes: Growing to 10 - 25 m high this tall tree has aromatic flower heads and strong smelling fleshy fruits and is partly deciduous. It may have an association with arbuscular mycorrhizas like some Rubiaceae do although there is no research on this.

Cultivation: Grown from seed and it adapts to most soils but requires ample moisture to be at its best. It has edible bitter tasting fruit and some indigenous use for medicinal applications. Fruitbats and birds also feed on it. Quite a large tree it is perhaps more suited to larger properties with an existing drainage line.

50. Syzygium armstrongii (Small White Bushapple)

TR F: Sep - Dec Ft: Dec - Feb
Habitat [2, 5, 7] Chart: Riverine 3.13
Myrtaceae

Notes: This species grows to 12 - 20 m high showing white flowers with numerous stamens in terminal branching panicles, white fleshy fruit with oil glands and containing single seed, dense foliage and full crown. It is likely that Syzygium armstrongii like many other Syzygium species has a dual association with arbuscular mycorrhizas (VAM) / ectomycorrhizas (ECM) or at least with one of them.

Cultivation: Propagated from fresh seed bush apple adopts to most well-drained soils. Given ample moisture it is fast growing and provides good shade and shelter tree for larger properties. The small white apple is edible but not widely eaten amongst indigenous people. The white flowers are attractive to pollinators.

51. Timonius timon (Timonius)

TR F: May - Nov Ft: Jul - Dec
Habitat [2, 3, 4, 7, 8] Chart: Riverine 3.14
Rubiaceae

Notes: This shapely small tree generally grows to anything between 5 -15 m with male and female white scented flowers and green globular dry pulp drupes turning brown when ripe and numerous seeds embedded. Timonius have an association with arbuscular mycorrhizas (VAM).

Cultivation: Propagated from seed they are very adaptable to a wide variety of soils and quite hardy. Find it at Holmes Jungle, Casuarina Coastal Reserve, East Point, Channel Island, Berry Springs and Howard Springs Reserves.

52. Melastoma polyanthum (Lasiandra)

SH F: All year Ft: All year
Habitat [2, 5, 7] Chart: Riverine 3.15

Melastomataceae

Notes: The generic name is derived from the Greek words mela (meaning black) and stoma (meaning mouth), it refers to the black stain which the edible berries leave in your mouth. It grows to 1 - 2 m high and produces large purple flowers with protruding yellow stamens at the centre that turn into black berries with numerous tiny seeds embedded in pulp. Melastoma's have an association with arborescular mycorrhizas (VAM).

Cultivation: Propagated from either seed or cuttings they grow quickly in well-drained soils in semi-shaded areas given they get ample moisture. Indigenous people peel the berries and eat them raw. As with the related M. malabathricum this plant requires pollination by bees. The two species differ in leaf size, distribution and flowering period. Both species in our garden grow well but don't produce fruit, sadly because there is no longer a presence of suitable pollinators in this location.

53. Themeda triandra (Kangaroo Grass)

GR F: Nov - Mar Ft:
Habitat [5, ?] Chart: Riverine 3.16
Poaceae

The word 'triandra' comes from the Latin word 'triandrus' meaning 'with three stamens'. T. triandra is found across Asia, Africa, Australia and the Pacific. It does not well under heavy grazing pressure, but benefits from the occasional fire.

Notes: This is a tussock-forming grass that grows in dense tufts to less than 1.5 m high displaying yellowish stems and golden brown drooping seed heads. The red-brown spikelets flowers on branched stems are compounded inflorescences with single racemen. Themeda spp have an association with arbuscular mycorrhizas (VAM).

Cultivation: Grown from seed, the linear leaves turn to brown at maturity and are palatable to stock while the seeds are utilised by several grass seed eating bird species especially finches. In nature this grass occurs in a wide variety of alluvial, red, brown and earthy soil habitats associated with creek lines. It makes a nice feature in a garden when grown in clumps.

54. Cordia subcordata (Sea Trumpet)

TR F: Feb - May Ft: Mar - June

Habitat [7, 8, 9]   Chart: Coastal 4.1
Boraginaceae

Notes: Easily recognizable by its large glossy leaves and growing to 5 -10 m tall the tree displays showy trumpet shaped orange flowers born in clusters turning to dry woody nuts. Some of the Boragniaceae are known to have associations with arbuscular mycorrhizas while others are nonmycorrhizal with Cordia subcordata being an unknown in this regard.

Cultivation: Propagation is from fresh seed and the plant being adaptable to most well drained soils. They can be found anywhere along the foreshore and in municipal plantings in most coastal parklands. The showy flowers attract pollinators and make attractive screening tree that also provide edible seeds.

55. <u>Dillenia alata (Red Beach)</u>

TR   F: Oct - Jan   Ft: Oct - Nov
Habitat [9]   Chart: Coastal 4.2
Dilleniaceae

Notes: Grows to 10 m high with a dense evergreen crown that displays bright yellow flowers on terminal pannicles and fleshy pink-red fruit. Dillenia has an association with arbuscular mycorrhizas (VAM).

Cultivation: Propagated from fresh seed the tree adapts to a variety of well drained soils. Provided there is ample moisture it is fast growing thus making it a great screening tree. Parts of the fruit are edible.

56. <u>Ipomea pes-caprae (Morning Glory)</u>

CL   F: Jan - Dec   Ft: May - Aug
Habitat [8]   Chart: Coastal 4.3
Convolvulceae

Notes: A coastal groundcover growing to less than 1m height it features large pink to purple flowers and a fruit with semi-woody capsules that containing four seeds. It has no known association with fungi.

Cultivation: From seed or cuttings this groundcover makes an excellent coastal and sand stabilization plant. The species has many applications in indigenous medicine.

57. Hibiscus tiliaceous (Beach Hibiscus)

TR F: Jan - Dec Ft: Jan - Apr
Habitat [7, 8, 10] Chart: Coastal 4.4
Malvaceae

Notes: This tree grows to a compact 5 - 8 m height and has large yellow flowers and semi-woody capsuled fruits. Some of the Malvaceae have a symbiotic relationship with arbuscular mycorrhizae and others are nonmycorrhizal.

Cultivation: Easily grown from seed or cuttings, it is very adaptable, hardy and fast growing. Roots, flowers and young leaves all are edible.

58. Vitex trifolia (Blue Vitex)

SH F: Mar - Oct Ft: Aug - Nov
Habitat [8] Chart: Coastal 4.5
Verbenaceae

Notes: A low sprawling semi-prostrate shrub between 0.5 - 3 m high it features pale-blue or purple-mauve flowers on terminal inflorescences with small black fruit. Some of the Verbenaceae are known to have associations with arbuscular mycorrhizas although it is not known if this is the case Vitex trifolia.

Cultivation: Best propagated from cuttings it is a versatile and proven hardy coastal screening shrub providing protective cover to ground dwelling organisms. It's flowering period extends from the late wet throughout the dry season and complements small yellow flowering shrubs very well.

59. Acacia dunni (Elephant Ear Wattle)

TR F: Mar - May Ft: Jun - Aug
Habitat [1, 4] Chart: Sandstone 5.10
Mimosaceae

Notes: This distinctive shrub grows to 2 - 4 m height and displays bright yellow flowers in grouped globular heads and woody pods with several oblong seeds and white-blue tinged leaves. Acacia species may have mycorrhizal associations with ECM and VAM, or only VAM.

Cultivation: Easily propagated from treated seed, Acacia dunni grows in full sun on well-drained and poor soils and as a pioneer species is extremely hardy and fast growing.

61. <u>Acacia mountfordiae (Mountford's Wattle)</u>

SH F: Jun - Oct Ft: Aug - Nov
Habitat [4] Chart: Sandstone 5.2
Mimosaceae

Notes: Displaying a distinct blue grey foliage this shrub grows to 3 - 4 m high and bears bright yellow flowers in dense cylindrical spikes and semi-woody pods which contain several black seeds, Acacia species may have mycorrhizal associations with ECM and VAM, or only VAM.

Cultivation: From treated seed this species adapts to a wide variety of well-drained soils, is hardy and very fast growing.

62. <u>Eucalyptus herbertiana (Herbert's Gum)</u>

TR F: May - Oct Ft: May - Oct
Habitat [1] Chart: Sandstone 5.3
Myrtaceae

The word eucalyptus comes from the Greek words 'eu' and 'kalyptus' which means well covered. It refers to the buds little cup called an operculum. Gum trees get their name from the dark gum that oozes from wounds on the trunk, it's purpose is to seal the wounds before insects such as borers can get in. In spring and summer, white sugary lerp appears on the leaves of gums made by the tiny orange nymphs of an insect called psyllid (Glycaspis blakei). The nymph sucks sugar from the leaf, eating some of it and using the rest to make a white shelter to hide under. Lerp is utilised by many birds to supplement their forage.

Notes: One of the smaller eucalypts, it grows to 3 - 8 m in a multi-stemmed or mallee-like growth form with small cream flowers in small clusters and small cup-shaped woody capsules and a white or pale-grey bark. It is likely to be dual ectomycoorrhizal (ECM) / arbuscular mycorrhizal (VAM) like other eucalytus species.

Cultivation: Propagated from seed it prefers sandy well-drained soils where it is fast growing.

63. Eucalyptus phoenicia (Scarlet Gum)

TR F: May - Jul Ft: Aug - Oct
Habitat [1] Chart: Sandstone 5.4
Myrtaceae

The species name is derived from the latin word phoenicius (meaning scarlet) referring to the trees spectacular heads of scarlet flowers.

Notes: Growing to 7 - 10 m this medium sized eucalypt has yellow to orange flowers in dense globular umbels, woody capsules, fibrous yellow to orange bark and multi-stemmed growth form with a light open crown. To grow well, symbiosis with fungi is required as with other eucalytpus.

Cultivation: Propagated from seed it prefers a sunny location in a well-drained sandy soil. Birds and other animals are attracted to feed on the plentiful nectar of the flowers.

64. Gardenia fucata (Cape Jasmine)

TR F: Sep - Feb Ft: Nov - Mar
Habitat [1] Chart: Sandstone 5.5
Rubiaceae

Notes: Growing to 3 - 4 m this gardenia like others typically features large white scented flowers and fibrous pulpy fruit with many embedded seeds. Gardenia's have a reported association with arbuscular mycorrhizas (VAM).

Cultivation: Propagation is from seed.

65. Grevillea formosa (Mt Brockman Grevillea)

SH F: Dec - May Ft: Feb - Apr
Habitat [1] Chart: Sandstone 5.6
Protaceae

Notes: A very low shrub to 0.5 m high it has yellow flowers on large terminal racemens, semi-woody follicles containing two seeds.

Cultivation: From seed or tip cuttings, grows in full sun in well-drained sandy soils, fast growing, good ground cover plant. Like other grevilleas the nectar-laden flowers attract small honeyeaters.

66. Grevillea refracta (Silver-leaf Grevillea)

TR F: Jan - Dec Ft: Jan - Dec
Habitat [1, 4] Chart: Sandstone 5.7
Protaceae

Notes: Growing to 3 - 5 m with red-yellow to orange flowers on short dense racemens that turn into woody follicles containing two winged seeds, the tree displays a distinct erect silvery grey foliage. As with other member of the Protaceae family, grevilleas are nonmycorrhizal (NM).

Cultivation: Propagated by seed it grows well in sunny sites on well drained soils and attracts honeyeaters.

67. Jacksonia dilatata (Jacksonia)

SH F: Jun - Oct Ft: Jul - Oct
Habitat [1, 3, 4] Chart: Sandstone 5.8
Fabaceae

Notes: A small shrub growing to 2 - 4 m with small yellow pea flowers and single seeded hairy capsules they grow in a relationship with arbuscular mycorrhizas (VAM).

Cultivation: Grown from seed, they are an excellent source of nectar for bees while also having applications in indigenous natural medicine.

68. Pandanus basedowii (Sandstone Pandanus)

TR F: Apr - Dec Ft: May - Dec
Habitat [1] Chart: Sandstone 5.9
Pandanaceae

Notes: The 3 - 5 m high tree has male and female flowers on separate trees and produces a large pale cream brown composite woody fruit. This species of Pandanus is often distinctively horizontally branched and unlike P. spiralis features prop roots. Pandanus generally have a relationship with arbuscular mycorrhizas (VAM) or are nonmycorrhizal (NM) with P. basedowii unknown.

Cultivation: Grown from seed this pandanus prefers a sunny position in well drained soil. Pandanus are a highly unusual plant form and the preferred habitat of Crimson Finch. Indigenous people extract the seeds from the fruit segments and roast the seeds before consumption. Frogs also often hide in leaf pockets which in turn attracts predators.

69. Acacia gonocarpa (Cloud Acacia)

SH F: Oct - Feb Ft: Feb - May
Habitat [1, 4] Chart: Woodland 6.1
Mimosaceae

Notes: A small shrub growing to 1 - 3 m height with pale cream-yellow flowers in cylindrical spikes and narrow woody pods with several brown seeds it displays a rounded form. Acacia species may have mycorrhizal associations with ECM and VAM, or only VAM.

Cultivation: They are propagated from treated seed and grow well in sandy well-drained soils. They are fast growing. The foliage can be used as a herb flavoring in cookery.

70. Acacia nuperima (Wattle)

SH F: Jan - Dec Ft: Jan - Dec
Habitat [1, 4] Chart: Woodland 6.2
Mimosaceae

Notes: A very low shrub to 0.5 - 1.5 m in height it features yellow flowers in globular heads and narrow woody pods with several brown seeds. Acacia species may have mycorrhizal associations with ECM and VAM, or only VAM ..

Cultivation: Propagated from treated seed they are hardy and fast growing, adapting to a variety of well-drained soils. They make a lovely addition to the garden as a compact showy shrub flowering year-round in cultivation.

71. Gardenia megasperma (Gardenia)

TR F: Jun - Oct Ft: Nov - Jun almost all year present
Habitat [1, 3, 4] Chart: Woodland 6.3
Rubiaceae

Notes: A small tree growing to 3 - 6 m with large white seven or eight pedaled fragrant flowers, they produce pulpy brown fruit with many seeds and require arbuscular mycorrhiza for healthy development. The beautiful butterfly Hypochrysops ignitus (Fiery Jewel) feeds on the leaves of this small tree.

Cultivation: They are propagated from seed and feature edible fruit on a partly deciduous rounded crown. A hardy understorey tree in open woodland and in sandy soils.

72. Eucalyptus alba (White Gum or Salmon Gum)

TR F: Jul - Sep Ft: Sep - Oct
Habitat [4] Chart: Woodland 6.4
Myrtaceae

Notes: A medium sized semi-deciduous tree growing to 5 - 10 m tall, features small cream flowers in clusters turning to woody cup-like capsules on a multi-stemmed growth form.

Cultivation: Grown from seed they adapt to a wide range of well-drained soils. Although not as fast growing as other eucalyptus trees they develop into a very decorative shade tree and provide a good source of nectar for bees.

73. Grevillea decurrens (Cloth Peg Tree)

TR F: Dec - Apr Ft: Jul - Oct
Habitat [1, 3, 4] Chart: Woodland 6.5
Proteaceae

The grevilleas are called after Charles Francis Greville who was a founder of the London Horticultural Society.

Notes: G. decurrens grows to a height of 3 - 5 m and has pale pink flowers on one side of long racemens with woody follicles that turn brown when ripe and contain two papery winged seeds.

Grevilleas like most Protaceae are nonmycorrhizal (NM).

Cultivation: It can be propagated from seeds and adapts to a wide range of well-drained soils. The raw seeds are edible after extraction from the seed pods and flowers provide a good source of nectar for bees. The pink flowers are arranged on spikes are also visited by lorikeets and other nectar eating birds, Indigenous people too eat the sweet nectar of the flowers.

74. Grevillea dryandri (Dryandri's Grevillea)

SH F: Feb - May Ft: Apr - Jun
Habitat [1] Chart: Woodland 6.6
Proteacceae

Notes: A low spreading shrub to 0.5 - 2 m in height it features pink or red flowers on racemens with several to prominent terminal inflorescences turning to hairy follicles with two seeds. Grevilleas like most Protaceae are nonmycorrhizal (NM)

Cultivation: Propagated from seeds this species adapts to a wide variety of well drained soils and are very fast growing. A showy ornamental and a good source of nectar for bees it is a must for the dry corner in your garden. The plant is naturally at home amongst rocks, scree slopes and in shallow sandy soils. Indigenous people lick and suck the flower heads for its sweet nectar.

75. Melaleuca minutifolia (Melaleuca)

TR F: Sep - Dec Ft: Apr - Sep
Habitat [4] Chart: Woodland 6.7
Myrtaceae

The name melaleuca comes from the Greek words for 'black' and 'white', referring to the dark bark of the trunk and white shade on the branches of some larger species

Notes: With a height of 3 - 7 m they display small white flowers and very small fruit as cup-shaped woody capsules with numerous fine seeds, papery bark in an often multi-stemmed bushy growth form. Melaleucas either have dual association with arbuscular mycorrhizas and ectomycorrhizas (VAM/ECM) or a leaning towards ectomycorrhizas (ECM) but the detail is unknown for this species.

Cultivation: From seed or cuttings it grows into an attractive small tree. Melaleuca are mostly pollinated by insects including the introduced honeybee, flies, beetles and wasps. Some birds such as lorikeets and honeyeaters also visit the flowers.

76. Pandanus spiralis (Pandanus, Screw-palm)

TR F: Apr - Jul Ft: Jun - Oct
Habitat [3, 4, 5, 6, 8] Chart: Woodland 6.8
Pandanaceae

Notes: This very widespread species of pandanus grows to 8 m in favorable conditions and has white inconspicuous male and female flowers in dense terminal spikes on different plants as well as wedge shaped woody fruits that are clustered in large composite heads. The Screw-palm gets is name from the distinctive growth form with a spirally marked trunk. The prickly leaves are spirally crowded towards the end of branches They are likely in symbiosis with arbuscular mycorrhizas (VAM).

Cultivation: It can be propagated from seed and is an important indigenous plant with various parts used for either food, medicinal purposes and also for weaving, The moist white bases of fronds are occasionally eaten throughout the year. The leaves are dried and strips torn off for weaving baskets and mats while the fruits are roasted and the kernels extracted and eaten either raw or roasted. Kernels have a nutty flavor. Fresh fruitlets are chewed and sucked for juice while the fruitstalks are also palatable after light roasting. P. spiralis provide important nesting sites for the Crimson Finch with the leaves also providing a hiding place for insects which in turn attracts insectivorous wildlife. The palmlike appearance of the pandanus and unusual display of graceful leaves give them a tropical appeal, making them one of the Top Ends most photographed plants. They constantly grow upward, producing new leaves at the top. The old dead leaves stay attached to the trunk and offer shelter to a variety of creatures such as the Long-tailed Finches and Crimson Finches but also tree snakes, frogs and geckos. The fringes of Holmes Jungle are lined with P. spiralis habitat, home to Crimson Finch.

77. Petalostigma pubescens (Quinine Tree)

TR F: Oct - Dec Ft: Feb - Sep
Habitat [3, 4] Chart: Woodland 6.9
Euphorbiaceae

Notes: Slow growing small tree to 3 - 6 m height which displays tiny cream male and female flowers on separate plants in small clusters and orange thin-fleshed woody capsules. It features a rough dark grey to black bark, and shiny green leaves on a round dense crown. Petalostigma have a symbiotic relationship with arbuscular mycorrhizas.

Cultivation: Propagation is from seed that grows into a hardy small tree that also has some indigenous medicinal applications. The dense crown offers good shelter for small birds and insects.

78. Xanthostemon paradoxus (Bridal Tree)

TR F: Jan - Apr Ft: Jun - Oct
Habitat [1, 2] Chart: Woodland 6.10
Myrtaceae

The name of this species is derived from the Greek word para (meaning compared with) and doxa (meaning glory) and refers to the spectacular flowering display which can be present at any time of the year.

Notes: Growing to a height of 4 - 10 m the tree displays showy bright yellow flowers with numerous stamens in roundish inflorescences turning to dry woody capsules brown when ripe and splitting into 3-4 segments. Like most Myrtaceae, Petalostigma has an association with arbuscular mycorrhizas (VAM).

Cultivation: It is cultivated from seed and provides a good source of nectar for birds and bees. It is slow growing and the young shoots are sometimes eaten by grasshoppers and caterpillars.

79. Calytrix estipulata (Turkey Bush)

SH F: May - Aug Ft: Aug - Oct
Habitat [1, 3, 4] Chart: Woodland 6.11
Myrtaceae

Notes: A small shrub growing to 1 - 4 m with deep pink to purple flowers turning to small nuts, it has an erect bushy growth habit. Part of the Myrtaceae family it typically has a symbiotic relationship with ectomycorrhizas (ECM) and also but to a lesser extent with arbuscular mycorrhizas (VAM).

Cultivation: Grown from seed it adapts to well-drained soils with little care. Crushed leaves make a good liniment for body aches and pains. The plant is commonly found on gravelly poor soils such as roadsides. It is a pioneer plant that establishes itself on bare areas. An excellent plant for a dry garden to offer nesting and shelter opportunities it appeals to smaller birds such as finches.

80. Buchanania obovata (Green Plum)

TR F: Jul - Oct Ft: Oct - Dec
Habitat [1, 3, 4] Chart: Woodland 6.12
Anacardiaceae

Notes: Also known as wild mango it belongs to the same family as the cultivated mango and produces edible fruit at the beginning of the wet season. Growing to 4 - 10 m it shows numerous small cream flowers on terminal panicles as fleshy drupes that turn to green-yellow when ripe and enclose a single seed. Buchanania grow in symbiosis with arbuscular mycorrhizas (VAM). The butterfly Arphopala eupolis feds on young growth leaves of the Green Plum.

Cultivation: Propagated from fresh seed, they are slow growing as a young plant, but matured leafes seem to be resistant to insect attack. The fruit can be eaten raw while leaves and bark have many medical applications for indigenous people. Green Plum will attract insects and fruit eating birds as well as butterflies and small mammals to the garden. Indigenous people collect the sweet and sought after fruit from the ground and also sun-dry the fruit to cover it with red ochre and wrap in paperbark for storage to consume the following dry season. The tree grows naturally as a common understorey in open forest and woodland and therefore lends itself for small sunny dry parts of the garden. The plants can produce fruit when still in their early development.

81. Terminalia ferdinandiana (Billy Goat Plum)

TR F: Sep - Nov Ft: Mar - Jun
Habitat [3, 4] Woodland 6.13
Combretaceae

Notes: The generic name 'terminalia' refers to the way the leaves are all crowded at the end of the branches. These leaves are very large and oval shaped up to 25 cm long and 15 cm wide. A common understorey tree in lowland and sandstone open forest and woodland, T. ferdinandiana grows to 4 - 10 m height. In the middle of the dry season up towards the end of the dry it puts on a new flush in anticipation of the coming wet season and shows off scented cream flowers on spikes and later on smooth fleshy ovoid drupes that turn yellow-green when ripe and contain a single seed. Most Terminalia grow in association with arbuscular mycorrhizas (VAM) which probably is also the case for this species.

Cultivation: The edible and slightly salty billy-goat plums are propagated from fresh seed. The fruit is eaten raw and has exceptionally high vitamin C values. Indigenous people also eat the gum exuded on branches and trunk as a result of insect damage.

82. Ficus opposita (Sandpaper Fig)

SH F: Ft: Jul - Feb
Habitat [1, 3, 4, 8] Chart: Woodland 6.14
Moraceae

Notes: Growing to a compact 3 - 8 m high tree, it is evergreen with inconspicuous male and female flowers on separate trees turning to fleshy receptacles green-brown turning black. It probably has a relationship with arbuscular mycorrhizas like other figs.

Cultivation: It is a common understorey tree in its natural habitat, and can be propagated from seed and grows well on a range of soils. Parts of the tree are used for traditional medicinal purposes. The true fruits of the fig are the tiny seedlike balls found inside the ripe synconium. The fig relies on flying-foxes and birds to disperse the tiny fruit as they feed on the syncornia and ultimately transfer the undigested seed to other areas of the woodland. Indigenous people eat the ripe syncornia and use the leaves to sand down spears.

83. Aidia racemosa (Archer Cherry)

TR F: Aug - Dec Ft: Mar - Jun
Habitat [2, 7, 9] Chart: Monsoon Vine Thicket 1.31
Rubiaceae

Notes: Growing to a small 4 – 10 m high tree, it features strongly jasmine scented white flowers and fleshy edible red fruit in clusters up to 20 fruits. Like other Rubiaceae this species likely grows in a relationship with arbuscular mycorrhizas. Leaves are arranged as opposite oval blades glossy green above and paler underneath with distinct central venation.

Cultivation: Propagated from fresh seed this tree requires ample water to grow well and is tolerating some shade thus suited to midstorey in the garden. The flowers attract butterflies and birds feed on the tasty shiny red fruit which is also palatable for humans.

84. Syzigium suborbiculare (Red Bush Apple)

TR F: Jul - Oct Ft: Nov - Feb
Habitat [3, 4, 8?] Chart: Woodland 6.15
Myrtaceae

Notes: Growing to a 8 –12 m high canopy this evergreen species features large white flowers and edible fleshy fruits. It is distinguishable from other Syzygiums by its relative large leathery dark green leaves that are shiny above and paler on the underside. Like other Myrtaceae it has probably a mutual beneficial relationship with both ECM and VAM mycorrhiza. A common understorey tree in open forest and woodland its lignotuber is resistant to fire damage and allows the plant to rebound from fire damage.

Cultivation: Propagated from fresh seed the plant adapts to most well-drained soils and makes a lovely wildlife friendly medium sized shade tree in the backyard. It is one of my favorite trees and you see a nice group of them near the entry of the Wangi Falls plunge pool in Litchfield National Park. The species has many traditional indigenous medicinal applications and also presents an excellent source of nectar to bees. The red apple is eaten either raw or slightly roasted.

84. Corymbia polycarpa (Long-fruited Bloodwood)

TR F: Mar - June Ft: Jun - Sep
Habitat: [3, 4, 5] Chart: 6.16
Mytaceae

Notes: Growing to a medium tall 10 - 15 m high tree with a rough grey tessellated bark and cream-white flowers, like other Eucalyptus relies on a mutually beneficial relationship with both ECM/VAM mycorrhizal fungi.

Cultivation: Grown from fresh seed the tree adapts to a wide range of soils and seems to tolerate seasonal inundation. It has a range of traditional traditional medical applications and is also an excellent source of nectar for bees and other honeyeaters such as lorikeets. The timber is strong and suitable for ground and poles as well as firewood.

85. Ficus aculeata (Sandpaper Fig)

TR F: all year Ft: all year
Habitat: [1, 3, 4, 8?] Chart: 6.17

Moraceae

Notes: One of the three NT species of Sandpaper Figs it grows to 6 - 8 m as a compact and is partly deciduous without irrigation. Growing as an understorey tree in open forest and woodland it is reputedly hardy and termite resistant. Like the other Sandpaper Figs it has male and female flower on separate trees and probably has a relationship with arbuscular mycorrhizas.

Cultivation: Propagation is similar to Ficus opposita. The sweet black and soft ripe fruit is eaten by indigenous people and also cherished by a range of fruit eating birds. If you want a fruiting Sandpaper Fig in your garden F. aculeata is probably the best choice but you are advised to plant several to ensure a presence of both male and female plants.

86. Triodia epactia (Spinifex)

GR F: all year Ft:
Habitat: [3, 4?] Chart: 6.18
Poaceae

Notes: A hardy clumping perennial grass species up to a height of 0.8 m it reportedly flowers in all seasons. It is not strictly local to the Top End but its growing range extents from the Pilbara in WA to the north-western part of the Territory right up to the border crossing near Kunanarra, It grows quite well in Darwin under cultivation and makes a very useful food plant for grass seed eating finches such as the Gouldian Finch.

Cultivation: Propagated from seed or by division it prefers deep sandy soils. I'm trialling it in large pots to observe how it behaves in variable growing mediums and how how the resident finch population takes to the seeds.

87. Ipomea abrupta (Bush Yam)

CL F: Nov - Mar Ft: Mar - Apr
Habitat: [2, 3, 4, 6, 7] Chart: 1.32
Family: Convolvulaceae

Notes: A woody climbing plant reaching high in surrounding trees with large mauve-pink. Its Morning Glory-like flowers can be an important source of nectar in your garden for bees, butterflies, small birds and small reptiles. The roots particularly from younger plants are eaten raw or cooked by indigenous people.

88. Ampelocissus acetosa (White Grape)

CL F: Sep - Feb Ft: Feb - Apr
Habitat: [1, 2, 3, 4, 7, 9] Chart: 1.33
Family: Vitaceae

Notes: This scrambling climber or semi-prostrate shrub has numerous tiny dark-red-brown flowers on branching inflorescences that turn into fleshy clusters of grape like fruit, purple-black when ripe. It also occurs in New Guinea, Western Australia and Queensland. The vine stem diameter can be up to 3 cm.

Cultivation: Propagated from seed it is not widely used in gardens but appears to have the potential to grow in a great variety of soils. The fruit is eaten raw and are initially sweet but leave a bitter aftertaste. Indigenous people refer to the roots as cheeky yams because it leaves a burning and stinging sensation when tasted and therefore are usually eaten roasted.

89. Flagellaria indica (Bangle Vine)

CL F: periodic Ft: periodic but mainly Dec-Mar
Habitat: [2, 3, 4, 5, 7, 9, 10] Chart: 1.34
Family: Flagellariaceae

Notes: This vine is vigorous and uses tendrils to get high into the canopy of trees and over the top of shrubs and smaller trees in wet to dry forests. It has very small cream flowers in dense terminal panicles that turn into small fleshy pink fruit that contain single seeds. The stem diameter is up to 2 cm.

Cultivation: Propagated from seed the climber should grow in a wide variety of soils judging from the occurrence in a range of habitats. Although thought to be edible only the flesh of the fruit is eaten by indigenous people as the seeds are considered toxic. Young leafy shoots can reportedly be cooked and eaten as a vegetable. The fruit is also eaten by fruit pigeons which themselves are not being harmed by the seeds because of their rapid gut transition time and not digesting the seed. F. indica is a food plant for the larval stages of the Common Tit and Large Darter Butterflies. The stems, softened and split are used for a variety of purposes for sewing in indigenous craft. The sap from stems and leaves also has a number of medicinal applications but it may also be poisonous. However leaf and stem material of this species has shown to be active against some tumors. In some parts of Papua the plant has been used as a contraceptive, and is thought to cause sterility in women. The plant has demonstrated antimicrobial activity and is also used traditionally as a diuretic,

90. <u>Gymnanthera nitida</u>

CL F: Dec - Jul Ft: Jan - Apr
Habitat: [5, 6, 9] Chart: 1.35
Family: Apocynaceae

Notes: A vigorous climber with green-cream to white scented flowers turning to smooth cylindrical capsules and containing numerous fine feathery winged seeds.

Cultivation: Although untried it may be worthwhile to be experimented with in the garden. Indigenous people use the latex of the plant for ceremonial purposes.

91. <u>Hoya sp (Waxplant)</u>

CL F: Dec - Mar Ft: Sep - Oct
Habitat: [1] Chart: 1.36
Family: Apocynaceae

Australian native Hoya species include H. australis, H. carnosa, H. macgillivrayi and H. serpens.

Notes: Growing naturally in rock crevices and outcrops in the NT, hoyas are evergreen perennial creepers or vines or rarely, shrubs. They often grow on trees, some grow terrestrially or occasionally in rocky areas. They climb by twining and with the employment of adventitious roots. They have simple leaves, arranged in an opposite pattern, that are typically succulent. Flower form is typically star-shaped, with five thick, waxy, triangular petals, topped with another star-shaped structure, the corona. Colours on most species range from white to pink. Pollinators include moths, flies, and ants although pollination is apparently poorly understood. Seeds are borne in twin pods and are generally light being dispersed by the wind by means of a small tuft of silky fluff. Germination is rapid, but viability is short.

Cultivation: Hoyas in general are easy to propagate by cuttings, and are commonly sold as cuttings, either rooted or unrooted, or as a potted plant. Some Hoyas are reported to be toxic to livestock. They grow in full sun and in well drained sandy soils and are therefore suited to rockeries in the garden. Indigenous people use the latex for ceremonial paint.

92. <u>Jasminum aemulum (Native Jasmine)</u>

CL F: Oct - Dec Ft: Apr
Habitat: [5, 9] Chart: 1.37
Family: Oleaceae

Notes: This scrambling evergreen shrub up to 2 m height or woody climber grows in the sun or semi-shade. It has shiny pinnate leaves and masses of white, strongly-scented, star-shaped flowers with a stem of up to 4 cm diameter. It develops fleshy shiny black fruit.

Cultivation: From seed or cuttings but is little tried.

93. Opilia amentacea (Opilia)

CL F: Aug - Oct Ft: Oct - Feb
Habitat:[2, 3, 4, 7, 9] Chart: 1.38
Family: Opiliaceae

Notes: Vigorous woody climber to 10 m high but also as a scrambling shrub growing to 2 – 5 m tall with thick stems and very small yellow green flowers that turn into single seeded pale orange yellow fruit. Vine stems of up to 9 cm diameter have been recorded.

Cultivation: Seedlings develop a taproot and grow on a wide range of soils and hosts responding well to watering but may be parasitic on the roots of other plants. The fruit is edible with indigenous people peeling the grape shaped fruit and eat the seed together with the fruit. However bark and leaves are used as fish poison.

94. Parsonsia velutina (Parsonsia)

CL F: Jan - Apr Ft: May - Aug
Habitat: [1, 4, 9] Chart: 1.39
Family: Apocynaceae

Notes: A hairy woody climber to reach tree tops it has small green-yellow flowers in dense clusters on long stalks, that develop into narrow cylindrical woody and very hairy follicles turning brown when ripe. The new growth is brown and hairy exuding a watery sap when cut. Their slender stems are less than 2 cm in diameter often climbing over rock faces to reach sunlight.

Cultivation: Untried

95. Smilax australis (Sarsaparilla)

CL F: Nov - Mar Ft: Feb - Jul
Habitat: [2, 3, 4, 7,9] Chart: 1.40
Family: Smilacaceae

Notes: A rambling climber with prickly climbing stems reaching up to eight meters long it has male and female creamy small flowers on separate plants and produces clustered globular berries black when ripe. Stems are under 2 cm diameter.

Cultivation: Is thought to be largely unsuited presumably because of its prickly thorns and therefore untried. However indigenous people eat the ripe fruit. It may have a place in ecological gardening such as protecting small nesting bird habitats from predation and as a food plant for the larval stages of the Miskin's Jewel and Cephenes Blue Butterflies.

96. Ziziphus oenoplia (Wild Jujube)

CL F: Nov - Feb Ft: Feb - Mar
Habitat: [4, 9] Chart: 1.41
Family: Rhamnaceae

Notes: Jujube has a broad distribution across tropical and subtropical Asia and Australasia. It is a small climbing thorny shrub reaching to 2 m high with green flowers and edible black and shiny fruit. The plant has many medicinal application in Asia particularly India where the root is used in Ayurvedic medicine. Leaves and stem bark is also used.

97. Alloteropsis semialata (Cockatoo grass)

GR F: Oct - Nov Ft:Nov - Jan
Habitat: Rainforests, woodlands and coastal grasslands Chart: 6.19
Family: Poaceae

Notes: This is a perennial grass across much of tropical Africa, Asia and Australia. Allopteropsis comes from the greek word 'allotrios' meaning 'belonging to another' and 'opsis' meaning appearance.

Growing to a tufted 20 – 150 cm high and deep rooted, it flowers sporadically throughout the year although the main period is after the first wet season rains. The seeds of this species are an important component of the wet season diet of many granivorous finches and parrots including the endangered Gouldian Finch. The rhizomes are also part of the dry-season diet of some animals.

Cultivation: Propagated from seed which loose viability after one year unless stored in a freezer. This grass grows mainly on sandy and loamy soils including Eucalypt woodland and is one of the first grass to commence growing after the onset of the wet season with seeding to occur only six weeks after the first rains.

98. <u>Asteromyrtus magnifica (Medicine Leaf)</u>

SH F: periodically Ft: periodically
Habitat: Woodlands Chart: 5.1
Family: Myrtaceae

Notes: A shrub 2 - 3 m high it shows attractive cream to yellow flowers with numerous stamens and is a good source of nectar for bees.

Cultivation: Propagated from seed the shrub grows well on well-drained sandy soils and makes an attractive wildlife friendly ornamental in a dry garden.

<u>**OTHER PLANTS**</u>

While the previoius chapter concludes my list of recommended native plants for residential gardens with a focus on wildlife, there is of course a plethora of exotic plants for sale in the local nurseries and not all of them are bad news for native wildlife. Only very few local nurseries have a comprehensive range of native plants including those species that have been recommended here. However most honeyeaters will take gladly to the interstate variety of callistemon (bottlebrushes), hybrid grevilleas (Grevillea 'Sandra Gordon', a hybrid between G. pteridifolia and G. sessilis and Grevillea 'Honey Gem', a cross of G. pteridifolia with a red form of G. banksii) , Metrosideros collina (Little Ewan), Xanthostemon chrysanthus (Golden Panda), Melaleuca linarifolia purple (a dwarf form of Melaleuca). Our figbirds as well as other frugivores also take to the fruiting trees of Syzigium australe (Lilly Pilly) and Psidium littorale (Cherry Guava). A very common and useful plant in Darwin is the groundcover Gardenia pisodiodies (Hann Gardenia). It has a semi-prostrate growth habit, with new central growth being very upright and then cascading outwards as the new growth lengthens. The leaves are deep green and have a slight crinkled look and have a slightly rough texture about them. This gardenia species produces pure white, slightly scented, star-shaped flowers throughout the warmer months of the year.

I grow a few exotic specimens as pot plants such as the Cherry Guava that can be trained on a fence. Cherry Guava can reach 3 m and has thick, smooth dark green leathery leaves and responds nicely to pruning. The single white flowers have many prominent stamens and flowers open sporadically throughout the year. The delicious oval shaped round apricot sized fleshy fruit attracts birds and mammals. It grows in the sun as well as in part shade and is drought tolerant, adaptable to clay, loam and sandy soils with an non-invasive roots and leaves that are pest resistant. The preferred method of propagation is by air-layering or by seeds. Expect air-layered plants to start fruiting in the second year. Metrosideros collina, a coastal plant from French Polynesia also makes a lovely pot plant and will reward you with several annual sporadic shows of intense vermilion red flowers that contain a good source of nectar and therefore attract the smaller honeyeaters.

THE OLD STYLE COLONIAL DARWIN GARDEN:

When I arrived in Darwin just before Christmas in 1982 the landscaping of public green spaces and backyard gardens had been dominated by what could be described as 'Old Style' (colonial) Darwin with many exotic palm and tree species intermingling with a few select native varieties. The most common palm and palm-like trees included:

1. Carpentaria acuminata (local species)
2. Roystonia regia (Caribbean origin)
3. Wodyetia bifurcata (Foxtail, QLD)
4. Cocos nucifera (Coconut, tropics)
5. Dypsis decaryi (Triangle palm, Asian)
6. Cyrtostachys rend (Sealing Wax Palm, Thailand and Malaysia)
7. Dypsis lutescens (Golden Cane, Madagascar)
8. Ptychosperma macarthurii (local species)
9. Caryota mitis (Fishtail, Philipines)
10. Livistonia humilis (local species)
11. Livistonia benthamii (local species)
12. Sabal palmetto (Malaysia)
13. Bismarkia nobilis (Madagascar)
14. Licuala spinosa (South East Asia)
15. Ravenala madagascariensis (Madagaskar)

16. Pandanus spiralis (local species)
17. Cycas armstrongii (local species)
18. Cycas revoluta (Japan)
19. Zamia furfuracea (Mexico)

The most commonly utilized Trees and shrubs species were:

1. Tabebuja pallida (Caribbean)
2. Pterocarpus indicus (Indian Rosewood)
3. Delonix regia (Madagascar)
4. Plumeria spp (Frangi Pani, South America)
5. Khaya senegalensis (African Mahagony)
6. Samanea saman (South America)
7. Ficus virens (local species)
8. Ficus benjamina (local species)
9. Ficus longifolia (Asian tropics)
10. Ficus elastica (South America)
11. Carica papaya (Paw Paw, West Indies)
12. Mangifera indica (India)
13. Leucaena leucocephala (Tropical Americas)
14. Nerium oleander (exotic and toxic)
15. Bougainvillea spp (South America)
16. Bauhinia spp (Eastern and southern Africa)
17. Croton (Queensland)
18. Mussaenda (African and Asian tropics)
19. Ixora spp (throughout the tropics except for two local species)
20. Schleichera oleosa (Himelayas, Sri Lanka and China)

I could go on and turn this into a longer list. Many people became so used to these plants they simply assumed them to be native plants. However I feel that such plant species shouldn't be here considering \ contemporary ecological understanding. Back then most public green spaces weren't irrigated and so were allowed to 'brown off' during the dry season, manifesting a distinct sense of place according to the time of the year, brown and flowering in many colors in the dry or mostly green in the wet. Darwinians simply wanted this look and considering the cosmopolitan nature of the Darwin population with a strong tropical Asian and Mediterranean contingent, this old style gardening made sense back then. Most people have a tendency to cling to the cultural familiar combined with a desire for the lush tropical look. The many exotic plants did just that and catered for the tropical style. Nowadays we have become a little bit wiser and acknowledge the ecological rightness in the use of native plants. After all native plants are perfectly adapted to the local environment, are normally not invasive of adjoining natural habitats and support native wildlife in a more appropriate manner. While Darwin still has a strong component of a transient population who may not really care much about a sense of place, perhaps missing home, there are now also increasing numbers of people born and raised in Darwin or long term residents decided to stay for good. Those 'life termers' may also have a more intimate knowledge of the beautiful and interesting vegetation of the Top End and therefore have developed a more meaningful appreciation. I consider myself as one of them and looking back at my first impressions of the Top End landscape back in 1982 compared to my current feelings for it I have to say we should do more to better integrate urban Darwin into its natural surroundings and so bring it closer to fit in. The extensive use of exotic plants in public urban spaces in particular creates a false impression of the place, a kind of pretense of what we are not. A beggar that dresses up as a king is not a king. We no longer need exotic plants here just to become more cosmopolitan so we can turn into another Singapore. To become more truthful we should proudly establish who we are, a part of the Top End landscape and deeply rooted into it. We plant native gardens to reflect our confidence and pride in our natural landscape and at the same time fulfill the need to act in accordance to principles of ecology.

POISONOUS PLANTS

Some plants have developed toxic substances in some or all off their parts in order to avoid being eaten by other lifeforms. Although rarely fatal to humans when such toxic parts get on the skin or are being digested they can create significant health problems for sensitive people and children. We have our share of toxic plants in the gardens of Darwin and since they are generally not know for their toxicity I cover a few below.

1. Abrus precatorius (Crabs Eye Vine)

CL F: Jan - May Ft: Jun - Jan
Habitat: [2, 4, 7]
Family: Fabaceae

This is a local deciduous twining vine which grows to 10 m high with pods containing red/black seeds. Reportedly even just one seed, including soft immature seed when chewed on before ingesting, can cause fatal poisoning in humans. Age does not destroy the toxin but heat reduces its potency. The chief phyto-toxin in Crabs Eye Vine is 'abrin'. The toxic seeds are often used in local craft such necklaces and since these beads are pierced the toxin can leak to the outside and may pose a real danger to small toddlers licking on it. This plant should not be placed in residential gardens.

2. <u>Calophyllum inophyllum (Beauty Leaf)</u>

T F: Dec - Feb Ft: Jun - Aug
Habitat: [8]
Family: Clusiaceae

The large white kernel, the size of a walnut is bitter when eaten and causes vomiting while the sap of the tree contains saponin and hydrocyanic acid, toxic skin irritants and traditionally used as an fatal arrow poison in Samoa. Calophyllum inophyllum is a popular large avenue tree and in parks in Darwin. I consider it unsuitable for backyard gardens because of its toxicity and also because of its large size. If you prune the tree and handle the branches be careful not to get the sap on your skin.

3. Cycas spp, Macrozamia spp and Lepida Zamia (Zamia, Cycad)

Famliy: Cycadaceae & Zamiaceae

The large seeds of most species of those families of plants contain glycosides and if ingested will cause abdominal cramps and diarrhea and in some cases, especially toddlers, can cause liver damage and muscular paralysis. Literally many hundreds of these plants have been used in recent urban landscaping projects along arterial roads and public parks. That's a little bit silly considering those plants species are mostly known exotic and toxic. Landscape architects, designers and managers should know better.

5. Erythrina spp (Coral Tree)

Family: Fabaceae

Quite a pretty native tree with its black pods containing yellow or red seeds that contain a toxin similar to the arrow poison 'Curare' which affects the central nervous system. Diarrhea and vomiting may also occur.

6. Grevillea 'Robyn Gordon' (Grevillea)

Family: Protaceae

Common exotic plant used in many Darwin's gardens for its spectacular flowers and attraction to nectar eating birds. However it is not very well known for its toxic effects in that scratching your skin by broken leaves may develop contact dermatitis in form of blisters 2-3 days after contact. Take care in pruning and working close to those plants.

7. Nerium Oleander (Oleander)

Family: Apocynaceae

All parts of this exotic plant are poisonous. Indeed very small quantities of the plant if ingested may be fatal. One leaf can kill a child. Many symptoms up to death have been recorded. This plant should not be sold by nurseries or be used in any landscaping project.

8. Plumeria spp (Frangipani) Apocynaceae

Family: Apocynaceae

An old time favorite little exotic tree to many people that is widely used in Darwin for its showy flowers and hardiness. But, have you ever seen any animals or insects on it? The answer is no, because the plant is next to useless to wildlife. The showy flowers provide fragrance in order to trick and attract wildlife including insects but have no nectar on offer, while for humans and possibly animals alike the milky sap may blister skin and seeds eaten will cause diarrhea. We don't need them as there are better native choices.

9. Caryota mitis (Clustered Fishtail Palm)

The fruit should be handled carefully because it contains stinging acid crystals which cause extreme irritation and are very dangerous to children. Keep this plant out of areas with young children including school grounds.

If you are interested in more information on poisonous plants I recommend to read 'Poisonous plants in Northern Australian Gardens (Betsy R. Jackes 1992)' available through your local Darwin library.

There are many other popular flowering shrubs that are used extensively in both private gardens and public landscapes and although they may not be seriously toxic they have not much to offer to wildlife. These plants include the exotic Crotons with its variegated colorful leaves and slightly toxic sap, thorny Bougainvilleas with a sap the cause of skin rashes the latter that are next to useless to birds, bees and butterflies because they have no nectar with their 'sudo' flowers as well as a range of other mainly hybrid shrubs such as exotic Ixoras and Mussaendas. Sometimes you can spot a few birds in such plants but they are not there for nectar, pollen or seeds, even insects tend to avoid those plants. If you are interested in attracting and caring for local wildlife rip these plants out of your garden.

Plant toxicosis in birds and other animals occurs if they chew on or ingest toxic plants. The toxic reaction can be due to pesticide residues on the plants, or to toxins within the plants themselves. Animals which chew on toxic plants may develop oral irritation; if they ingest enough, systemic clinical signs can occur such as vomiting or diarrhea. There are likely significant species differences in sensitivity and sadly often we don't know as studies are lacking. I may add a few plants to the above list of toxic plants for humans, which have been reported as toxic in some birds and animals particularly or which are considered to be potentially toxic and include Codiaeum sp. (Croton, sap), Dieffenbachia (leaves), Solanaceae sp. (Eggplant, every part except fruit), Colocasis sp. or Alocasia sp. (Elephant's ear, leaves and stems, Anthurium sp (Flamingo flower, leaves and stems), Ilex (Holly, berries), Lantana sp. (immature berries), Philodendron sp. (Leaves and stems). Some of these plants are quite shade tolerant and therefore often kept in posts on a verandah and so can be accessed easily by wildlife and of pets you may have.

WEEDS

The dictionary defines 'weed' as a plant growing and spreading wild where unwanted. The emphasis is on unwanted from a human-centric viewpoint. From an ecological point of view a weed is an introduced plant in an ecosystem or habitat where it normally does not belong and where it can cause displacement of competing native plants as well cause interruption to other ecological processes. 27,000 plant species have been imported into Australia of which some 2,700 of these are now listed as environmental weeds. Weeds are not inherently bad and in some instances can be beneficial to fauna and soils. Many also have medicinal value. Weeds in gardens can become a problem from where they are able to invade adjoining lands and natural areas very often through dispersal of seeds by birds and other animals. There is legislation on such invasive noxious weeds with landholders required to manage or remove them.

This text includes descriptions of the most common weeds in the Darwin area (also see chart of plants section 8 in the appendix) and prescriptions on how to manage them. Some of the aquatic weeds such as Cabomba, Mimosa, Olive Hymenachne, Para Grass and Salvinia are not covered here since there it is unlikely to find them in the home garden but they are a concern in larger landholdings that have natural waterbodies on the property.

The key point is to be able to recognize these listed plants as a weed, then be vigilant and remove them before they disperse. It is important to correctly identify a weed because control methods differ considerably for each species. One excellent resource to help you identify a local weed is 'Weeds of Northern Australia: a field guide” published by the Environment Centre NT in 2011 and authored by Nicholas Smith. Other sources include the Northern Territory Government website on weeds. When you look out to identify weeds, keep an eye on your neighbors garden as well because in many cases inaction on weeds is based on ignorance that is not being able to recognize a weed as a weed. The method to remove weeds depends on the species and the extent of the area of infestation but mechanical removal by hand is usually the most efficient for small urban plots and residential gardens. Preventing weeds to establish is the most effective and cheapest form of control but often requires you to recognize a weed in its juvenile form. Legal requirements in the Northern Territory refer to classification of the declared weeds with Class A required to be eradicated, Class B required to be controlled and Class C to be disallowed entry. In any case all declared weeds are illegal to grow, sell, transport or use in the NT.

The agricultural industry and allied industries are readily promoting the sale and use of herbicides including for the home garden. Be aware that herbicides are poisons. Many of them can be easily absorbed through the skin, by breathing in its vapors and by ingestion. Some of the chemicals which are added to herbicides have the potential to seriously affect the quality of aquatic ecosystems. We have very little knowledge and in most cases no knowledge of how herbicides affect fauna including invertebrates and microbes in the soil. So I think there is absolutely no place for the applications of herbicides in small home gardens whatsoever. Simply don't use them.

Here is a short description of the most common weeds you may encounter in local gardens.

1. <u>Alternanthera philoxeroides (Alligator Weed)</u>

AQ F:Jan - Mar Ft: Mar - Apr
Habitat: Wetlands Chart: 8.1
Family: Amaranthaceae

Notes: Originating from South America, A. philoxeroides is a Class A weed of national significance. There were two infestations in suburban Darwin that have now been eradicated. It forms a floating mass that spreads over water and can double its biomass in 50 days. It also grows on land as a rooted form and both forms have silvery white flowers. The aquatic form has hollow stems with large airspaces to facilitate floating.

2. Baleria prionitis and Baleria lupulina (Baleria)

SH F: Mar - Dec Ft: Apr - Jan
Habitat: Woodland and along watercourses Chart: 8,2
Family: Acanthaceae

Notes: Growing to 1 - 1.8 m tall with an extensively branched form, B. prionitis is native to Island and Mainland Southeast Asia, China, the Indian Subcontinent, the Arabian Peninsula and northeastern Africa. B. lupolina is distinguished by longer dark green leaves which have a distinct red mid-vein. Both species have spread and naturalized around the world including the Top End of Northern Australia primarily from its use as a ornamental shrub for hedging and cultivation as a medicine plant. The clustered large golden yellow flowers are easily recognizable. In Australia with flowering and fruiting times being trimodal, from March to June, August to October and December, the shrub is found on roadsides, thickets, and dry places in evergreen broad-leaved forests but can also occur on pastures and pastoral areas. It able to grow in a wide range of climates and soil types and is adapted to grow in open, full sunny areas and in highly disturbed sites as well as understorey of secondary forests. It has great dispersal capability, spreading sexually by seeds and vegetatively by stem fragments. The shrub has potential to cause economic and environmental damage in that it forms dense thickets that displace native vegetation and so prevent revegetation by native plants. Stock movement cam be impeded, waterway access restricted and aesthetic values diminished. In Australia, the plant is on an alert list for environmental weeds, as it has the potential to seriously degrade ecosystems. Some butterfly species reportedly use it as a food plant for their larvae and the plant also has many medicinal benefits. First recorded in the Northern Territory in 1963, it has been declared as a noxious environmental weed in 2001. It is controlled by hand pulling or grubbing and foliar spray.

3. Jatropha gossypifolia (Bellyache Bush)

SH F: Jan - May Ft: Mar - Aug
Habitat: Riparian Chart: 8.3
Family: Euphorbiaceae

Notes: A perennial growing to an erect 2 and 3 m tall shrub, with small red flowers, Bellyache Bush is a Class A weed except for areas where it has been classified as a Class B weed. Native to Central and South America, there have been multiple deliberate introductions to Australia because of its ornamental and medicinal values since the 1920's and as a result it has become naturalized. In Northern Australia widespread along watercourses in many locations, this weed forms dense thickets where native vegetation is compromised particularly in riparian zones but spreading also into savannah areas and woodland. Seeds are highly toxic to stock and humans, splitting open when ripe to expel seeds away from the parent plant and thus spreading to form dense thickets. Seeds are also dispersed by vehicles and animals. Native bees of the Trigona species are attracted to the sticky leaves and stems. Control of this weed is by hand pulling and grubbing as well as foliar spray, cut stump, basal bark and soil application.

4. Clitoria ternata (Butterfly Pea)

CL F: Feb - Jun Ft:May - Jul
Habitat: Riparian and gardens Chart: 8.4
Family: Fabaceae

In India, it is revered as a holy flower, used in daily puja rituals. The flowers of this vine were imagined to have the shape of human female genitals, hence the Latin name of the genus "Clitoria", from "clitoris". This plant is native to equatorial Asia, including locations in South Asia and Southeast Asia but has also been introduced to Africa, Australia and the Americas.

Notes: A perennial invasive herbaceous plant it can climb to 7 m. It has elliptic, obtuse leaves and establishes readily in moist soils. The solitary flowers are of a vivid deep blue, with light yellow markings. The flowers are about 4 cm long by 3 cm wide and form bean like seed pods. Some varieties yield white flowers. It is grown as an ornamental plant and for medicinal purposes in some countries and requires little care when cultivated. As a legume, its roots form a symbiotic association with soil bacteria known as rhizobia, which transform atmospheric N2 into a plant-usable form (a process called nitrogen fixing), therefore, this plant is also used to improve soil quality through the decomposition of nitrogen rich plant material. It is considered a palatable pasture species.

5. Calopogonium mucunoides (Calopo)

CL F: Apr - Aug Ft: Jun – Oct
Habitat: In heavy soils, near creeks and at the edge of monsoon forests Chart: 8.5
Family: Fabaceae

Notes: A flowering annual vine in the family Fabaceae, native to tropical America it was introduced as a forage crop and a green manure to the tropics of Africa, Madagascar, the Indian Subcontinent, Asia, Papuasia, and Australia. In some locales it has become a serious invasive species. The flowers are similar to the Butterfly Pea but leaves are distinctly broader and heartshaped and pods are densely hairy. The weed is often spread in contaminated hay and through vehicles and stock. Control is by hand pulling, grubbing and mulching.

6. Senna alata (Candle Bush)

SH F: May - Jun Ft: year round
Habitat: Along creeks, in gullies and wet drainage channels Chart: 8.6
Family: Fabaceae

Notes: Native to Central and South America this weed has spread to many parts of the world including Australia and in the NT has been declared as a Class B weed. An evergreen spreading shrub it has spread into wetter bushland areas of the coastal region of Darwin where it can form dense thickets. Growing up to 4 m tall it develops a shallow mat root system and is easily recognizable for its large candle like yellow flowers and dark long pods. Seeds generally disperse close to parent plants hence the tendency to form thickets but it can also disperse downstream after downpours and flooding and attach to vehicles. It displaces native vegetation and impedes access to waterways. Control is by hand pulling and grubbing but also by foliar spray, cut stump and basal bark applications.

7. Centrosema molle (Centro)

CL F: May - Oct Ft: Sep - Oct
Habitat: Disturbed sites Chart: 8.7
Family: Fabaceae

Notes: Another type of the Butterfly Peas twining perennial vines with blue-violet flowers growing to about 3 m height but belonging to a different genus. Seed is often spread intentionally as a pasture species but also through mud adhering to vehicles. It invades disturbed areas and chocking out other pioneer species thus preventing natural regeneration. The recommended control is by hand pulling and grubbing.

8. Ziziphus mauritiana (Chinee Apple)

SH F: Dec - Apr Ft: Jan - Aug
Habitat: Wide variety but prefers riparian margins Chart: 8.8

Notes: Growing to 4 to 6 m tall, it features thorns and tiny bad smelling cream colored flowers in small clusters, The edible fruit turns from green to yellow to reddish-brown when ripe. Native to southern

Asia and eastern Africa it was introduced as a fruit tree but since then has been classified as a Class A weed in the NT with a statuary legal requirement for its control. This is in response to the plants habit of forming impenetrable thorny thickets which hamper movement of humans and native animals and out compete native plant species. Growing well in disturbed areas and cleared areas it forms dense thickets and dramatically alters native habitats. Seeds are mainly spread by birds and native animals but also stock and humans who eat the fruit and expel the seeds. Larger trees need to be removed by machinery or alternative cut stump and basal bark treatment.

9. Leucaena leucocephala (Coffee Bush)

TR F: all year Ft: all year
Habitat: disturbed Chart: 8.9
Family: Fabaceae

Notes: A small fast-growing tree of the mimosoid sub family it is native to southern Mexico and northern Central America and has naturalized throughout the tropics including the Top End of Northern Australia. During the 1970s and 1980s, it was promoted as a "miracle tree" for its multiple uses such as fencing, soil fertility, firewood, fiber, and livestock fodder, disregarding the fact that it also spreads like very quickly in some places. While this legume provides an excellent source of high-protein cattle fodder, it contains mimosine, a toxic amino acid which makes horses and donkeys which feed on it, lose their hair. It is a highly invasive species in the arid parts of Taiwan, the Bahamas, the Hawaiian Islands, Fiji, Puerto Rico, Hong Kong, South Africa, and northern Australia, as well as in South America and Europe. The plant is also found in parts of the U.S., including California, Arizona, Texas, and Florida. As any long term resident in Darwin can attest, it takes over and forms dense thickets that crowd out all native vegetation. In urban areas, it is an especially unwanted species, growing along arid roadsides, in carparks, and on abandoned land. Further this species is susceptible to insect infestations particularly by psyllids. It is considered unsuitable for urban planting because of its tendency for up to 80 % to get uprooted in rain and wind. This weed produces vast quantities of seed which usually falls close to the parent plant hence facilitation the development of thickets that outcompete native vegetation with the resultant decrease of biodiversity.

Problems such as caused through ill-considered and deliberate introduction of fodder plants like Coffee Bush demonstrate that advice by agricultural authorities and the associated pastoral industrial machinery cannot be trusted. Consider the problems that Buffel grass and Gamba Grass have created, the two species that are now killing biodiversity across the Northern Territory. The lesson that we should have learned by now is that our interventions with nature must be strictly based on the science of ecology and not on the desire by landholders to increase their profit margins. We can no longer afford to compromise the health of nature, the basis for our own existence.

10. <u>Antigonon leptopus (Coral Vine)</u>

CL F: all year Ft: all year
Habitat: Monsoon forests Chart: 8.10
Family: Polygonaceae

Notes: This perennial semi-deciduous vine with prolific pink or white flowers and heart shaped leaves is native to Mexico. The attractive flowers are borne in panicles and attract bees. The vine forms underground tubers and large rootstocks. It is a prolific seed producer with the seeds readily float on water. The fruit and seeds are eaten and dispersed by a wide range of mammals and birds. The tubers will resprout if the plant is cut back.

11. <u>Eulophia graminea (Exotic Ground Orchid)</u>

OR F: Jan - Mar Ft:
Habitat: mulched areas Chart: 8.11
Family: Orchidaceae

Notes: A species of orchid native to Asia developing a pseudobulb mostly on wood-chipped mulched areas. Flowers are green-brown with some pink. They are easily removed by hand pulling especially from mulched areas.

12. <u>Sida cordifolia (Flannel Weed)</u>

SH F: Dec - May Ft: Dec - May
Habitat: in disturbed areas Chart: 8.12
Family: Malvaceae

Notes: Native to India this plant has spread throughout the world and is classified as a Class B invasive weed in Northern Australia. The name cordifolia refers to the heartshaped leaf. S. cordifolia grows to 40 – 200 cm tall, with the entire plant covered with soft white felt-like hair that is refers to its common name, "Flannel Weed". It invades cultivated and overgrazed fields, competing with more desired species and contaminating hay. The plant has a few medicinal applications. The awned seeds develop from yellow flowers and are spread by adhering to clothing, livestock or mud as well as contaminants in hay and seed crops. Control is by hand pulling, grubbing and slashing as well as by foliar spray.

13. Panicum maximum or Megathyrsus maximus (Guinea Grass)

GR F: Feb - Oct Ft: Mar - Nov
Habitat: low lying areas, near creeks and along roads Chart: 8.13
Family: Poaceae

Note: This is a dense shallow rooted tussock forming perennial grass that grows to 3 m tall and produces a vast quantity of seed which can be dispersed by water. A native of Africa it is now widespread throughout the tropics and has been introduced to Australia as a fodder plant. It forms dense stands that suppress early flowering native grasses and contributes to increased fuel loads. Hairs on its lower stems can cause skin irritation and it has been reported to be toxic to sheep. The recommended control is by hand pulling and slashing as well as foliar spray.

14. Hyptis suaveolens (Hyptis)

SH F: Feb - Aug Ft: Feb - Aug
Habitat: roadsides, watercourses, pastures and open forest Chart: 8.14
Family: Lamiaceae (mint family)

Notes: A declared Class B weed it was first recorded in 1845 by explorer Leichardt and now widespread in the Northern Territory. An annual shrub or woody herb native to Central America it prefers overgrazed and other disturbed areas growing to thickets to 1 – 1.5 m height on most soils except waterlogged soils. The leaves have a mint like appearance with small lavender-blue colors growing in the leaf joints. Typically they have a strong minty smell when crushed. Tbe small seeds stay in the spined capsule and can be transported by lifestock, animals and clothing, The seed float in water but can also contaminate hay. In the garden this weed can easily be controlled by hand pulling preferably prior to seed development.

15. Rottboellia chochinchinensis (Itch Grass)

GR F: Jan - Sep Ft: Feb - Oct
Habitat: Open forest, riverine and disturbed areas Chart: 8.15
Family: Poaceae

Notes: Native to tropical Asia and Africa, this is an erect and tall, tufted annual grass whose stems grow up to 300 centimeters in height with leaf-blades of up to 45 centimeters in length. The common name Itchgrass comes from the bristly leaf-sheath which can be irritating to the skin. The species can be found in a diverse array of habitats including grassland and marginal land, as well as being a major weed of perennial and rotation crops across the tropics. They are dispersed by floodwater, birds, small mammals and latterly by humans and vehicles. The eliastome (callus knob) which is disseminated with the caryopsis, contains oils which may attract ants and aid dispersal.

16. Lantana camara (Lantana)

SH F: all year Ft: all year
Habitat: wide range but prefers richer soils Chart: 8.16
Family: Verbenaceae

Notes: Although classified as a Class B weed of national significance native to the Americas there are only a few small infestations in the Darwin area. It thrives in disturbed areas and has a potential to become a dominant spreading understorey plant and growing to 2 - 4 m height. Lantana is allelopathic, meaning it can release chemicals into the soil which suppress native species. Leaves and seeds are toxic even potentially lethal to many animals. The opposite mint-like leaves emit a pungent odor when crushed while flowers can vary between pink, orange, yellow, purple and red. The main dispersal agent are frugivorous birds that eat the fruit and void the seeds. Such birds have a short gut transition times and do not digest the seeds, Flower color is variable. Control is by hand pulling, grubbing and slashing.

17. Lantana montevidensis (Lantana)

SH F: all year Ft: all year
Habitat: wide range of soil Chart: 8.17
Family: Verbenaceae

Notes: Lantana montevidensis is a creeping low shrub with small strongly scented flowering and oval-shaped green leaves. With support it can also grow as a climbing 'vine' form. The inflorescence is a circular head of several purple to lavender to white funnel-shaped flowers with lobed corollas each nearly a centimeter wide. The plant is well recognized worldwide as a garden and landscape plant, and in some areas, such as parts of Australia also a noxious weed and invasive species. Like L. camara it is toxic to livestock.

18. Cenchrus polystachios (Perennial Mission Grass)

GR F: Mar - Jun Ft: Apr - Jul
Habitat: Creek and swamp margins, roadsides, degraded pastures Chart: 8.18
Family: Poaceae

Notes: Perennial Mission Grass is a deep-rooted tussocking declared Class B noxious weed native to tropical Africa. First noticed as a naturalized grass in the NT in the 1970's it has since spread widely through the Darwin area and along many roads. Because it remains green well into the late dry season it potentially provides fuel (3 - 5 times compared to natural fuel loads) for hot burns at the end of the dry. It then exerts further dominance over native grasses by repeated burns. Infestions result in displacement of native vegetation in most cases. Mechanical control is by repeated slashing or mowing before it seeds and hand pulling for smaller infestations. The light and fluffy seeds are easily spread by wind, vehicles, animals and hay mulch. Burning is known to accelerate its spread and for this it has turned into a serious threat to biodiversity across vast landscapes in the Top End.

19. Azadirachta indica (Neem)

TR F: Jul - Sep Ft: Oct - Nov
Habitat: Settlements, monsoon vine forests and riverbanks Chart: 8.19
Family: Meliaceae

Notes: Native to Myanmar, India and China, this tree grows to a height of 15 m and displays sprays of white honey scented flowers. It has recently been declared Class B weed and has a statuary weed management plan. It is illegal to buy, sell or transport Neem plants in the NT. While the removal of mature trees in gardens and landholdings is not actively enforced, removal is encouraged and seedling must be destroyed to prevent further spread, Unfortunately after deliberate introduction into the NT the Neem tree has now proliferated in many creek and drainage systems particularly in the Katherine District south of Darwin and remains a common garden plant in Darwin. Its deep tap roots have a preference for wet systems which allows it to easily invade and eventually dominates riparian systems from where it is difficult to dislodge. It produces a prolific amount of seed of up to 50,000 seeds per tree which is readily dispersing by bats and birds which eat the fruit. Such fruit-eating birds commonly include Blue-faced Honeyeaters, friarbirds and bowerbirds which eat the fruit and dispel friable seeds in their droppings. Although fire kills seedlings and saplings, trees above 2 m height cope with moderate intensity savannah fires. The tree also produces suckers regenerating from roots which leads to the development of dense stands and requires follow-up control measures. A. indica is easily recognizable by its toothed leaf edges, opposite leaf arrangement, clustered white flowers and rough brown bark. The recommended control is by hand pulling, grubbing and felling.

20. Annona glabra (Pond Apple)

TR F: Oct - Mar Ft: Jan - Apr
Habitat: all wet areas Chart: 8.20
Family: Annonaceae

Notes: Pond Apple is a weed of national significant and is a declared Class A weed in the NT. A semi-deciduous trees native to the swamplands of America and Africa it has been found in small sporadic outbreaks in Darwin and surrounding rural areas. Pond Apple has the potential to invade all Top End waterways creating dense stands that compete with native vegetation and changing habitat for fauna by displacing food plants. This species can quietly establish in undisturbed areas and are difficult to displace. Growing to 3 - 6 m height they have white to light yellow flowers and a distinct custard apple look-alike edible fruit. Seeds germinate around the parent plant and form thickets over time. Some animals eat the seeds and so facilitate the plants wider dispersal. Control methods are hand pulling, grubbing, felling and chemical treatments including stem injection.

21. Cryptostegia grandiflora (Rubber Vine)

Vine F: Feb - May Ft: Apr - Jun
Habitat: Fringing riparian Chart: 8.21
Family: Apocynaceae

Notes: A vigorous vine recognizable by distinct pairs of right angled pods that contain seeds and a display of tufts of white silky hairs. There are some infestations near the NT/Queensland borders as well as in Western Australia. It has the potential to severely affect native vegetation and ecosystems primarily by invading riparian systems. The plant strangles native vegetation and is poisonous to livestock. A multistemmed woody vine it is capable to reach up to 30 m high into the tree canopy. Flowers are white on the outside and purplish on the inside. Seeds are large pods that grow mostly in pairs. If you think you have seen this plant on your property don't attempt to control it but contact the Weeds department immediately. Seed is dispersed by wind and water as well as with vehicles, machinery and stock. Control treatment is by foliar spray.

22. Senna obtusifolia (Sickle Pod)

CL F: Feb - Aug Ft: Feb - Aug
Habitat: Drainage channels Chart: 8.22
Family: Fabaceae

Notes: An annual or short-lived perennial shrub growing to a height of 2 m height it has distinct leaflets of usually 3 opposite leaves and yellow flowers and is a native of the Caribbean that competes with and displaces native plants. It develops large seed reserves in the soil which can germinate at any time of the year given the right signals. It is easily recognized by its long sickle shaped pods that contain dark brown flattened seeds. Dispersal is many by adhesion to mud, vehicles and animal hooves.

23. Stachytarpheta sp (Snake Weed)

SH F: all year Ft: all year
Habitat: creek lines and monsoon forest Chart: 8.23
Family: Verbenaceae

Notes: Stachytarpheta is a plant genus in the verbena family (Verbenaceae) of generally perennial shrubs growing to 2 m height and have opposite leaves. The flowers are rich in nectar and popular with many butterflies mainly attracted to the nectar of their flowers.

24. Sida acuta (Spinyhead Sida)

SH F: Apr - Sep Ft: Apr - Sep
Habitat: In disturbed areas and human settlements Chart: 8.24
Family: Malvaceae

Notes: Thought to originate in Central America but now firmly established in the tropics, Sida acuta is considered an invasive species in Northern Australia. The beetle Calligrapha pantherina has been introduced as a biological control agent in an attempt to control the plant. Growing as a small shrub with alternate acute leaves it displays small axillary yellow flowers. The awned seeds adhere to clothing, livestock and mud on vehicles and as contaminants in hay as it means of wider dispersion. Control is through a variety of mechanical, chemical and biological means.

25. Cenchrus pedilatus (Annual Mission Grass)

GR F: Apr - Jun Ft: May - Jul
Habitat: disturbed areas, roadsides and wet margins Chart: 8.25
Family: Poaceae

Notes: Annual Mission Grass unlike the perennial species has not been declared as a noxious weed in the NT but is recommended to be treated at the same time where they occur together. It readily competes with and displaces native grass species and by expanding rapidly it now poses a serious threat to biodiversity in the northern third of the Northern Territory. Native to Africa. The tussocking annual Mission Grass can be controlled by slashing prior to seeding and will generally not persist into the following year although repeated slashing may be required to rid of residual seed banks. The light and fluffy seeds are readily dispersed by wind and adhere to fur and clothing. They also float on water and spread as a contaminant in hay. Control treatments consist of hand pulling, grubbing, slashing and foliar spray.

26. Andropogon gayanus (Gamba Grass)

GR F: Apr Ft: May - Aug
Habitat: Creeklines, floodplain margins, roadsides and pastures Chart: 8.26
Family: Poaceae (grass family)

Notes: In the NT Gamba is classified as a Class A weed except in areas where it is deemed to be a Class B weed such as for the Greater Darwin Area. Class A areas require eradication while in Class B areas the weed is to be controlled and its spread prevented. As a landowner you are legally required to control it according to the Weed Management Plan 2020-2030. Gamba originates from Africa and was deliberately introduced into the NT in the 1930's as a pasture species. It needs at least 600 mm of rainfall annually and grows up to 4 m high as wide shallow rooted tussocks on any soil types except heavy clays. Gamba is a very invasive weed and generates high fuel loads with resulting uncontrollable hot fires that destroy native vegetation including large trees and animal habitat. It is easily recognizable from other similar grasses by its distinctive white midrib except from Itch Grass which also has a white midrib but lack the furry white hairs on stems and leaves. Gamba stays green long after native grasses have died back. Seeds are produced at the end of the dry season and are readily carried by wind, animals, vehicles and people. Vehicles and machinery that are traveling over infested areas must be thoroughly cleaned before leaving the infested area. While flowering and seed production of the weed occurs between April and August germination is during November to February in the wet season. The best time period for various control option is between December and May as outlined in the published Gamba Management Guideline and Weed Management Plan 2020-2030. In smaller urban gardens the most direct action as for most other weeds is mechanical removal by pulling of the entire plant including roots as soon as they germinate and before seed development. The main control methods are by grubbing and slashing as well as foliar spray.

27. Passiflora foetida (Wild Passionfruit)

CL F: all year Ft: all year
Habitat: can occur in most habitats including coastal dunes Chart: 8.27
Family: Passifloraceae

Notes: Native to the tropics of America the plant has been introduced to the tropics around the world. A perennial creeping vine it is popular for its fruit but has proven to be very invasive particularly in moist areas. While the yellow-orange fruits can be eaten raw, when green they are highly toxic. The seeds are eaten and dispersed by birds. Wild Passionfruit flowers provide nectar and attract a range of pollinators. While the leaves are considered toxic to stock due to high levels of cyanide, young leaves and plant tips are reportedly edible.

28. Spathodea campanulata (African Tulip Tree)

TR F: May - Aug Ft: Jul - Sep
Habitat: Monsoon Forest and Mangrove margins Chart: 8.28
Family: Bignoniacae

Notes: This tree grows to 20 m with spectacular scarlet flowers. It readily escapes from gardens and naturalizes in the wild. The woody fruit is poisonous. Birds are attracted to large amounts of nectar.

29. Caryota mitis (Clustered Fishtail Palm)

PA F: Ft:
Habitat: Rainforest Chart 8.29
Family: Arecaceae

Notes: This popular palm is long-lived and capable of flowering on each stem. When the stem dies it is replaced by new suckers from the base. The birds spread the fruit into surrounding gardens and bushland where it readily germinates in wet areas where it has very few natural adversaries.

30. Cassia fistula (Golden Rain Tree)

TR F: Jul - Feb Ft: Jan - Apr
Habitat: Monsoon forest Chart: 8.30
Family: Fabaceae

Notes: Native to south-east Asia this tree grows to 8 m height and produces masses of clustered yellow flowers followed by an abundance of seeds carried in brown pods. The seeds are spread by birds and germinate wherever they are dropped. This is a highly invasive plant.

31. Delonix regia (Poinciana, Flame Tree)

TR F: Nov - Dec Ft: Jan - Mar
Habitat: Monsoon forests Chart: 8.31
Family: Fabaceae

Notes: Originating from Madagascar this large deciduous tree grows to about 15 m high and can be found in many places in Darwin due to past popularity. Its intense red flowers appear with young leaves and produces large long seed pods. The tree is highly invasive as the seeds are attractive to birds and germinate wherever they fall.

32. Thunbergia grandiflora (Blue Trumpet Vine)

CL F: all year Ft: all year
Habitat: along watercourses Chart: 8.32
Family: Acanthaceae

Notes: Fast growing and vigorous evergreen creeper that may reach up to 15 m height it is popular for its drooping clusters of large blue to violet flowers. It develops viable seeds that are spread into bushland by birds.

Concluding the chapter on the kingdom of plants, we turn to the next kingdom of life that of the fungi. Fungi were once considered a part of the plant kingdom but after much research in the last two centuries they are now in their own kingdom. Technically defined, fungi are eukaryotic organisms—that is, they consist of cells that contain membrane-bound nuclei, as do plants and animals. Scientists believe that fungi, plants, and animals once shared common ancestors, and all were grouped into the same kingdom: Eukaryota. Although they are related, these three types of organisms have enough distinct differences that each is now placed in its own kingdom. Fungi, commonly known as mushrooms are unable to extract carbondioxide from the air because their cells do not contain chlorophyll and so are neither plants or animals. They are ecologically important because without fungi there simply would be no or very few plants. Amazingly, we simply don't know much about them especially in the Northern Territory, actually next to nothing here. Yet, in order to establish healthy self sustaining gardens and plants we depend on the presence of fungi in the soil especially those of the mycorrhizal variety. While we may take fungis for granted the right type of fungi is needed to interact with specific plants in your garden but these may be absent for a whole array of reasons thus leading to poor growth and failures of healthy establishment of plants.

FUNGI

"Without the higher fungi, live on earth as is would cease"

Almost everyone has seen mushrooms popping up in Darwin's gardens, parks and reserves and perhaps knows that they mostly appear early in the wet season, with each mushroom lasting for a short time before rotting away to a sloppy mess. Typically, there's a stem, a cap and gills under the cap. However unknown to most there is a mostly invisible body, also organisms that don't really look like fungi but are and many microfungi that completely remain out of our sights. When you look at a mushroom growing out of the ground, you are looking at just part of a fungus - not the whole organism. The vast biomass of this organism is underground and consists of a network of microscopically thin "threads" which spread through the soil. An individual thread is called a hypha and the network of hyphae is called a mycelium. The mycelium is there throughout the year, feeding and expanding. The mycelium is referred to as the vegetative part of the fungus. Because the world of fungi are so crucially important to the sustainability of plants and thus all of life, in this text you find a more detailed introduction relevant to ecological gardening.

The discipline of biology devoted to the study of fungi is known as mycology (from the Greek 'mykes', 'mushroom'). The English word fungus is directly adopted from the Latin fungus (mushroom), used in the writings of Horace and Pliny. This latin word in turn is derived from the Greek word sphongos meaning sponge, which refers to the macroscopic structures and morphology of mushrooms and molds: the root is also used in other languages, such as the German "Schwamm" meaning sponge and "Schimmel" meaning mould. Fungi appear to have emerged around one billion years ago (around the start of the Neoproterozoic Era).

A fungus (plural: fungi or funguses) is any member of the group of eukaryotic organisms (whose cells have a nucleus enclosed within a nuclear envelope) and so includes microorganisms such as yeasts and molds, as well as the more familiar mushrooms. The macrofungi are those that produce the easily visible fruiting bodies such as mushrooms, puffballs, polypores and so on - while the microfungi are the molds, plant rusts, smuts, mildews and some others. More numerous than macrofungi, the microfungi species too are exceedingly important from the ecological angle. A characteristic that places fungi in a different kingdom from plants, bacteria, and some protists is chitin in their cell walls which is composed of glucans and chitin. Glucans are also found in plants and chitin in the exoskeleton of arthropods. Fungi are the only organisms that combine these two structural molecules in their cell wall. Unlike those of plants, fungal cell walls do not contain cellulose. Fungi, like animals, acquire their food by absorbing dissolved molecules, but unlike animals they typically do this by secreting digestive enzymes into their environment. Fungi do not photosynthesize. In the soil they are mobile through growth and in water and air also through spores in the air mostly transported by wind. Dry or hydrophobic spores do not absorb water and so are readily scattered by raindrops for example. In a mushroom, the spores are produced on the gills that are on the underside of the cap from where they are released, falling down under the force of gravity and are then carried away by air breezes. Mushroom spores are tiny, typically less than a hundredth of a millimeter long, and so are easily dispersed by even the slightest of breezes. The role of the mushroom stalk is to raise the cap above the grass, twigs or stones that are close to the ground. If the cap is raised a suitable distance, the spores released from the gills have a good chance of being carried away a substantial distance - rather than getting trapped by obstacles such as the grass, twigs or stones mentioned above. Fungi manifest as symbionts of plants, animals, or other fungi and also as parasites. Most fungi grow as hyphae, which are cylindrical, thread-like structures 2–10 µm in diameter and up to several centimeters in length. Hyphae grow at their tips (apices); new hyphae are typically formed by emergence of new tips along existing hyphae by a process called branching. Hyphae also sometimes fuse when they come into contact, a process called hyphal fusion (or anastomosis). These growth processes lead to the development of a mycelium, an interconnected network of hyphae. There is no photosynthesizing green pigment (chlorophyll) in the mycelium, so the organism doesn't make it's own food (as plants do). The hyphae cannot swallow food fragments (as animals do). Rather, enzymes are secreted from the tips of the hyphae in the mycelium and these enzymes break down the complex molecules found in organic matter in the soil, into smaller molecules, which are then absorbed through the hyphal walls near the growing tips. As the mycelium exhausts its food supply it grows outward, seeking more food sources. There is little point in maintaining the inner mycelium, since the food in that area has been exhausted. Therefore the inner mycelium dies, with the organism extracting from there whatever nutrients it can re-use and transporting those outward. Thus the mycelium does not expand as a circle but as a ring, with most of the activity near the ring's outer edge. Not surprisingly, mushrooms often appear to grow in a ring, the so-called fairy ring, that reflects the underground mycelial presence.

Ecological significance of fungi:

Fungi are the principal decomposers in ecological systems, and therefore are the cornerstone in the self-sustainable ecological garden for wildlife. As such they perform an essential role in the decomposition of organic matter and so have a fundamental role in nutrient cycling and nutrient exchange in the environment. They do this as an enormously diverse group with many manifestations such as saprobes (fungi that feed on dead tissues), parasites (fungi that feed on animals, living plants and other organisms) and mutualistic symbionts of algae, animals and plants. Although little is known of the true biodiversity of Kingdom Fungi, which has been estimated at 2.2 million to 3.8 million species, about 148,000 have been described, with over 8,000 species known to be detrimental to some plants and at least 300 that can be pathogenic to humans. The number of new fungi species discovered yearly has increased from 1,000 to 1,500 per year about 10 years ago, to about 2000 with a peak of more than 2,500 species in 2016. In the year 2019, 1882 new species of fungi were described but it is estimated that more than 90% of fungi remain unknown. Where plants produce and animals consume, the fungi recycle, and as such they ensure the sustainability of the all of life in its current form. Despite their vital importance to life little is known about fungi in Australia. The total number of fungi in Australia, including those not yet discovered has been estimated around 250,000 species, including about 5,000 mushrooms with only roughly 5 % of fungi being described.

While there is no single fungal lifestyle, one thing common to all fungi is that (unlike the green plants, for example) they do not make their own food. Fungi get their nutrients from existing organic matter and there are many sources of organic matter in the world, leaf litter, dung, soil, animals, dead wood, living plants and more. Fungi use them all. A fungus that feeds on dead organic matter is a saprotroph. Fungi that get their nutrients from living organisms do so in a variety of ways but can be put into two broad categories. Where there is no benefit to the other organism, the fungus in question is a parasite. If there is some benefit to both the fungus and the other organism, the fungi are mutualistic. Note that in mutualistic associations, the benefits need not be equally shared. You will often see the word symbiotic used to describe associations between different organisms and that word literally means "living together". It’s a general term covering all types of associations, with no implication about the nature of the association. Hence, parasitic and mutualistic are two examples of symbiotic associations. Agaricus is a common genus of saprotrophic fungi. The ordinary Field Mushrooms belong to this genus and you will often see various Agaricus species growing in gardens, parks and paddocks. In such situations the mycelium is feeding on dead organic matter in the ground. Commercially, Agaricus is grown on composted plant material.

There are several systems to describe fungi, one of the more popular being by type of form of their fruiting body commonly known as mushrooms. These forms include disc and cup fungi (the fertile layer or hymenium is in a disc-like fruit-body with the disc may or may not be supported by a stipe), club and antlerfungi (their hymenium is on the outside of a club-like fruit-body), crust and cushion fungi, flask fungi, honeycomb, brain and convoluted fungi and pin fungi. More generally however, fungi are divided into two groups related to their size, they either belong to Micromycetes (microscopic) or Macromycetes also known as macrofungi or mushrooms. Most of the Macromycetes have the visible fruiting body (commonly known as mushroom) also called sporophore that carries the fertile hymenium. Upon maturity, the hymenium releases the spores in their thousands. Spores are a common method of reproduction in the fungi, but they are tiny and not the same as seeds in plants although performing the same function. They are around 1/200 th of the size of a 2 mm pinhead or 10 micrometers. In the right conditions the spores germinate and produce a complex network of underground threads, known as the mycelium. Its individual mycelial filaments are known as hyphae and when fusing at opportune times produce a new fruiting body to complete the life cycle of the fungus.

Fungal mycelia can become visible to the naked eye, for example, on various surfaces and substrates, such as damp walls and spoiled food, where they are commonly called moulds. Fungi cultivated on solid agar media in laboratory petri dishes are usually referred to as colonies. These colonies can exhibit growth shapes and colors (due to spores or pigmentation) that can be used as diagnostic features in the identification of species or groups. Some individual fungal colonies can reach extraordinary dimensions and ages as in the case of a clonal colony of Armillaria solidipes, which extends over an area of more than 900 ha (3.5 square miles), with an estimated age of nearly 9,000 years

Symbiotic fungi:

Symbiosis is defined broadly as “two or more organisms living together” usually with both partners benefiting. Fossil evidence shows that plants have symbiotic relationships with fungi since they first colonized land in the early Paleozoic, and these associations seem to have changed very little in the hundreds of millions of years since roots evolved. In fact it is now hypothesized that roots gradually evolved from rhizomes to provide more suitable habitats for mycorrhizal fungi and balance the increased needs for water and nutrients of large plants with leaves.

Most fungi contribute to maintaining the biological balance of nature by using their many enzymes to break down organic matter in the soil or dead plant matter. Others such as parasitic fungi develop at the expense of living trees. Symbiotic fungi are particularly vital in Australia to help trees to assimilate minerals as well as water in the soil by means of mycelial filaments intertwining with the roots of young trees. The tree produces organic matter that promotes the growth of the fungus in return. Most forest-dwelling mushrooms form such mycorrhiza.

Although often inconspicuous, fungi occur in every environment on earth and along with bacteria are the major decomposers in most terrestrial (and some aquatic) ecosystems. They therefore play a critical role in biogeochemical cycles and in many food webs. As decomposers they cycle nutrients and degrade organic matter to inorganic molecules, which can then re-enter anabolic metabolic pathways in plants or other organisms. Mycorrhizal symbiosis between plants and fungi is one of the most well-known plant to fungus associations and is of significant importance for plant growth and persistence in many ecosystems. Indeed over 90% of all plant species engage in mycorrhizal relationships with fungi and are dependent upon this relationship for survival. In many of these associations between 10% and 30% of the food produced by the plant moves through to the fungi. In a mycorrhizal association the fungal hyphae of an underground mycelium are in contact with plant roots, but without the fungus parasitizing the plant. Through photosynthesis a chlorophyll-containing plant makes simple carbohydrates (using carbon dioxide, water and sunlight) and transfers some of it to the fungi while the associated fungal mycelia are adept at extracting minerals, especially nitrogen and phosphorus from the soil and these pass through to the plants in return. In addition mycorrhizal fungi can also protect plants against pathogenic fungi and micro-organisms. All in all, mycorrhizal fungi are very important for plant health. The eucalypts, almost synonymous with Australia, are mycorrhizal, as are other genera in the same family (the Myrtaceae) - for example, Kunzea, Leptospermum and Melaleuca. Outside the Myrtaceae the genera Acacia and Casuarina are further examples of common mycorrhizal genera. The mycorrhizal symbiosis is ancient, dating back to at least 400 million years. Later the super continent Gondwanaland is thought to have begun to break apart and drift north about 125 million years ago. Fossil records of plants containing arbuscular mycorrhizal (AM) fungi like structures have occurred then. In general, population of AM fungi is higher in cultivated soil compared to virgin soil. They are mostly seen in the top 15-30 cm of soil and their numbers decrease markedly below the top 15 cm. They are normally not found in depths beyond the normal root range of plants. They like other mycorrhizal fungi often increase the plant's uptake of inorganic compounds, such as nitrate and phosphate from soils having low concentrations of these key plant nutrients. The fungal partners may also mediate plant-to-plant transfer of carbohydrates and other nutrients. Some fungal species inhabit the tissues inside roots, stems, and leaves, in which case they are called endophytes. Similar to mycorrhiza, endophytic colonization by fungi may benefit both symbionts; for example, endophytes of grasses impart to their host increased resistance to herbivores and other environmental stresses and receive food and shelter from the plant in return. In vesicular-arbuscular mycorrhizas (or VA mycorrhizas) the fungal hyphae penetrate root cells and form intricately branched, shrub-like arbuscles within the cells and, at times, bladder-like vesicles as well. These associations are often called just arbuscular mycorrhizas, since not all the fungi that are involved form vesicles. They are the most abundant type of mycorrhiza and the most ancient. The hyphae of ectomycorrhizal fungi form a mantle around the root and also grow into the spaces between root cells - but do not penetrate the root cells. The hyphae form a net-like covering, called a Hartig net, around the cells. While the VA mycorrhizas are the most abundant, no more than a few hundred species of fungi are involved, whereas over 6,000 species of fungi are involved in ectomycorrhizas. Many of the world’s dominant forest trees form ectomycorrhizas and the ectomycorrhizal fungi produce many of the commonly seen fungal fruiting bodies in Australian forests or gardens. Though a great many Australian plants form mycorrhizas, especially VA mycorrhizas, there are some noteworthy exceptions. For example, many genera in the

Proteaceae (which includes the widespread genera Banksia, Grevillea and Hakea) do not form mycorrhizas. Even in artificial conditions, when attempts are made to force mycorrhizas these genera seem to actively resist mycorrhizal formation. The fungi that form mycorrhizas are quite varied. Ectomycorrhizal fungi produce many of the easily seen fruiting bodies that you commonly come across. Many of the VA mycorrhizal fungi do not produce fruiting bodies, the spores often being produced on hyphae in the soil near plant roots. Where fruiting bodies are formed they are usually more-or-less spherical in shape and truffle-like, in that they are hidden in the soil or leaf litter. Many fruiting bodies are small, only a millimeter or so in diameter, though some can get to a couple of centimeters or more in diameter.

Considering the nutrient poor soils in most of Darwins backyard plots, specifically the lack of phosphor and nitrates, the presence of the right type of fungi is crucially important for the successful growth of most plants. The process of clearing for residential development often removes the top soil layer that contains most of the fungi of the original vegetation layer. We can perhaps assume most residential soils to be poor in mycorrhizal fungi thus further constraining the establishment of vegetation. The chapter on gardening will suggest a few techniques to inoculate your gardens with the right fungi.

Fungi as pathogens and food:

Some fungi can be used as biological pesticides to control weeds, plant diseases and insect pests. They tend to be species which produce bioactive compounds called mycotoxins, such as alkaloids and polyketides, that are also toxic to animals including humans. Other pathological fungi can cause serious diseases in humans, several of which may be fatal if untreated. These include aspergillosis, candidiasis, coccidioidomycosis, cryptococcosis, histoplasmosis, mycetomas, and paracoccidioidomycosis. Persons with immuno-deficiencies are particularly susceptible to disease by genera such as Aspergillus, Candida, Cryptoccocus, Histoplasma, and Pneumocystis. Other fungi can attack eyes, nails, hair, and especially skin, the so-called dermatophytic and keratinophilic fungi, and cause local infections such as ringworm and athlete's foot. Fungal spores are also a cause of allergies, and fungi from different taxonomic groups can evoke allergic reactions. Many fungi produce biologically active compounds, several of which are toxic to animals or plants and are therefore called mycotoxins. Of particular relevance to humans particularly during Darwin's wetseason are mycotoxins produced by molds causing food spoilage as well as poisonous mushrooms commonly labelled as toadstools. Other notable mycotoxins include the aflatoxins, which are insidious liver toxins and highly carcinogenic metabolites produced by certain Aspergillus species often found growing in or on grains. While there are many fungal parasites on humans, the bulk of them are microfungi. Thrush, ringworm and athlete’s foot are three commonly known examples of such infections. However many macro mushroom species are also poisonous to humans and cause a range of reactions including slight digestive problems, allergic reactions, hallucinations, severe organ failure, and death. Genera with mushrooms containing deadly toxins include Conocybe, Galerina, Lepiota, and, the most infamous, Amanita. The latter genus includes the destroying angel (A. virosa) and the death cap (A. phalloides), the most common cause of deadly mushroom poisoning. The false morel (Gyromitra esculenta) is occasionally considered a delicacy when cooked, yet can be highly toxic when eaten raw. Fly agaric mushrooms (Amanita muscaria) also cause occasional non-fatal poisonings, mostly as a result of ingestion for its hallucinogenic properties. Some macrofungi have also been found in humans. Schizophyllum commune is a cosmopolitan species, found on dead wood of many plant species as well as on mulched gardenbeds in Darwin and, for most of the time, gets along with its decaying of wood and doesn't bother humans. However, the Schizophyllum mycelium has been found in humans, especially those with an imperfect immune system – such as HIV patients and those given immuno-suppressive drugs. In at least one case the actual fruiting bodies of Schizophyllum commune were found growing in the sinuses of a patient. The species appears to be an opportunistic human pathogen and, given the chance, will infect humans but in the great majority of cases human immune systems easily keep the fungus out. The mycelium of Coprinus cinereus, has also been found within the human body. Ordinarily this is a saprotrophic species that produces medium-sized greyish mushrooms as fruiting bodies. Both of these species are examples of the ability to move from one behaviour to another. Are you worried? There is no escape from becoming infected because microbes such as bacteria, pollen, spores, viruses and others weave trough the air everywhere, some sources say 100 million of cells for every cubicmeter of air. However research demonstrated that spending time in the garden everyday and so getting regular exposure to microbes will build resistance and so strengthen your immune system the natural way. In other words your immune system get stronger through exposure and weakens by avoidance of microbes through excessive hygiene and may not be able to overcome a pathogen when exposed to it in a weakened state brought on by a chronic lack of exposure. Vaccinations and excessive sterilisation are a double edged sword. While such measures often work they also make one weaker in the long run. Considering fungi as a source of food we find that many mushrooms have antibiotic chemistry and stimulate the immune system. However of the staggering number of fungal species only 30 species are widely accepted as food despite numerous species of mushrooms to be known as therapeutic and nutritious. Mushrooms as a food are rich in minerals, low in fat, high in protein, and low in calories. They help prevent disease and are anti-inflammatory. They facilitate wound healing and may provide protection from cancer. The fact that about 95 percent of all cultivated mushrooms are saprobic and can be relatively easily cultivated on various dead organic materials such as straw, wood, and wastepaper in the backyard garden is not widely known. To me it appears strange why mushrooms are not more widely grown, perhaps this is due to our mental conception and lack of know-how arising from generations growing up on addictive and heavily advertised take-aways and 'easy-to-get' cheap manufactured foods from the supermarkets. This was not always so. The human use of fungi for food preparation or preservation and other purposes is extensive and has a long history. I remember spending a good part of my childhood roaming the forests around my home village in Germany for mushrooms and blueberries. This is common and legal there and then. Gathering mushrooms in the Northern Territory may be illegal on public land as far as I know and in any case it is not advisable unless you are 200 % certain your collection is edible. There is insufficient reliable local knowledge of what is edible and what is not in the NT, so I stick to what is on offer in the local supermarket mostly white and swiss brown button mushrooms, shiitake and oyster mushroom.

Around fifty saprobic mushrooms are cultivated in China but only eight of these make up the lion's share of the market worldwide: the button mushroom (*Agaricus bisporus* and *A. bitorquis*), shiitake (*Lentinula edodes*), oyster mushroom (*Pleurotus* spp.), wood ear (*Auricularia* spp.), straw mushroom (*Volvariella volvacea*), enokitake (*Flammulina velutipes*), white jelly fungus (*Tremella fuciformis*), and nameko (*Pholiota nameko*). The other cultivated saprobic mushrooms are consumed in relatively small quantities, although locally they can be very important. For example, *Hypsizygus marmoreus*, *Hericium* aff. *Erinaceus*, and *Grifola frondosa* are important in East Asian countries, and *Stropharia rugosoannulata* is eaten widely in Germany, Hungary, and Poland. Many other saprobic mushrooms are not cultivated at all, and supplies of many are restricted to what can be collected from nature.

Mushroom farming and mushroom gathering are large industries in many other countries. The study of the historical uses and sociological impact of fungi is known as ethnomycology. Because of the capacity of this group to produce an enormous range of natural products with anti-microbial or other biological activities, many species have long been used or are being developed for industrial production of antibiotics, vitamins, and anti-cancer and cholesterol-lowering drugs. More recently, methods have been developed for genetic engineering of fungi, enabling metabolic engineering of fungal species. For example, genetic modification of yeast species which are easy to grow at fast rates in large fermentation vessels, has opened up ways of pharmaceutical production that are potentially more efficient than production by the original source organisms.

Fungi habitats:

Fungi show a wide range of behaviors and interactions. There are numerous interactions, both between different species of fungi and also between fungi and other organisms. Over time there may be a change in the species present in any area. Certain species are quick colonizers of disturbed areas – but are then replaced by others. Some species develop rapidly, reproduce quickly and then die whereas others are longer lived. Then there are those which are found in limited habitats whereas others can turn up almost anywhere. Fungi can be found growing on all sorts of organic matter. Just as plants have preferences for the soils they grow in, so fungi have likes and dislikes. For example, ammonia is toxic to many fungi but there are species that can tolerate relatively high levels of ammonia. You can find such species growing near old carcasses, since a rotting carcass releases ammonia into the underlying soil. Until that carcass has rotted away and the ammonia levels dropped, the ammonia-tolerant fungi will be favored. Numerous fungi grow on dung and nowhere else. What was said about wood can also be said about dung. Dung from herbivores is different to dung from carnivores. The fungi found on fresh dung are quite different to the fungi found on old dung. Herbivore dung seems to be a lot more interesting to fungi as it supports a wide variety of Coprophilous fungi. The word 'coprophilous' literally means "dung loving". There are also various mushroom-producing coprophilous species – especially in the genera Coprinus, Panaeolus and Psilocybe. If you incubate a dung sample and observe it for many weeks you will see a sequence of fruiting bodies appearing on it. Some people may refer to this as a succession of fungi appearing on the dung and make analogies with a plant succession in a disturbed area. First come the pioneering plants and these are later displaced by other species as fresh seeds arrive or as buried seeds germinate.

Wood is host to numerous fungal species and offers numerous habitats. For example, some fungi will grow only on dead wood, while others are found only on live plants. Not even all dead wood is the same. There are many differences between the environments offered by recently dead wood, partly rotted wood and well-rotted wood and related to the source of wood ,palm trees, hardwoods, softwoods and coniferous woods for example. Some fungi are considered bad because they can attack live trees. But are they really? An example is Ganoderma zonatum (Butt Rot of Palms) that is blamed for wiping out many mature Golden Cane Palms in Darwin and also for attacking other palm species. It is easily recognizable by its fruit body, the basidarp (conk) growing at the base of the palm clump while the top of the palm is dying off. There are several Ganoderma species in Australia and they are not easily identified usually requiring DNA sequencing to specifiy the species. Ganoderma is not a disease as the Department of Primary Production wants to make us belief but is a naturally occurring and ecologically useful fungi in Top End monsoon forests. The reality of a non-judgmental universe is that fungi are inherently neither good nor bad. Whether a particular interaction is good or bad is always a matter of human interpretation. If you're a forester, then a wood-rotting fungus that destroys the heartwood in a tree is going to be a serious pest in your eyes because there's an economic loss. From the tree's point of view, the same fungus may be neither harmful nor beneficial. The heartwood is dead wood, with the living tissue confined to a relatively thin skin under the bark. As long as the fungus is not harming that living skin the tree can go on living quite happily. In fact, there are numerous old, healthy, hollowed-out trees in existence. Moreover, an empty cylinder can resist some stresses better than a solid cylinder. If you're a possum or a parrot, then you'd probably look very favorably on that fungus because it is helping to create potential nesting hollows. Every living organism is useful in some way or other whether we humans like it or not. For our own sake we need to develop an attitude of nurture in respect to the web of life and figure out how we can fit in without destroying it or components of it.

Many fungi exploit the leaf and twig litter that can be found on forest floors, with the mycelia confined just to the litter layer – extending neither to the soil below nor to the larger pieces of fallen wood. This is especially the case in the tropics, but also in sheltered temperate areas (where the litter layer is protected against the drying effects of sun and wind). Many of the fungi that exploit the litter layers produce tiny fruiting bodies, but at times in great abundance and are similar to the ones found on all the wood that is spread around parks and home gardens in the form of woodchip mulch. The combination of deep woody litter and regular disturbance provides a habitat with no natural equivalent and appears quite diverse. I'm a strong believer in the usefulness of shredded trees as a mulching material. The leaves provide a different habitat to organisms than the chipped wood and both combined create a habitat for a more diverse range of organisms overall. Fungi help to break down both.

Fungi have all kinds of interactions and connections to fauna as a source of food or habitat for insects and other organisms. For example, If you take a medium to large mushroom cap and shake it gently (gills facing down) over a sheet of paper you are likely to end up with a collection of varied invertebrates on the paper. Amongst them will be a mixture of juvenile and adult forms with various feeding strategies. Some will be generalist feeders on any fungal tissue while others will be specialists, perhaps just feeding on the spores, for example. Then there will be those feeding on other invertebrates. The corky to woody bracket fungi are also often good harbours of invertebrates. Such interactions are largely unexplored by science particularly in the NT.

At least 30 species of Australian mammals have been found to eat fungal fruiting bodies. The animals form quite a varied group: Mountain Pygmy-possum, various native rodents, various macropods (kangaroos, wallabies, pademelons, Quokka), Yellow-bellied Glider, Mountain Brushtail Possum, Common Brushtail Possum, Bettongs, Potoroos, Bilby, Bandicoots and the Common Wombat. These animals are distributed over a wide variety of habitats, from rainforest to desert. Given the lack of comprehensive dietary studies, the current list of fungal-eating native mammals is likely to be incomplete. In some cases there have been sightings of fungal consumption, but most of the evidence comes from fungal spores found in animal droppings. The spores of many fungal species are fairly robust and able to pass, undamaged, through an animal's digestive system and out with the feces. A number of the mammals are only occasional eaters of fungi. However, fungal consumption by some of the smaller mammals has been well-studied in south-eastern Australia and it has been found that the truffle-like fungi feature heavily in the diets of these mammals.

Various Australian birds are happy to eat some types of fungal fruiting bodies. In northwest Victoria, the Malleefowl has been seen eating small mushrooms (seemingly in the genus Paxillus), Cassowaries are known to regularly eat some bracket fungi, Brush Turkeys have been happy to eat small mushrooms of the genus Mycena that were offered to them and Emus have taken immature puffballs (Lycoperdon and Bovista species). However, there has been no systematic study of birds and fungi.

MYCORRHIZAL FUNGI

The soil food web is a most incredibly diverse and mostly invisible community of organisms that inhabit the soil. While emphazising the ecological importance of symbiotic (mutually beneficial) relationships with mycorrhizal fungi we should also consider that there are other relationships among bacteria, rhizobia, and legume plant roots that result in nitrogen fixation and further that bacteria can also form a symbiotic relationship with plant roots just like fungi and even work in unison with fungi. When scientists examined the DNA that makes up arbuscular mycorrhizal spores, they discovered that a significant amount of the spore mass comprises symbiotic bacteria. One study indicated that as much as 40 percent of the total spore mass contained DNA from bacteria. This is of interest because the DNA of a fungus can be exchanged with the DNA of a bacterium; this may occur in the spore as a result of environmental conditions. More of bacteria later.

'Mycorrhizal' is the adjective used to describe the fungus or fungi, as in mycorrhizal fungi. 'Mycorrhiza' is the singular noun used to describe the partnership of root and mycorrhizal fungus. The term always refers to the root and the fungus together. 'Mycorrhizae' is the plural form of mycorrhiza. The term refers to relationships, associations, partnerships—between and consisting of both fungi and roots.

We now know that without mycorrhizal relationships, most plants would probably not exist. That in itself is vital information, because when we establish a garden we must consider how to establish a diverse habitat for fungi first. Most members of the plant kingdom have formed associations with mycorrhizal fungi, including bryophytes (such as mosses), angiosperms (most land plants), pteridophytes (such as ferns and club mosses), and many gymnosperms (such as conifers). These plant–fungal associations have remained much the same despite all manner of other evolutionary changes that have occurred. Although mycorrhizae are important to most plants, not all plants depend on these relationships to the same degree. Some plants will not survive without mycorrhizal fungi, while a few others do not require mycorrhizae at all. Obligatory mycorrhizal plants cannot survive without mycorrhizal associations. These plants often have thick, nonbranching roots that cannot effectively explore soil for nutrients. Even their seeds may not germinate without mycorrhizal colonization, or if they germinate, seedlings will not survive. Facultative mycorrhizal plants on the other hand can survive without forming mycorrhizae until nutrients become scarce. When this happens, mycorrhizal associations form or the number of existing mycorrhizae increases. Roots of facultative mycorrhizal plants tend to be extensive and branching, and they are capable of reaching large volumes of soil and nutrients even without an extraradical mycorrhizal network.

German scientist Albert Bernhard Frank was the first to prove the symbiotic relationship of plants with fungi in 1885 by comparing pine trees grown in sterilized soil to those grown in soil inoculated with forest fungi. The seedlings in the inoculated soil grew faster and much larger than those in sterilized soil. Even so, right up into the 1990's, this fact was not well known in principle by farmers and gardeners but today inoculation is a well established practice in forestry, agriculture and horticulture. The benefits that plants derive from mycorrhizal fungi include increased uptake of nutrients, increased resistance to drought, increased resistance to root pathogens, earlier fruiting, and bigger fruits and plants. These fungi are helping farmers better withstand drought and use less fertilizer, particularly phosphorus, because mycorrhizal fungi find and restore phosphorus in the soil, making it available to plant roots, particularly important in the phosphorus poor Australian soils. Mycorrhizal fungi are also being used to remediate and reclaim spoiled land and to prevent erosion of valuable soils.

Biology of mycorrhizal fungi

Fungi can be complex multicellular or simple unicellular (single cell) organisms. Mycorrhizal fungi however are multicellular, comprising masses of branching filaments, or hyphae (hypha, singular). Hyphal fungi thrive in myriad environments, including soil if oxygen is available; they are aerobic organisms and need oxygen to survive. Hyphal fungi can be lurking on spoiled food in a container tucked away in the refrigerator. They grow in some cheeses such as brie and Roquefort. And they are the mildew that crops up on bread. In contrast to multicellular mycorrhizal fungi, yeasts are single-cell fungi—the type found in packets used to make bread and beer. Yeasts can survive in anaerobic (oxygen-free) conditions such as pockets in compacted soil; however, none of these types of unicellular fungi form mycorrhizae.

Each tiny mycorrhizal hyphal strand comprises connected cells, each filled with cytoplasm, organelles, and one or more nuclei. Tubular cell walls and septa (septum, singular) surround each cell and serve as structural supports. Septa are perforated by septal pores that allow cytoplasm to flow throughout a hypha’s cellular compartments, transporting minerals, enzymes, and other intracellular materials between cells.

Most hyphal tubes have diameters of only 2 to 10 micrometers, though they can grow larger in some fungi. In comparison, the diameter of a human hair is about 100 micrometers (1.0 micrometer equals 0.001 millimeter). Fungal hyphae can grow from a few centimeters to several meters in length. They are so thin that it takes hundreds of thousands of individual hyphal strands to form a network thick enough for the human eye to see. In fact, a single teaspoon of good garden soil may contain several meters of fungal hyphae that are invisible to the human eye.

Mycorrhizal associations start when soil hyphae respond to the presence of a root by growing towards it, establishing contact and growing along its surface. Hyphae can grow as much as 40 micrometers a minute. Cells grow apically, at the tips, in response to water, gases, and nutrients in the soil, moving toward favorable and away from unfavorable food sources. Hyphal growth gives a fungus the ability to move relatively long distances.

At about 2 to 10 micrometers in diameter, mycorrhizal fungi hyphae are considerably thinner than plant root hairs, which average 15 micrometers. Some of the mycorrhizal hyphae are extraradical (or extramatrical), meaning they extend beyond the root into tiny soil pores that root hairs would be too large to penetrate. Mycorrhizal fungal hyphae can grow to several centimeters in length, which enables them to access nutrients and water that the roots cannot reach. New molecules are constantly being pushed into the hyphal tip and along the cell wall, extending the wall outward and elongating the hyphal tube. The fungal cytoplasm transports vesicles containing the building materials necessary for wall construction. As the hyphae grow, they form new branches of hyphal tubes that explore and exploit new areas. Each tip of every newly formed hyphal branch performs exactly the same function as the original hypha. While growth is occurring in the apical zone, at the other end of the hypha, in the older parts, things are deteriorating. The cells undergo autolysis, or self-destruction. What can be reused is moved toward the hyphal growing tip, while the nutrients contained in the rest of the decaying fungus become available to other organisms in the soil food web. Importantly hyphae leave behind a system of microscopic tunnels in the soil, through which air and water can flow, contributing to soil structure and health.

As a root grows, it slowly takes up nutrients from the surrounding soil. The plant eventually uses up the available nutrients in this zone of depletion or takes them up at a rate that cannot be sustained at a high enough level for the plant to thrive. As a result, roots continue to grow to reach new areas of soil to mine for nutrients. By associating with fungi, however, a plant’s roots can use the nutrients brought back by the fungal hyphae growing beyond the zone of depletion. Moreover, because the hyphae are considerably thinner than the roots with which they associate, they are able to reach smaller pores in the soil within and outside the depletion zone that were not available to the larger roots. Although the mycorrhizal hyphae are smaller than roots, they greatly add to the surface area and increase absorption. One study, for example, found that fungal hyphae associated with a pine tree added 20 percent more mass to the tree’s root system.

Symbiont fungi are mutualistic, deriving food from hosts in a way that mutually benefits both organisms. Mutualistic fungi are partners in all lichens, which consist of a fungal symbiont and an algal or cyanobacterial partner. Mycorrhizal fungi are clearly mutualistic. The fungal symbiont provides its botanical symbiont (host plant) with nutrients and receives carbon in return. Mycorrhizal fungi are also saprobes, capable of breaking down organic materials as well as mineralizing inorganic matter. They are not the best decomposers of lignin and cellulose, but they can nibble at them. They are weak saprobes and decompose material that is already in an advanced stage of decay.

Mycorrhizal fungi are commonly divided into two groups according to how the fungal cells associate with plant cells. The hyphae of endomycorrhizal fungi penetrate the cell wall, but they do not enter the cell beyond the plasma membrane; these mycorrhizal types are most often associated with the roots of vegetables, grasses, flowers, shrubs, and fruit and ornamental trees. The hyphae of ectomycorrhizal fungi do not penetrate all the way through the cell wall; they form ectomycorrhizae mainly with conifers and some deciduous trees such as oaks.

Endomycorrhizal fungi

Endomycorrhizal fungi fall into three main subgroups, each of which has adapted to particular types of host plants, after which the relationship is named: arbuscular, ericoid, and orchid mycorrhizae. Of these, arbuscular mycorrhizae are by far the most common and widespread type. They are of great importance to growers. The process of forming arbuscular mycorrhizae is initiated by the plant when soil nutrient conditions, specifically phosphorus levels, are low. Such conditions increase the production and release of 'strigolactones' from the host plant’s roots. These specialized hormones attract fungal spores or hyphae in the soil. Once the strigolactones are discovered by the fungus, they guide the fungal hyphae to the host plant’s roots. An arbuscular mycorrhizal spore has about seven to ten days to reach a root to get carbon before its own on-board supply runs out and it dies. Once discovered by germinating arbuscular fungi, strigolactones cause fungal hyphae to undergo extensive branching. This increases the number of hyphal tips and thus improves the chances of timely contact with the plant roots. Strigolactones also guide the fungi to grow toward the roots and aid them in the formation of an appressorium, the penetrating mechanism used by fungi to enter the roots. The fungi also produce and send chemical signals necessary to prevent the plant from turning its defenses against the incoming mycorrhizal fungi. When one of the hyphal tips comes into contact with a root as a result of the signaling, an appressorium forms and the epidermis in the root is penetrated. The appressorium is a specialized cell that produces a peg, which is pressed into and then grows into the root. The action that follows is the coordination of fungal hyphal membrane and the plant’s cell membrane. As the arbuscule develops, its cell wall thins and loosens. In the meantime, vacuoles in the plant cell break up, and the resulting pieces of double membrane concentrate around the invading fungi. These membrane bits merge with the existing plant cell plasmalemma. The hyphal tip is completely surrounded, so it never penetrates the membrane.

Ectomycorrhizal fungi

Ectomycorrhizal associations (short ECM) are formed predominantly on the fine root tips of the host, which are unevenly distributed throughout the soil profile, being more abundant in topsoil layers containing humus, than in underlying layers of mineral soil. ECM fungi can make a significant contribution to the biomass of forest ecosystems Some ECM can form mushrooms, the specialized fruiting bodies that play a role similar to that of flowers in plants. These mushrooms can grow below the soil, as do truffles, or above, as do morels. Their caps can be gilled or nongilled. Some have economic and gastronomic value, such as porcinis and chanterelles. While not all mycorrhizal fungi produce mushrooms, all mushrooms are fungi. Ectomycorrhizal fungi are modern compared to endomycorrhizal fungi. They evolved to associate with plants about 250 million years ago. Although there are several thousand different types of ectomycorrhizal fungi, only about 5 percent of terrestrial plants form ectomycorrhizal associations. Many of these fungi produce mushrooms next to their plant hosts and are often of economic and culinary value. Ectomycorrhizal fungi are more acidophilic than other mycorrhizal fungi in that they prefer acidic soils with a low pH. Ectomycorrhizae formation begins with fungi to root contact below the apex of young, actively growing roots. The hyphae first grow on the surface of the root. After a day or two, a mantle is formed around the root, followed by penetration between the host cortex cells, branching, and growth, which results in the formation of the Hartig net between the cells. In angiosperms (herbaceous plants, shrubs, and most trees), this is usually a single cell layer and it does not move out of the root's epidermal cells. In gymnosperms (conifers, ginkgo, and cycads) that associate with ectomycorrhizae, the Hartig net can penetrate the cortex.

Typically the part of the fungus that carries and disperses fungal spores are called sporangia (sporangium, singular) and are enclosures in which the spores are formed. Tiny spores are released that give rise to a hypha, which in turn branches and grows into hyphae and so advances to the mycelial web. The mushroom itself requires a lot of water which is rapidly pulled in from its mycelium and grows and fills the fruitbody often in less than a day. Mushrooms have outer membranes, or veils, that dehydrate rapidly, so they usually appear only when temperature and moisture conditions are right.

Mycorrhizae can help host plants to become tolerant of drought conditions. As has been demonstrated by studies, an amazing 50 to 100 times more water is available to plants when their roots associate with mycorrhizal fungi and form mycorrhizae. The net of mycorrhizal fungal hyphae branches surrounds plant roots and holds water, acting as a storage reservoir. The interface between some hyphae and the host plant root cells also holds water, as do vesicles, those special storage organelles inside the roots. It is also important from a commercial standpoint, as agriculture accounts for about 70 percent of all water use worldwide, and mycorrhizal crops require less water during dry periods thus withstanding drought periods more readily.

There is a lot of information available on mycorrhizal fungi, both on the internet and in printed form. An excellent mycorrhizal website, especially from an Australian perspective, has been created by Mark Brundrett of the University of Western Australia [http://mycorrhizas.info/]. It deals mainly with ectomycorrhizas and VA mycorrhizas and gives detailed information, numerous illustrations, many references and links to numerous other mycorrhizal sites.

Most scientists now recognize seven phyla, the class below the kingdom level of fungi, but only three of these include mycorrhizal fungi which we are mostly concerned as gardeners and these can be placed into one of three divisions called Acomycota, Basidiomycota and Glomeromycota.

ASCOMYCOTA

Ascomycota are sac fungi that form a diverse phylum including over 65,000 species. All ascomycetes develop an ascus, a saclike reproductive structure that contains microscopic ascospores. Many ascomycetes are plant or animal pathogens though others are edible mushrooms. It is the phylum to which morels, truffles, brewer's and baker's yeasts, and penicillin belong. These fungi break down cellulose in plants and collagen in animals, two extremely resistant materials. As the largest group in the kingdom fungi it contains approximately 6500 genera in three subphyla: Taphrinomycotina, Saccharomycotina, and Pezizomycotina. Fungi in the subphylum Taphrinomycotina, which contains approximately 140 described species, are largely plant parasites with both a yeast state and a hyphal state. Characteristically they infect leaves, catkins and branches, but not roots. Fungi in the subphylum Saccharomycotina, which contains approximately 1500 described species, are predominantly yeasts, most of which live as saprotrophs in association with plants and animals. The subphylum Pezizomycotina consists of hypal fungi with differentiated tissues, and is the largest group in the phylum, with more than 63,000 described species that occupy a wide range of ecological niches, occurring as saprotrophs, parasites and mutualists with plants, animals and other fungi. As gardeners we are mainly interested in the mutualists and saprotrophs.

BASIDIOMYCOTA

This phylum of about 30,000 filamentous fungi reproduce via a microscopic, spore-producing basidium, which is attached to the fruiting body. The word basidium means little pedestal and is derived from the way the fruiting body supports the spores. This phylum includes mushrooms, chanterelles, puffballs, stinkhorns, bird's nest fungi, shelf fungi, rusts, and smuts. Basidiomycota contains three subphyla: Pucciniomycotina, Ustilaginomycotina, and Agaricomycotina . Pucciniomycotina is the second largest subphylum in the Basidiomycota and contain approximately 8500 with about 90% belonging to a single order, Pucciniales. The fungi in this subphylum are predominantly parasitic rusts and smuts. Some species are responsible for diseases in crops, animals and humans, while other species have been used for biological control of invasive plants and pathogenic fungi. Ustilaginomycotina contains about 1500 described species, all of which are plant parasites. During their life cycle they have a saprobic yeast phase followed by a parasitic hyphal phase. Amongst the parasitic fungi these have been the most studied. Agaricomycotina is the largest subphylum in Basidiomycota, containing about 21,000 described species, including all the fungi with large fleshy fruitbodies tradtionally recognized as mushrooms.

GLOMEROMYCOTA

As a group they are primitive fungi at the base of the tree of higher fungi and have no known sexual state. Mycorrhizal associations produced by Glomeromycotan fungi are known as arbuscular mycorrhizas, or vesicular-arbuscular mycorrhizas (formerly also endomycorrhizas, or endotrophic mycorrhizas) and are abbreviated as VAM. VAM associations form when host roots and compatible fungi are both active in close proximity and soil conditions are favorable. Mycorrhizal associations may be initiated by spore germination. Hyphae may also originate from fragments of roots. In many cases there already is a pre-existing network of hyphae resulting from previous root activity. Hyphae resulting from spore germination have a limited capacity to grow and will die if they do not encounter a susceptible root within a week or so. Hyphae emerge from a germination shield within the spore in Scutellospora and Acaulospora species.

Spores form as swellings on one or more hypha in the soil or in roots. These structures contain lipids, cytoplasm and many nuclei. Spores usually develop thick walls with more than one layer and can function as propagules. Spores may be aggregated into groups called sporocarps. Glomeromycota produce microscopic structures or relatively small truffle like sporocaps.

The phylum Glomeromycota includes fewer species than the other two phyla, at about 230, but they are among the most abundant and widespread of all fungi and form mycorrhizal associations with the majority of plants. Arbuscular mycorrhizal fungi are glomeromycetes that form mutualistic relationships with the roots of most herbaceous plants and many trees. Most species reproduce asexually.

How to ensure to get the right mix of such symbiotic fungi growing in your garden will be explained in the chapter gardening techniques.

Non mycorrhizal plants:

There are a number of plants that are nonmycorrhizal (NM) and are highly resistant to mycorrhizal fungi and normally remain uncolonised. One of the largest groups of NM plants have cluster roots - dense aggregations of lateral roots with long root hairs. These include many Proteaceae members, especially those occurring in highly infertile soils. One example in the Top End flora is Banksia dentata. The cluster roots of NM plants tend to promote nutrient uptake by their large surface area and produce exudates that increase nutrient solubility. These cluster roots often form a dense mat near the soil surface in contact with decomposing litter that supports populations of P-solubilising bacteria and organic acids. The cluster roots are also very efficient at P adsorption. These mechanisms are thought to increase the availability of nutrients such as phosphorus that are normally immobilized in soils. Roots of members of the Proteaceae, are usually highly resistant to mycorrhizal fungi, even when exposed to high inoculum levels. The Cyperaceae (Sedges), Restionaceae (Rushes) and Juncaceae (Rushes) are generally considered to by NM families.

LICHEN

A lichen is a composite organism that arises from algae or cyanobacteria living among filaments of multiple fungi species in a mutualistic relationship. Lichens are classified by the fungal component. Lichen species are given the same scientific name (binomial name) as the fungus species in the lichen and are being integrated into the classification schemes for fungi. The algae bears its own scientific name, which bears no relationship to that of the lichen or fungus. It is estimated that an incredible 6–8% of Earth's land surface is covered by lichens of about 20,000 known species. Some lichens have lost the ability to reproduce sexually, yet continue to speciate. Lichens can be seen as being relatively self-contained miniature ecosystems, where the fungi, algae, or cyanobacteria have the potential to engage with other microorganisms in a functioning system that may evolve as an even more complex composite organism. Lichens may be long-lived, with some considered to be among the oldest living organisms. They are also considered as pioneer species as they are usually the first living things to grow on bare rock or areas denuded of life by a disaster. Lichens may have to compete with plants for access to sunlight, but because of their small size and slow growth, they thrive in places where higher plants have difficulty growing. Lichens are often the first to settle in places lacking soil, constituting the sole vegetation in some extreme environments. They are among the first living things to grow on fresh rock exposed after an event such as a landslide. The long life-span and slow and regular growth rate of some lichens can be used to date events (lichenometry). English lichen derives from Greek leichēn ("tree moss, lichen, lichen-like eruption on skin") via the Latin lichen. The Greek noun, which literally means "licker", derives from the verb 'leichein' meaning "to lick".

Lichens have properties different from those of their component organisms. Lichens come in many colors, sizes, and forms and are sometimes plant-like, but lichens are not plants. Lichens may have tiny, leafless branches (fruticose), flat leaf-like structures (foliose), flakes that lie on the surface like peeling paint (crustose),a powder-like appearance (leprose), or other growth forms. A macrolichen is a lichen that is either bush-like or leafy; all other lichens are termed microlichens. Here, "macro" and "micro" do not refer to size, but to the growth form. Common names for lichens may contain the word moss (e.g., "reindeer moss", "Iceland moss"), and lichens may superficially look like and grow with mosses, but lichens are not related to mosses or any plant. Lichens do not have roots that absorb water and nutrients as plants do, but like plants, they produce their own nutrition by photosynthesis. When they grow on plants, they do not live as parasites, but instead use the plant's surface as a substrate. The part of a lichen that is not involved in reproduction, the "body" or "vegetative tissue" of a lichen, is called the thallus. The thallus form is very different from any form where the fungus or alga are growing separately. The thallus is made up of filaments of the fungus called hyphae. The filaments grow by branching then rejoining to create a mesh, which is called being "anastomose". The mesh of fungal filaments may be dense or loose.

Within the symbiotic relationship between fungi and photosynthetic algae or cyanobacteria, the photosynthetic partner in the relationship is referred to in lichen terminology as a "photobiont". The fungi benefit from the carbohydrates produced by the algae or cyanobacteria via photosynthesis. The algae or cyanobacteria benefit by being protected from the environment by the filaments of the fungi, which also gather moisture and nutrients from the environment, and in most cases provide an anchor to it. Although some photosynthetic partners in a lichen can survive outside the lichen, the lichen symbiotic association extends the ecological range of both partners, whereby most descriptions of lichen associations describe them as symbiotic.

Two forms of reproduction can be found amongst living organisms - sexual and asexual. It is by the mixing of genes from two individuals, via sexual reproduction, that genetic diversity is effected, whereas in asexual reproduction there is no such mixing of genes. Both sexual and asexual reproduction can be found amongst the lichens. When talking of plants or lichens, asexual reproduction is commonly called vegetative reproduction. Though lichens, as a whole, may reproduce both sexually or vegetatively, there are species in which both types of reproduction may be common but also species where one type is rare or even unknown. In lichens only the fungal partners may reproduce sexually. A number of photobiont species found in lichens can be found free-living and could then reproduce sexually but within a lichen sexual reproduction of the photobiont is suppressed.

Both partners in a lichen gain water and mineral nutrients mainly from the atmosphere, through rain and dust. The fungal partner protects the alga by retaining water, serving as a larger capture area for mineral nutrients and, in some cases, provides minerals obtained from the substrate. When growing on mineral surfaces, some lichens slowly decompose their substrate by chemically degrading and physically disrupting the minerals, contributing to the process of weathering by which rocks are gradually turned into soil. While this contribution to weathering is usually benign, it can cause problems for artificial stone structures. In addition to distinct physical mechanisms by which lichens break down raw stone, recent studies indicate lichens attack stone chemically, entering newly chelated minerals into the ecology. Over time, this activity creates new fertile soil from lifeless stone. Over time, this activity creates new fertile soil from lifeless stone. The algal or cyanobacterial cells are photosynthetic and, as in plants, they reduce atmospheric carbon dioxide into organic carbon sugars to feed both symbionts. Phycobionts (algae) produce sugar alcohols (ribitol, sorbitol, and erythritol), which are absorbed by the mycobiont (fungus). Cyanobionts produce glucose. Lichenized fungal cells can make the photobiont "leak" out the products of photosynthesis, where they can then be absorbed by the fungus.

Nitrogen constitutes about 80% of the volume of the earth's atmosphere and is essential for life, yet the majority of organisms cannot make direct use of atmospheric nitrogen. Cyanobacteria are amongst the organisms that are able to make direct use of atmospheric nitrogen and such organisms are said to be able to fix atmospheric nitrogen. Hence, lichens with cyanobacterial photobionts fix atmospheric nitrogen. After fixation the nitrogen can become available to plants following the death and decay of the lichen thallus or through herbivore defecation after consumption of such lichens. Some nitrogen may be leached from the lichen and be trapped by other epiphytes (for eventual release through the same processes of death or consumption) or drain into the soil. Various studies have shown that lichens can be a significant source of nitrogen for plants. Even when not nitrogen-fixing lichens can still contribute significantly to nutrient cycling. Lichens absorb mineral nutrients through their thalli. Think of forests where the trees are covered with thick epiphytic lichen communities. The large surface area of such a dense epiphytic growth is a very effective means of trapping mist and rainfall (and the nutrients, such as ammonium nitrate, present in rain or mist).

It appears many, probably the majority, of lichen also live in a symbiotic relationship with an order of basidiomycete yeasts called Cyphobasidiales. The absence of this third partner could explain the difficulties of growing lichen in the laboratory. The yeast cells are responsible for the formation of the characteristic cortex of the lichen thallus, and could also be important for its shape.

Many lichens are very sensitive to environmental disturbances and can be used to assess air pollution, ozone depletion, and metal contamination. Lichens have been used in making dyes, perfumes, and in traditional medicines. A few lichen species are eaten by insects or larger animals, such as reindeer. When air is very badly polluted with sulphur dioxide, there may be no lichens present; only some green algae can tolerate those conditions. If the air is clean, then shrubby, hairy and leafy lichens become abundant. A few lichen species can tolerate fairly high levels of pollution, and are commonly found in urban areas, on pavements, walls and tree bark.

Unlike simple dehydration in plants and animals, lichens may experience a complete loss of body water in dry periods. Lichens are capable of surviving extremely low levels of water content. They quickly absorb water when it becomes available again, becoming soft and fleshy. Reconfiguration of membranes following a period of dehydration requires several minutes or more. Many lichens reproduce asexually, either by a piece breaking off and growing on its own (vegetative reproduction) or through the dispersal of diaspores containing a few algal cells surrounded by fungal.

The fungal part of the relationship is composed mostly of various species of ascomycetes and a few basidiomycetes. Lichens occur in every ecosystem on all continents, play a key role in soil formation and the initiation of biological succession. Lichenization is a common mode of nutrition for fungi; around 27% of known fungi—more than 19,400 species—are lichenized. Characteristics common to most lichens include obtaining organic carbon by photosynthesis, slow growth, small size, long life, long-lasting (seasonal) vegetative reproductive structures, mineral nutrition obtained largely from airborne sources, and greater tolerance of desiccation than most other photosynthetic organisms in the same habitat. You find many lichens in natural rainforests and can have them too in your garden as it matures over the years.

You can find lichens growing on a wide variety of natural and man-made substrates. It should therefore not surprise you to learn that, as a group, lichens show a wide range of behaviors and interactions with other organisms. Lichen colonies provide niches for numerous invertebrates, often the very tiny invertebrates, which are then eaten by larger invertebrates which, in turn, are eaten by other creatures. Such lichen colonies are thus indirectly important in various food chains. Many bird species from Eurasia, the Americas and Australasia are known to use lichen fragments in their nests, most likely for camouflage. To give one situation as an example, consider a small bird that builds its twig nest in the dappled light found within many shrubs. In such a setting a nest built just of twigs would be discernible as an eye-catching dark mass in an otherwise dappled setting and could arouse a predator's curiosity. Fragments of lighter-colored lichen thalli, affixed to the outside of the nest, would give it a dappled look, better able to blend with the dappled light.

Lichens are eaten by many small invertebrates, including species of bristletails (Thysanura), springtails (Collembola), termites (Isoptera), psocids or barklice (Psocoptera), grasshoppers (Orthoptera), snails and slugs (Mollusca), web-spinners (Embioptera), butterflies and moths (Lepidoptera) and mites

(Acari). The mite Camisia segnis lays eggs in lichens and during egg laying a softening substance is excreted by the female and this causes the lichen to swell, grow over the eggs and so protect them.

A variety of invertebrates shelter within lichen colonies that grow on rocks, bark or on the ground. Many other invertebrates are colored in ways which allow them to be inconspicuous when they come to rest on lichen colonies. Various invertebrates carry lichen fragments as camouflage and some examples are given in the Australian moths case study referred to above. In addition some lacewing larvae cover themselves with moss or lichen fragments which, at least in some cases, helps these predatory invertebrates take their prey by surprise.

Many lichens grow on trees (and other plants) as well as structural elements (paving, walls, fences etc). A particular tree may have numerous microhabitats - north side, south side, rough bark, smooth bark, trunk, branches, leaves. Go outside and have a look in your garden. Lichen are everywhere when you know where to look and what to look for. For example have a close look at the trunks of Carpentaria Palms which are usually covered by a layer of lichen. I have included background information on lichen mostly to arouse your interest because they are present in every garden and largely beneficial but commonly not recognized. Sometimes we are eager to clean surfaces that show some degree of discoloration often caused by lichen. An understanding of the ecology may help us to tolerate and even appreciate those unique and useful organisms.

SLIME MOLDS

My favorites in the garden they are unique amoeba-like organisms that occur on damp rotting wood, leaves , manure, lawn, rotting mushrooms and other organic material. They spend most of their time pursuing bacteria and yeasts in the soil and are in many ways like fungi but eat foodstuffs in a different way. Fungi digest their food externally and then bring the foods inside them, while slime molds engulf food and digest it internally. Slime molds ingest bacteria, fungi spores and small protozea while they themselves area eaten by insect larvae, worms and specialized beetles. They have three forms, a mobile manifestation called the plasmodium, a fruiting form called the sporangium and also a dormant stage when environmental conditions do not allow the other two stages.

SELECTED FUNGI SPECIES

What follows is some information on commonly encountered fungi species in Darwin gardens all of which are summarized together with other known NT fungi species in the charts 'Fungi and micro organisms list' in the Appendix. The information has been gained from three different Australian Field

Guides of Fungi as well the online 'Atlas of Living Australia' fieldguide extract for the Darwin area including 94 fungal species. Please note that there is not much information on the local fungal species, the more a reason to present the little we know. Identification of fungi often relies on microscopic examination well beyond my level of knowledge but which is needed for correct identification of the species as simple morphological attributes are not always sufficient to identify a species. As with most topics subjected to detail level, our lack of knowledge then reveals itself. The more you know the more you will realize how little you actually know which was my experience precisely. Further many of the visual features used to identify a fungal species can also be modified by its environment creating a degree of uncertainty in our interpretation of those features. As we attempt to identify the fruit-body with those in the literature or from photos found we often encounter a level of doubt.

A good way to increase an interest and knowledge on mushrooms is to heavily mulch your own garden and inoculate the mulch with a handful of soil transfered from natural areas. Indeed many of the species descriptions that follow are from my backdoor garden, in the main saprobic fungi species. It is likely that you may encounter them in your garden too. More of inoculation, the easy way how to get more fungi, is explained the practical section of this book. As you observe your garden on a daily basis in the wet season you learn more about the species that you encounter under such and which conditions the fruit bodies arise, how long they last and thereby discovering how fascinating fungi really are or can be. Mushrooms also pop up on occasion during the dry season when there is an unseasonal rainfall event even as little as 5 mm. Perhaps fungi are sensitive to chemicals or mineral content and require rainwater rather than town water. Here are a few of the species.

1. Leucocoprinus birnbaumii (Flowerpot Parasol)

Chart: 1.6
Family: Agaricaceae
Type: Saprotrophic

Notes: This distinctive saprotrophic fungi is considered toxic and usually appears on soil in litter in a variety of tropical and subtropical forest types, at times also popping up in planters and pots. It has a chrome-yellow gilled cap to 60 mm diameter, ovoid at first then turning bell-shaped and flattened. Stems of the same color grow to 80 mm high. Although this fungus can be found solitary it usually appears in small groups. It lives off very decayed matter such as humus or compost. The yellowish color comes from the alkoloids (birnbaumins) this fungus contains.

2. Chlorophyllum molyblites (False Parasol)

Chart: 1.7
Family: Agaricaceae
Type: Saprotrophic

Notes: This species has quite a large fruiting body with the cap growing to 120 mm and greater diameter initially resembling a drumstick to changing to almost flat with brownish scales on top of the cap arranged concentrically towards the centre. This fungi is quite common in Darwin and can be found in small groups or clumps to very large colonies mainly on pastures or grassland. It is extremely toxic in its raw state. Symptoms include violent stomach pains and vomiting with hospital treatment being essential. This fungi has a rare greenish sporeprint and greenish gills. The fruiting bodies generally appear with wet season rains often as a perimeter of a large circle in many local parks.

3. Lycoperdon perlatum (Common Puffball)

Chart: 1.8
Family: Agaricaceae
Type: Saprobic

Notes: The mature fruit bodies of this puffball are about 60 mm wide and are generally found in small clusters amongst leaf litter in forested areas. When mature it becomes brown, and a hole in the top opens to release spores in a burst when the body is compressed by touch or falling raindrops. A saprobic species this puffball also grows in fields, gardens, and along roadsides. It is edible when young and the internal flesh is completely white, although care must be taken to avoid confusion with immature fruit bodies of poisonous Amanita species and other similar puffballs. Interestingly this puffball bio-accumulates heavy metals present in the soil and can be used as a bioindicator of soil pollution by heavy metals and selenium. L. perlatum biomass has been shown experimentally to remove mercury ions from aqueous solutions, and is being investigated for potential use as a low-cost, renewable, biosorptive material in the treatment of water and wastewater containing mercury.

4. Leucoprinus fragilissimus (Fragile Dapperling)

Chart: 1.10
Family: Agaricaceae
Type: Saprotrophic

Notes: A gilled mushroom with the cap growing to 45 mm across, bell-shaped when young and becoming convex in maturity it has a pale yellow color and white gills, the cap sitting on a very fragile thin stalk. It lives on very decayed plant matter including compost and humus either solitary or sparsely in wooded areas. Its edibility is unknown.

5. Lycoperdon scabrum

Chart: 1.11
Family: Agaricaceae
Type: Saprotrophic

Notes: This is another similar puffball to 40 mm across which however is more densely covered with soft dark pointed scales that fall off as the 'ball' expands leaving a smooth, shiny surface skin. Generally occurs on the ground in open forest and woodland.

6. Amanita hemibapha (Half Dyed-slender Caesar)

Chart: 1.14
Family: Amanitaceae
Type: Mycorrhizal

Notes: A pretty little gilled species of a mycorrhizal fungi with a orange to reddish coloring of both cap and stem. The mature cap is convex and flat. The variant Amanita hemibapha var. ochracea found in China have been reported to cause dizziness and nausea after eaten in large quantity, thus consumption is recommended against. The species is also noted to be confusable with the lethally toxic Amanita subjunquillea.

7. Auricularia cornea (Hairy Jew's Ear)

Chart: 1.16
Family: Auriculariaceae
Type: Saprotrophic

Notes: A jelly fungi with a sloppy hat like fruit body 100 mm across and a gelantineous, brownish translucent flesh is mainly found on dead wood in tropical to subtropical forest habitats where it can form beautiful large colonies on fallen logs. Like Most Auricularia species it is edible and grown commercially and widely can be purchased in Asian food shops.

8. Bolbitius titubans

Chart: 1.17
Family: Bolbiiaceae

Notes: The gilled yellowish cap reaches 30 to 50 mm across starting out conical and becoming flattened with age. The stem is white-yellowish with a distinct mealy powdering. Delicate and watery it is mainly found on manure, decaying grass and sometimes on manured lawns. This species is not edible. Fruiting bodies are shortlived rise by the morning and collapse in the afternoon.

9. Boletellus emodensis (Shaggy Cap)

Chart: 1.18
Family: Boletaceae
Type: Mycorrhizal

Notes: The broadly convex reddish caps reach 100 mm across and feature thick, fibrillose scales that are splitting with age and exposing rosy to bright crimson in the cracks between the scales, so creating a distinct 'pine' look. Pores are yellow to gold turn blue instantly when bruised. The shaggy fungus shows up either solitary or in twos on dead wood in eucalypt forest or woodlands and often on dead casuarina logs or stumps.

10. Austroboletus lacunosus

Chart: 1.19
Family: Boletaceae

Notes: A typical pored fungi of the boletes it displays beautiful fruiting bodies with caps reaching to 150 mm across and can be found in eucalypt and mixed forests. The caps have a dry granulous brownish texture while the stems are distinctly lacunose.

11. Descolea recedrens

Chart: 1.21
Family: Cortinariaceae
Type: Ectomycorrhizae

Notes: The caps of this fungi are 40 mm across and flatten with age. It has soft fibrillose scales on the top of the cap, remains of the veil. Of a somewhat drab appearance it has a link to ancient Gondwana and can be found as far as New Zealnd and South America. The fruiting bodies can be found in small groups on litter mainly in eucalypts forests with which this fungi has mycorrhizal relationships.

12. Laetiporus sulphureus

Chart: 1.23
Family: Formitopsidaceae
Type: Brown Rot

Notes: The distinct stemless bracket or fanshaped caps reach 100 – 300 mm and features a brilliant reddish-orange to sulphur-yellow coloration that fades with age. Both flesh and pores are whitish to yellow. This spectacular polypore can be found locally on the East Point Reserve walking tracks where in grows in a multitude of rosettes on fallen or dead standing tree trunks. It is untested in Australia for edibility.

13. Marasmius elegans

Chart: 1.35
Family: Marasmiaceae
Type: Saprotrophic

Notes: A little fungus with red-orange caps to only 5 mm across, widely spaced gills and slender stems to 12 mm long, it colonizes shed eucalyptus bark often forming large colonies. Interestingly the caps have an ability to rehydrate.

14. Filoboletus manipularis

Chart: 1.39
Family: Mycenaceae
Type: Saprotrophic

Notes: The caps are 20 mm across and have fine pores rather than gills on the underside of the cap. The species is related to similar species of Mycena however which is gilled. F. manipulars grows in picturesque dense clusters of 50 or more mostly on decaying wood in rainforests.

15. Phallus multicolor (Crinoline Fungus)

Chart: 1.45
Family: Phallaceae
Type: Saprotrophic

Notes: Locally known as the 'penis mushroom' it belongs to the stinkhorn group. Its distinctly shaped fruit bodies reach a height of 180 mm with stem to 30 mm across. The indusium varies from white to shades of yellow or orange. This species can be found in the tropics on organic debris in rainforest and on garden wood mulch and compost.

16. Hexagonia tenuis

Chart: 1.56
Family: Polyporaceae
Type: Saprotrophic

Notes: This common pored bracket fungi it is typically found on dead logs and branches in tropical forests. The upper surface of the brownish fungi is radially grooved.

17. Panus fasciatus

Chart: 1.60
Family: Polyporaceae
Type: Saprotrophic

Notes: The fruitbody is funnel-shaped with distinct inrolled margins. The caps reach 50 mm across, This species is found on dead wood Australia wide mostly in drier eucalypt and mallee woodlands and extending into desert habitats.

18. Schizophyllum commune

Chart: 1.63
Family: Schizophyllaceae
Type: Saprotrophic

Notes: A hairy cap to 30 mm across is supported by irregularly fan-shaped stem. This fungis is pale pink to creamy pink above becoming greyish with age and features a distinctly split, double-edged gills. It populates many kinds of dead wood in small colonies after rainy weather and is very common in eucalypt woodland and forests. It is the only fungus capable of retracting by movement and has recently attracted the medicinal industry for its immunomodulatory, antifungal, antineoplastic and antiviral activities that are higher than those of any other glucan complex carbohydrate. Notably it can cause disease in humans. However it is edible to humans and known for its high medicinal value and aromatic taste profile.

19. Xylaria polymorpha (Dead Man's Fingers)

Chart: 1.72
Family: Xylariaceae
Type: Saprotrophic

Notes: The black finger shaped fungi is 30 – 100 mm tall and 10 to 20 mm across is usually found in clusters on dead wood such as fallen logs. The clubs may be dusted white with conidiospores.

20. Hygrocybe sp red

Chart: 1.78
Family: Hygrophoraceae
Type: Symbiotic

Notes: Hygrocybe species are usually found in woodlands and have brightly colored waxy caps. They are mostly soil dwelling and can be found locally in many natural locations.

21. Microporus xanthopus

Chart: 1.79
Family: Polyporaceae
Type: Saprotrophic

Notes: They are funnel-shaped polypores to 90 mm across and distinctly zones on their inner surface. Xanthopus translates to 'yellow foot' referring to the yellow colored disk at its attachment to the growing medium, often dead logs and branches in tropical forests. Very photogenic it can often be found in small colonies on the forest floor.

21. Fuliga septica (Dog's Vomit)

Chart: 1.85
Family: Physaraceae
Type: Slime Mold

Notes: Slime molds are no longer classified as a fungi but belong to a separate kingdom, the Protoctista and share the characters of both amoeba and fungi. The mature fruit body is called the sporangium that produce the spores that develop into a creeping slime-like mass called the plasmodium which feeds on bacteria, fungi and decaying organic matter. They are really fascinating organism but have not very well studied. F. septica has a yellowish irregular mass resembling a somewhat solidified mass of scrambled egg often with a whitish trail connected to it. Following rain they suddenly appear on a variety of surfaces such as wet grass, dead wood, woodchip mulch but also low on tree trunks. Their spores can become airborne to spread and are known to trigger asthma in susceptible people. Like fungi their ecological role is to break down and recycle organic material. Interestingly they are one of the few organisms capable to cope with toxic levels of metals especially zinc.

BACTERIA & SOIL BASED ORGANISMS

Fungi as microorganisms have been covered in detail in the previous chapter and while they are hugely important for healthy productive soils and plants there is another whole universe of other microscopic or very small organisms equally important to make the soil food chain work. These organisms while belonging to different kingdoms of life include bacteria, nematodes, gastropods, protozea, archaea, algae and earthworms.

ECOLOGICAL SIGNIFICANCE

Microbes here are defined as microscopic organisms and constitute a large percentage of Earth‘s biodiversity. They are a structurally and functionally diverse group of organisms that include archaea, bacteria, cyanobacteria, and single-celled eukaryotic organisms. Microbes are the pioneer colonizer of the earth surface that had created a platform for origin, survival and persistence of other biosystems. They produced a layer of soil crust by secreting acidic substances and bring about weathering of rocks thereby eventually forming the fertile layer of the soil. Of these, cyanobacteria are one of the major and most vital microorganisms that have developed oxygen metabolism and make it possible the evolvement of a diverse and advanced present day organisms. Microorganisms synthesize complex compounds from simple ones and vice versa, resulting in the continuation of nutrient cycles, which is essential for persistence of life forms on the earth surface. Moreover, they can transform unavailable sources of nitrogen into available forms of nitrogenous compounds, mobilize organic phosphates into inorganic phosphates, synthesize growth promoting hormones, and most importantly cope with fluctuation in physic-chemical behavior of soil and anthropogenic climate change.

You may think of such organisms as somewhat disconnected from your own body, something that lives largely invisibly in the soils outside. However contrary to common belief is that in reality you are not a stand alone organism rather a superorganism; a collective of many species, living side-by-side and cooperatively running the body that sustains you. You own cells, though far larger in volume and weight, are outnumbered ten to one by the cells of the microbes that live in you. In humans, these 100 trillion microbes – known as the microbiota – are mostly bacteria: microscopic beings made of just a single cell each. Alongside the bacteria are other microbes – viruses, fungi and archaea. Viruses are so small and simple that they challenge our ideas of what even constitutes 'life'. They depend entirely on the cells of other creatures to replicate themselves. The fungi that live on us or in us are often yeasts; more complex than bacteria, but still small, single-celled organisms. The archaea are a group that appear to be similar to bacteria, but they yet they are as different evolutionarily as bacteria are from plants or animals. Combined, the microbes living on the human body contain 4.4 million genes – this is the microbiome: the collective genomes of the microbiota. These genes collaborate in running our bodies alongside a mere 21,000 human genes making us, or what we think of us, just half a per cent human. Consider that what we can extract from our food depends on what our microbial factory has been set up to extract. If a vegetarian were to indulge in a big juicy steak, this vegetarian would probably not have enough amino-acid-loving microbes to make the most of it. But a regular meat-eater would have a sizable collection of suitable microbes, and would extract more calories from the steak than the vegetarian. And so it follows for other nutrients and type of foods. A person who eats very little fat would have very few microbes that are specialized for fat, and the odd doughnut or chocolate bar might make it through the large intestine without being efficiently stripped of its remaining calorific content. What your gut absorbs is only what your microbes deliver to you. It's also about what your body chooses to do with that energy: whether it stores it away for a rainy day, or burns it off immediately. The anatomy of our digestive system, with its emphasis on the large intestine as a home for plant-loving microbes, and a long appendix that acts as a safe-house and storage facility, serves to remind us that we are not pure carnivores, and plants are our staple diet. The nutrient we're missing out on is fiber, but it is plants that we're forgetting to eat. In summary the make-up or mix of your internal biome is to a great extent influenced by what you put into your mouth, but it is also directly influenced by exposure to open fresh air since many microbes are also airborne, we think there is 100 million of bacteria cells present in one cubic meter of air. You breathe in and touch microbes any time you go outdoors and some of those microbes will multiply or interact with other microbes or your own cells inside you, all unknown to you. In our macro-scale world, a bare patch of rock will accumulate lichens, then mosses, until the turnover of these pioneers results in enough soil to sustain small plants, and eventually bushes and trees. The same goes for the 'bare ground' of the gut – the microbiota begins with a simple selection of lactic acid bacteria, then grows increasingly complex and diverse. This is ecological succession – each stage provides the habitat and the nutrients necessary for the next. Among those 100 trillion microbes inside you are perhaps 2,000 different species. And within those 2,000 species are countless different strains, all with an arsenal of different genetic capabilities. They are mostly 'friendly' but among one another it's not always so peaceful as populations compete for space and displace weaker opponents just as is outside as the survival of the fittest. Species defend their patch through chemical warfare, killing those that dare to invade. Individuals compete for nutrients, growing tails to propel themselves into more profitable territories. There is a constant flux of microbes between air, soil and water as we get into contact with each other. Despite all the death and life warfare between a multitude of organisms in the end there is balance. My personal attitude has always been to get my hands dirty in the soil, breath in the fresh air and dip into water anywhere in the knowledge that this is where I originated from and will return to. Think of the soil in your garden just like a body as yourself a connected organism that is also connected to you when you are out there.

Good soil has microbes and other small creatures such as worms, centipedes, springtails, ants, slugs, larvae, bacteria, fungi, protazoa, nematodes and more organisms in staggering numbers and most of it on the surface and to about 100 mm deep. A mere teaspoon of good soil contains a billion invisible bacteria, several yards of fungal hyphae, several thousand protozea and a few dozen nematodes. There are about 500 earthworms in one square meter of rich soil. Apart from a few bacteria all of these organisms derive energy from carbon mostly from organic material produced by plants and other organisms or decaying stuff. Everything in this body of soil eats something and/or gets eaten by something and the whole of such relationships make up the soil food chain, however the origin of this complex chain is almost always plants. A great deal of energy gained through photosynthesis is used to produce root exudates in the form of carbohydrates and proteins within the rhizosphere, the approximately 1 mm of space around the roots. Most of the organisms particularly bacteria and fungi, compete for resources within this rhizosphere and in turn are eaten by the many other organisms. The wastes that organisms produce contains nutrients in a form that plant roots can absorb. Individual plants can control the numbers and type of fungi and bacteria within the rhizospehre throught their exudates as a result waxing and waning the life of organisms. The protozea and nematodes feast on bacteria and fungi are eaten by arthropods, which also eat each other and in turn are eaten by birds, snakes, lizards and other animals. The smallest organisms, the bacteria produces a slime to avoid getting washed away but the slime also holds soil particles together. In a similar way fungal hyphae too bind soil particles and together with other moving organisms create soil structure and a pathway for air and water to move through soil. In one way or another nutrients are always locked up in the organism and released in small quantities everywhere but mostly in the rhizosphere of plant roots. Without this system of the soil food web, nutrients would simply drain away by leaching. A healthy soil food web keeps itself in perfect balance through the diversity of organism that provide a living niche for all without letting any organism dominate. Bacteria and fungi in particular are protective of plant roots by producing inhibitory compounds. Research shows that the least disturbed soils have more fungi than bacteria while the reverse is true for disturbed soils. For example, agricultural soils have a fungi to bacteria biomass of 1 in 1 while forest soils have a ratio of 10 in 1. In general trees and shrubs prefer fungally dominated soils while annuals, grasses and vegetables prefer bacteria dominated soils. Fungi produce acids and tend to lower pH and so reduce bacteria that in general prefer alkaline conditions.

When we, the so-called 'wise man' interfere with our soils in the garden we tend to destroy the soil. Chemical fertilizers are generally washing out because mostly they are not reaching the rhizosphere of roots. Chemical fertilizers and excessive soil turning completely destroy the natural soil food web by introducing nitrogen in the form of nitrates. Plants then bypass the microbial – assisted natural way of obtaining nutrients and that in turn will have ripple effects for the microbes throughout the entire soil food web. Rototilling for example breaks up fungal hyphae, decimates worms and rips and crushes arthropods and destroys soil structure. Once a gap in the soil food web opens the system is liable to break down and stop functioning. In this way soil becomes lifeless just a healthyhuman body can become sick and even lifeless through the excessive ingestion of antibiotics, vaccines, processed food and chemical drugs. A healthy soil provides potential to grow a wide variety of plants while a sterile soil can support only the toughest of species.

The ideal garden soil is loam, a mixture with relatively equal parts of sand, silt and clay. A perfect structure in these soils is supported by bacteria, fungi and worms that produce glues (polysaccarides, sticky carbohydrates) that bind individual soil particles into aggregates. Bacteria exude slime that allows them to stick to particles as well as to each other to form colonies together with particles. In a similar way some fungi produce glomalin, a sticky protein. The fungi's hyphae growth through soil pores use glomalin like superglue to create small clumps of aggregates which makes it easier for the soil to hold capillary water and soluble nutrients. All organisms that move through the soil create spaces according to the size of their bodies together contributing to perfect soil structure, characterized by good water and nutrient retention. A good example of this are termites with their extensive tunneling activity in the soil. Termites are kept in check by some ant species that also utilize the same tunnels. As ecological gardeners we aim to support these natural processes always. Whatever you do, consider repercussions of your actions on microbes first. A termite treatment or application of fertilizers in your garden may do more harm than good.

To analyze your current state of soil dig a hole 30 cm wide and put the excavated soil on a tarp or box . Sift through the soil and look out for what visible organisms you find. Presence of worms is a good indicator for a healthy soil because the worms serve a food for mammals while eating bacteria, fungi, protozea and even nematodes, in other words the whole set of soil food web organism at work in the soil. Similarly the presence of millipedes and centipedes, beetles, spiders and springtails even a few slugs and snails indicate a healthy soil food web. If your soil is hard to dig up and shows none of these organisms you will have to re-awaken the 'soil corpse' in order to grow anything at all.

BACTERIA

Bacteria are everywhere. They are prokaryotic cells generally one tenth of the size of eukaryotic cells (about 0,5 to 5 µm in length) and as prokaryotes their DNA is typically contained in a single chromosome that is not enclosed in a nucleus. Bacteria reproduce by single cell division and can produce an offspring of 5 billion in 12 hours. When soils dry out bacteria become dormant. Bacteria are primary decomposers second to fungi. Bacteria break up organic matter into smaller, electrically charged pieces and then transport these through their cellular membranes, ready for use. Once inside the bacteria, the nutrients are locked up until the bacteria die or are eaten by other organisms such as protozoa in the main. Root exudates are favorite foods for certain bacteria apart from any organic matter made up of large complex molecules and which the bacteria break into smaller molecules outside using enzymes before ingestion of the smaller molecules. There are two main groups of bacteria, aerobic and anaerobic. Clostridium are an example of anaerobic invading decaying matter from the inside and don't need oxygen. They are recognizable by releasing foul smelling hydrogen sulfide, butric acid, ammonia and vinegar. Anaerobic bacteria often foster pathogenic bacteria and kill off aerobic bacteria. We want aerobic bacteria which rely on oxygen and are adept to break down cellulose and chitin too difficult to digest carbon containing compounds. Lignin, the tough brown component of barks and woody material is too difficult for bacteria and is left to fungi to decay. Some bacteria can convert nitrogen from the atmosphere into plant available forms and include Azotobacter, Azospirillium, Costridium and Rhizobium, the latter species living in the root tissues of certain plants, particularly legumes, where they form visible nodules. Other special nitrite bacteria such as Nitrosomonas are able to convert ammonium compounds from protozoa and nematode waste into nitrites. From there another type of bacteria, the Nitrobacter finally convert nitrites into nitrates which then can be uptaken by plants. Bacteria lock up material that would otherwise be washed out of the soil, the nutrients later released in the waste products that eat the bacteria. Existing in just about every habitat of planet earth, bacteria were one of the first DNA based lifeforms and perhaps will also be the last following the next extinction particularly their anaerobic manifestation which depend on oxygen.

NEMATODES

Nematodes are non segmented, blind roundworms, that along with protozea, mineralize nutrients contained in bacteria and fungi. There name is from the Greek 'nema' which means 'thread'. Over

20,000 species of nematodes have been identified and as a whole are considered the second most dominant form of animal life next to arthropods, may be as many as 1 million species in total. The roughly 2,271 genera are placed in 256 families. The many parasitic forms include pathogens in most plants and animals. A third of the genera occur as parasites of vertebrates; about 35 nematode species occur in humans. Nematodes are very small, slender worms: typically about 5 to 100 µm thick and 0.1 to 2.5 mm long. The smallest nematodes are microscopic, while free-living species can reach as much as 5 cm length, and some parasitic species are larger still, reaching over 1 m in length.

A teaspoon of good soil has about 20 bacteria eating nematodes, 20 fungal feeders and a few predatory and plant eating nematodes in it. From a gardeners perspective mineralization is the most important beneficiary action by nematodes particularly nitrogen. If the soil is too compacted or the wrong texture it will subdue nematodes and with it also the flow of nitrogen to plants.

Nematodes have successfully adapted to nearly every ecosystem: from marine to fresh water, soils, from the polar regions to the tropics, as well as the highest to the lowest of elevations. They inhabit the Earth's topsoil, or approximately 60 billion for each human, with the highest densities observed in tundra and boreal forests. Their numerical dominance, often exceeding a million individuals per square meter and accounting for about 80% of all individual animals on earth, their diversity of lifecycles, and their presence at various trophic levels point to a vitally important role in many ecosystems. Different free-living species feed on materials as varied as bacteria, algae, fungi, small animals, fecal matter, dead organisms, and living tissues. Even in the marine enviroment the free-living nematodes play a very important role in the decomposition process by aiding in the recycling of nutrients and are sensitive to changes in the environment caused by pollution.

The oral cavity of nematodes is lined with cuticle, which is often strengthened with structures, such as ridges, especially in carnivorous species, which may bear a number of teeth. The mouth often includes a sharp stylet, which the animal can thrust into its prey. In some species, the stylet is hollow and can be used to suck liquids from plants or animals. No stomach is present, with the pharynx connecting directly to a muscleless intestine that forms the main length of the gut. This produces further enzymes, and also absorbs nutrients through its single-cell-thick lining. The last portion of the intestine is lined by cuticle, forming a rectum, which expels waste through the anus just below and in front of the tip of the tail. The movement of food through the digestive system is the result of the body movements of the worm. The intestine has valves or sphincters at either end to help control the movement of food through the body.

Nitrogenous waste is excreted in the form of ammonia through the body wall, and is not associated with any specific organs. However, the structures for excreting salt to maintain osmoregulation are complex.

The bodies of nematodes are covered in numerous sensory bristles and papillae that together provide a sense of touch. Behind the sensory bristles on the head lie two small pits, or 'amphids'. These are well supplied with nerve cells and are probably chemoreception organs.

Nematodes that commonly parasitise humans include ascarids (Ascaris), filarias, hookworms, pinworms (Enterobius), and whipworms (Trichuris trichiura). The species Trichinella spiralis, commonly known as the 'trichina worm', occurs in rats, pigs, bears, and humans, and is responsible for the disease trichinosis. Baylisascaris usually infests wild animals, but can be deadly to humans, as well. Dirofilaria immitis is known for causing heartworm disease by inhabiting the hearts, arteries, and lungs of dogs and some cats. Haemonchus contortus is one of the most abundant infectious agents in sheep around the world, causing great economic damage to sheep. In contrast, entomopathogenic nematodes parasitize insects and are mostly considered beneficial by humans, but some attack beneficial insects.

Depending on its species, a nematode may be beneficial or detrimental to plant health. From agricultural and horticulture perspectives, the two categories of nematodes are the predatory ones, which kill garden pests such as cutworms and corn earworm moths, and the pest nematodes, such as the root-knot nematode, which attack plants, and those that act as vectors spreading plant viruses between crop plants. Plant-parasitic nematodes are often known as eelworms and attack leaves and buds.

About 90% of nematodes reside in the top 15 cm of soil. Nematodes do not decompose organic matter, but, instead, are parasitic and free-living organisms that feed on living material. Nematodes can effectively regulate bacterial population and community composition. For example they may eat up to 5,000 bacteria per minute. Also, nematodes can play an important role in the nitrogen cycle by way of nitrogen mineralization.

GASTROPODS

Gastropods (Slugs and snails) greek for 'stomach-foot' and often called mollusks, as a group of 40,000 species area are extremely susceptible to dehydration, Slugs don't have a shell like snails and so have lost its protection but gained greater mobility and can squeeze into smaller spaces and so increasing its scavenging range to up to a mile at night. Garden slugs and snails are nocturnal to take advantage of greater humidity and reduced susceptibility to predators and by day hiding in the soil or under debris. Both snails and slugs eat leaves but also fungi, algae, lichen and rotting organic matter. Snails and slugs speed decomposition in the soil food web in action similar to earthworms. They themselves area a good food source for ground beetles, spiders, snakes , lizards and birds.

PROTOZEA

The term Protozoa is formed from the Greek words prôtos, meaning "first", and zoa, plural of zoon, meaning "animal".

Scientifically Protozoa is a term for a group of single celled eukaryotes (single celled organism with a nucleus), either free-living or parasitic, which feed on organic matter such as other microorganisms or organic tissues and debris. Historically, protozoans were regarded as "one-celled animals", because they often possess animal-like behaviors, such as motility and predation, and lack a cell wall, as found in plants and many algae. Parasitic and symbiotic protozoa live on or within other organisms, including vertebrates and invertebrates, as well as plants and other single-celled organisms. Association between protozoan symbionts and their host organisms can be mutually beneficial. For example flagellated protozoans such as Trichonympha and Pyrsonympha inhabit the guts of termites, where they enable their insect host to digest wood by helping to break down complex sugars into smaller, more easily digested molecules A wide range of protozoans live in the rumens of ruminant animals, such as cattle and sheep. Some are harmless or beneficial to their host organisms; others may be significant causes of diseases, such as babesia, malaria and toxoplasmosis. In the soil Protozoans obtain their nutrients by ingesting bacteria primarily but also fungi on occasion and to a lesser extent protozoa. Soil protozea are between 5 to 500 micrometers at least ten times the size of bacteria. A teaspoon of good soil contains a billion count bacteria but only several thousand protozea,

Organisms traditionally classified as protozoa are abundant in both, aqueous environments and soil, occupying a range of trophic levels. The group includes flagellates (which move with the help of whip-like structures called flagella), ciliates (which move by using hair-like structures called cilia) and amoebae (which move by the use of foot-like structures called pseudopodia). Some protozoa are sessile, and do not move at all. Over 60000 kinds of protozea are known, the majority of them living in soil and a protozea can eat thousands of bacteria a day. Protozea need moisture to live, travel and reproduce and when things dry up most of them stop feeding and dividing and go dormant, encasing themselves in a cyst. These protozoa have two-phase life cycles, alternating between proliferative stages (e.g., trophozoites) and dormant cysts. As cysts, protozoa can survive harsh conditions, such as exposure to extreme temperatures or harmful chemicals, or long periods without access to nutrients, water or oxygen. Being a cyst enables parasitic species to survive outside of a host, and allows their transmission from one host to another. When protozoa are in the form of trophozoites (Greek tropho = to nourish), they actively feed. The conversion of a trophozoite to cyst form is known as encystation, while the process of transforming back into a trophozoite is known as excystat.

As components of the fauna, protozoa are an important food source for microinvertebrates. Thus, the ecological role of protozoa in the transfer of bacterial and algal production to successive trophic levels is important. As predators, they prey upon unicellular or filamentous algae, bacteria, and microfungi. Protozoan species include both herbivores and consumers in the decomposer link of the food chain. They also control bacteria populations and biomass to some extent. The waste of protozea contains carbon and other nutritional compounds now available to plants. About 80 % of the nitrogen a plant needs comes from the wastes produced by protozea. Certain nematodes and worms rely on a healthy population of protozoa as do many microarthropods. In summary they are a crucially important component of the soil food web and a must have in your garden. You can grow protozoa quite easily by putting your grass clippings into a bucket with water and let it rest for a couple of days. The water will be teaming with protozoa which you then transfer where its needed to improve the level of protozoa and thus other microbial life in the soil.

ARCHAEA

Archaea are a weird and unusual bacterialike microorganism that plays a key role in nitrogen fixing in soils, converting atmospheric nitrogen to a plant usable form. Archaea are in their own kingdom next to bacteria and the Eukaryotes (protists, plants, fungi and animals) and believed to be the oldest of all kingdoms, being able to survive the extreme conditions that existed during the establishment of life on earth. Archaea superficially look like bacteria but are chemically different on the genetic level. They are also hugely important in the carbon cycle, similar to plants using CO_2 as a source of carbon. They are abundant, in fact it is believed the archaea are the most abundant lifeform on earth. Archaea like bacteria are decomposers and break down organic and inorganic materials. When they go about their business they produce methane, a key greenhouse gas. It is believed that 10 -25 % of methane emissions come from archaea and a significant part of that from rice production as well as from the archaea in the stomach of ruminants such as cattle.

ALGAE

Algae are broadly defined as single-celled or thread-like photosynthetic organisms. Unlike bacteria and fungi, algae are primary producers that is they make their own food by using energy from the sun. A teaspoon of soil may contain between 10,000 and 100,000 cells of green algae, yellow green algae and diatoms. The decay and chemical weathering brought about by algae is sometimes aided by fungi in the form of a symbiotic relationship known as lichen. Lichen contribute nitrogen to soil and blue-green algae fix nitrogen where algae exist in soils in as they excrete sticky stuff to help bind and aggregate soil particles.

EARTHWORMS

An earthworm is a terrestrial invertebrate that belongs to the phylum Annelida. Depending on the species, an adult earthworm can be from 10 mm long and 1 mm wide to 3 m long and over 25 mm wide, but the typical Lumbricus terrestris grows to about 360 mm long. Earthworms are classified into three main ecophysiological categories: (1) leaf litter- or compost-dwelling worms that are nonburrowing, live at the soil-litter interface and eat decomposing organic matter (epigeic), (2) topsoil- or subsoil-dwelling worms that feed (on soil), burrow and cast within the soil, creating horizontal burrows in upper 10–30 cm of soil (endogeic); and (3) worms that construct permanent deep vertical burrows which they use to visit the surface to obtain plant material for food, such as leaves (anecic, meaning "reaching up"). They exhibit a tube-within-a-tube body plan, are externally segmented with corresponding internal segmentation. All these occur worldwide where soil, water and temperature allow and are commonly found in soil, eating a wide variety of organic matter. This organic matter includes plant matter, living protozoa, nematodes, bacteria, fungi, and other microorganisms. An earthworm's digestive system runs the length of its body. It respires through its skin. It has a double transport system made of coelomic fluid that moves within the fluid-filled coelom and a simple, closed circulatory system.

Earthworms are hermaphrodites and each carries male and female sex organs. As invertebrates, they lack a true skeleton, but maintain their structure with fluid-filled coelom chambers that function as a hydrostatic skeleton.

There are almost 7000 species of earthworms to good garden soil which on average can contain 100 or more per square meter, that is a lot more than in natural forest soils which contain about 25 per square meter. It takes two worms to produce offspring, although worms caring both sets of sexual organs. Earthworms are integral in the shredding of organic matter, the aeration of soil, the aggregation of soil particles and the movement of organic matter and microorganism throughout the soil. They increase microbial populations and aid plant growth. Earthworms have neither eyes nor teeth and primarily eat bacteria but also fungi, nematodes, protozea and organic matter, really anything that gets into its way. The ingested food is ground up by powerful gizzard muscles with the help of sand and small rock particles that it contains. Fresh earthworm casts are five times richer in available nitrogen, seven times richer in available phosphates, and 11 times richer in available potassium than the surrounding upper 150 mm of soil. Earthworms shred debris so other organisms can more readily digest them, increase porosity, waterholding capacity, fertility and organic matter of soils. Rototilling and other mechanical means of turning soil destroy worm burrows and worms themselves, while chemical fertilizers irritate worms and displace them from the garden. With them gone, the rest of the soil food web disintegrates also. Ultmately what your soil can support will in part depend on the relative presence of earthworms.

Earthworms do not have eyes with few exceptions, although they do have specialized photosensitive cells called "light cells of Hess". Earthworms have no special respiratory organs. Gases are exchanged through the moist skin and capillaries, where the oxygen is picked up by the haemoglobin dissolved in the blood plasma and carbon dioxide is released. Water, as well as salts, can also be moved through the skin by active transport. At birth, earthworms emerge small but fully formed, lacking only their sex structures which develop in about 60 to 90 days. They attain full size in about one year. Scientists predict that the average lifespan under field conditions is four to eight years, while most garden varieties live only one to two years. Copulation and reproduction are separate processes in earthworms. The mating pair overlap front ends ventrally and each exchanges sperm with the other. The clitellum becomes very reddish to pinkish in colour. Sometime after copulation, long after the worms have separated, the clitellum secretes material which forms a ring around the worm. The worm then backs out of the ring, and as it does so, it injects its own eggs and the other worm's sperm into it. Thus each worm becomes the genetic father of some of their offspring and the genetic mother of the rest.

Earthworms travel underground by the means of waves of muscular contractions which alternately shorten and lengthen the body (peristalsis). The whole burrowing process is aided by the secretion of lubricating mucus. As a result of their movement through their lubricated tunnels, worms can make gurgling noises underground when disturbed. Earthworms move through soil by expanding crevices with force; when forces are measured according to body weight, hatchlings can push 500 times their own body weight whereas large adults can push only 10 times their own body weight.

Earthworms are preyed upon by many species of birds, snakes, mammals and invertebrates (e.g. Ants, flatworms, ground beetles and other beetles, snails, spiders, and slugs). Earthworms have many internal parasites, including protozoa, platyhelminthes, and nematodes; they can be found in the worms blood, seminal vesicles, coelom, or intestine, or in their cocoons. Touching an earthworm, which causes a "pressure" response as well as (often) a response to the dehydrating quality of the salt on human skin (toxic to earthworms), stimulates the subepidermal nerve plexus which connects to the intermuscular plexus and causes the longitudinal muscles to contract. This causes the writhing movements observed when a human picks up an earthworm.

Earthworm populations depend on both physical and chemical properties of the soil, such as temperature, moisture, pH, salts, aeration, and texture, as well as available food, and the ability of the species to reproduce and disperse. One of the most important environmental factors is pH, but earthworms vary in their preferences. Most favour neutral to slightly acidic soils. Nitrogenous fertilizers tend to create acidic conditions, which are fatal to the worms, and dead specimens are often found on the surface following the application of substances such as fertilizer, lime sulphur, and lead arsenate. In Australia, changes in farming practices such as the application of superphosphates on pastures and a switch from pastoral farming to arable farming had a devastating effect on populations of the giant Gippsland earthworm, leading to their classification as a protected species. Globally, certain earthworms populations have been devastated by deviation from organic production and the spraying of synthetic fertilizers and biocides, with at least three species now listed as extinct but many more endangered.

Composting of all organic "wastes" and addition of this organic matter, preferably as a surface mulch, on a regular basis, can improve food and nutrient supplies to earthworms, and together with improved conditions of temperature and moisture will naturally stimulate their activity. The earthworm activities aerate and mix the soil, and so is conducive to mineralization of nutrients and their uptake by vegetation. Certain species of earthworm come to the surface and graze on the higher concentrations of organic matter present there, mixing it with the mineral soil. Because a high level of organic matter mixing is associated with soil fertility, an abundance of earthworms is generally considered beneficial by farmers and gardeners. As long ago as 1881 Charles Darwin wrote: "It may be doubted whether there are many other animals which have played so important a part in the history of the world, as have these lowly organized creatures”.

Earthworms are fundamental indicators of soil health. They feed on the decaying matter in the soil and analyzing the contents of their digestive tracts gives insight into the overall condition of the soil. The earthworm gut accumulates chemicals, including heavy metals such as cadmium, mercury, zinc, and copper. The population size of the earthworm indicates the quality of the soil as healthy soil would contain a larger number of earthworms. In many soils, earthworms play a major role in the conversion of large pieces of organic matter into rich humus, thus improving soil fertility. This is achieved by the worm's actions of pulling below the surface deposited organic matter such as leaf fall or manure, either for food or to plug its burrow. Once in the burrow, the worm will shred the leaf, partially digest it and mingle it with the earth. Worm casts can contain 40 percent more humus than the top 23 cm of soil in which the worm is living. In addition to dead organic matter, the earthworm also ingests any other small soil particles into its gizzard, wherein the minute fragments of grit grind everything into a fine paste which is then digested in the intestine. When the worm excretes this in the form of casts, deposited on the surface or deeper in the soil, minerals and plant nutrients are changed to an accessible form for plants to use.

Earthworms accelerate nutrient cycling in the soil-plant system through fragmentation/mixing of plant debris and physical grinding/chemical digestion. Darwin estimated that arable land contains up to 13 earthworms per squaremeter, but more recent research has produced figures suggesting that even poor soil may support 62 earthworms per squaremeter, whilst rich fertile farmland may have up to 432 earthworms per squaremeter, meaning that the weight of earthworms beneath a farmer's soil could be greater than that of the livestock upon its surface. Richly organic topsoil populations of earthworms are much higher, averaging 500 worms per squaremeter such that, for the 7 billion of us, each person alive today has support of 7 million earthworms.

The ability to break down organic materials and excrete concentrated nutrients makes the earthworm an outstanding functional contributor in landscape restoration projects and an absolutely crucial biological agent in gardens. Thus in response to ecosystem disturbances in many sites earthworms are being utilized to prepare soil for the return of native flora. In a similar way we too can increase earthworms on the gardenscale by adding large amount of organic mulch and compost to the surface of planted areas in conjunction with measures to aerate soils and compaction remedies. This will not only increase biological activity and biodiversity within the soil but also help to increase the waterholding and drainage capacity of soils all to the benefit of the plants we grow in it.

Concluding the description of life forms that can be found in a Darwin garden with basic considerations of links and relationships with other organisms and between them I think that many of these relationships are not known or poorly researched. We may know what an organism feeds on for example such as a certain bird species by analyzing its stomach contents or droppings but that in itself may not mean much because individuals within the same species may respond differently to both local and seasonal food variability. The remainder of this book aims to help you to plan, design and construct a self sustaining garden that provides a habitat to wildlife, not just for your preferred cute animals but also to the organisms that those animal needs. The web of life often contains numerous pathways and even just the food chain of a single animal can turn out to be incredibly complex. Your wildlife friendly garden will almost certainly become an experiment of one that is as unique and wonderfully inspirational as much as you wish and plan for it.

GARDENING FOR WILDLIFE

PLANNING PROCESS

Planning starts with a clear definition of objectives a formulation of the purpose of the garden. This of course is a personal matter and for many a life-style choice. For me it is a strong desire to connect with wildlife on a daily basis by bringing the native plants and its animals, particularly the birds of my choice close to home. What I envisaged was: to walk three steps, sit outside, watch and connect with a flock of birds and other creatures or simply enjoy the beauty of native flowers. Having determined what you really want, you may then evaluate this purpose of your garden within the bigger context of the surrounding landscape and analyze as to how realistic the purpose of your garden is and perhaps adjust the overall goal when discovering opportunities or obstacles. For example if you happen to live close to a reserve with rainforest and grassy edges there may be the opportunity to draw in some wildlife such as Brown Quails or the elusive Rainbow Pitta from the reserve by replicating and extending the floristic make up. Or you may talk to your neighbor and discover he has a breeding pair of a particular animal in his garden thus providing an opportunity to extend the theme by providing supporting habitat. In any case it is a very good idea to ask yourself a few questions before pondering on anything else in order to formulate the context of your garden, the answers making it easier to clarify purpose, objectives and required actions later on.

• Can the current state of your garden or land, particularly the soils facilitate spontaneous or natural regeneration? Where damage is relatively low and topsoil retained, or where sufficient time frames and nearby populations exist to allow recolonization, plants and animals may be able to recover given the right management regime. Thus animal species may be able to recolonize the site if there is sufficient habitat connectivity, and plant species may recover through resprouting or germination from remnant soil seed banks or seeds that naturally disperse from nearby sites such as by frugivorous birds.

• Can the current state of your garden facilitate assisted regeneration? Restoration at sites of intermediate or greater degradation requires removal of the causes of degradation and active interventions to correct abiotic and biotic damage and trigger biotic recovery. Interventions include: actively restoring growing conditions perhaps after reshaping landforms, applying artificial disturbances to break seed dormancy as well as introducing habitat features such as hollow logs, rocks, woody debris piles, soil microniches, and perch trees.

• Does your garden require a significant degree of reconstruction? Where damage is high such as in cleared and compacted land, not only do all causes of degradation need to be removed or reversed and all biotic and abiotic damage corrected to suit a suitable reference ecosystem, but also all or a major proportion of its desirable biota need to be reintroduced wherever possible. The biota can then interact with abiotic components to drive further recovery of ecosystem attributes. In some cases where sequential recovery is a characteristic of the ecosystem or is needed (e.g., to help recovery of soils), earlier succession species may be reintroduced earlier than later succession species rather than all species to be introduced from the outset.

• What vegetation is present in your garden and all around it in the neighborhood and beyond? Is exising your garden a simple open lawn and a few scattered trees or is the site large enough and structurally complex with lots of layers of different vegetation such as trees and shrubs of different heights, grasses, ground covers, leaf litter? A more structurally diverse garden will support more animal species. Understanding the wider context of habitat within your neighborhood will assist you in selecting the plants suitable for your garden later on. Consult information sources such as the Greater Darwin Landunit Survey, the Darwin Remnant Vegetation Survey and look up high resolution satellite imagery in Google Map to analyze what is around you and consider it in historical context.

• What wildlife is using the garden and what is in the wider area? Know which species you are trying to encourage. You should be trying to encourage wildlife that occurs in the area around your garden and are realistically going to use the site in the first instance. It is no good creating a habitat for Superb Fairy-wrens if they haven't been seen anywhere near the site in 20 years. However if they are located a short distance away then creating a habitat for them has a much greater chance of success. While the amount and type may vary, all animals need food and water, shelter and a safe place to nest, whether that is a dense thicket, tall tree or hollow. Most of these requirements can be met by the availability of suitable vegetation. In most cases locally native vegetation is the only appropriate type for local wildlife because instinctual knowledge of it and specific adaption to it that has been in their DNA for thousands of years. Because urban habitats are so fragmented, one garden will not be large enough to provide all of the requirements that some animals will need. However, each garden can make a contribution in forming the web of habitat that wildlife uses.

• What type of soil do you have in your garden: Specific soils not only support specific types of vegetation but also provide different types of habitat for trillions of microbes such as bacteria, fungi, protozea and viruses as well as soil dwelling insects and other creatures. Australian research has recently discovered that the more diverse the microbes living in the soils around us, and the more you are exposed to them through the airborne microbes and by touching soil, the healthier you become. We literally become our gardens because ultimately everything around is is physically connected with us through the air we breathe in. Microbiome restoration moves degraded sites to a more bio-diverse state and involves restoring the balance of good and bad bacteria in the soil through improving soil, mulching and planting. If your topsoil is shallow and/or compacted because it had been striped or degraded then you may consider ways to enrich it through mulches or imported organic materials. Mulch will decompose very quickly in the wet season and is one of the best ways to restore a diverse and balanced microbe habitat particularly if the mulch is improved by added compost.

• Do you need to remove vegetation? Wherever possible do not remove vegetation immediately: instead wait until new vegetation establishes and produces flowers and/or fruit. Some weeds are popular with wildlife and provide important habitat so even their removal should be carefully considered and staged. If removing weeds or undesirable plants, remove only small patches of vegetation at a time and replace it immediately with new plantings. Be aware that it can take years for new woody vegetation to establish but many animals may abandon the garden, or be preyed upon if all or large portions of the intact vegetation are removed too quickly.

• What do I need to plant? Always plant appropriate locally sourced plant species. This vegetation is traditionally used by wildlife in the area and is likely the best suited to the conditions of the site. Once established, many native plants in Darwin are not only drought tolerant but also withstand prolonged wetting as long as your soil is well draining. Use many different species throughout the planting rather than a select few plants. Gardens that contain a broad range of plant species, are more likely to support a broad range of animal species. Plant clumps of 5 - 7 plants of the same species together so there is enough of the resource (food or shelter) available to be used by the animals. Numerous groupings or thickets of different plant species are also better for overall aesthetics and design. You may need to check availability of native plants and if not available plan and learn to propagate them. This can be very time consuming and take more than a year.

• What plant structure is required? The key is to create structural diversity – so lots of different plants and lots of different layers. Having a mix of trees, shrubs of varying heights, grasses and ground covers will maximize the numbers of animals using a site. Gardens do not have to have trees to attract wildlife, therefore if space is an issue a garden consisting of shrubs and grasses can still be effective. Retaining patches of open grass is also important for some birds and the insects they may seek out. Gardens with tall trees and grass but without shrubs are more likely to have large and aggressive birds. Restoring a shrub layer is key for providing a habitat that small animals can use. A good model of vegetation type in Darwin to look at for inspiration is that of the East Point Reserve which according to Russell-Smith (1991) falls with in group 9 (Dry coastal) semi-deciduous rainforest and vine thicket. This habitat in the case of East Point Reserve provides a shady environment of an interesting grouping of 79 native plant species to support a rich fauna habitat that could serve as a good model for most Darwin gardens. Naturally there are some plant species that are not suitable for very small urban plots such as Acacia auriculiformis or Terminalia microcarpa. You can find valuable ideas in terms of vegetation structure and floristic groupings from the 'East Point Biodiversity Report' that is available through the Darwin City Council website.

• What should my garden look like? Small animals like dense shrubs. A more formal and neater garden can be created by the use of pruning to shape these shrubs and most native plants respond very well to pruning. Pruning also encourages a much denser growth pattern, which provides good protection for small birds. Hedges which provide privacy from neighbors as well as bird habitat can be made using native plants. Use local native plants rather than hybrids bred to produce spectacular flowering and as a result may encourage mostly large and aggressive honeyeaters that can chase away smaller birds. Select plants with smaller flowers, ones that small honeyeaters can fit their beaks into but large ones cannot. Many evergreen monsoon-vine thicket trees can be pruned to retain a smaller and more compact shape. You can plant several trees of the same species close together and they would tend to retain a smaller size compared to their size in the natural habitat.

After the purpose of your garden has been determined, objectives can then be more easily formulated. For example if your purpose is to connect with a native garden of a certain type of habitat, the objectives would then be to create matching components that can be found in the natural habitat. Also you have to consider about of how the objectives can be realized. In my instance I considered the range of animals I desire to observe on a daily basis and how to entice them to be present when and where I wanted them to be. You may be interested in birds, perhaps just one type of birds but also butterflies, bees. lizards or mammals or all of them. You then study the species including their habits and requirements for food, shelter and breeding enabling you to precisely plan a floristic and physical structure of plants and other means around those requirements. You may find you want certain species of plants for certain animals, for example providing the favorite food plants such as Umbrella trees for the Red-collared Lorikeet. You look up the flowering time for this tree and perhaps also find other nectar providing plants to extend nectar source beyond the flowering range of umbrella trees. The Red-collared Lorikeet nests in tree hollows or cavities and if you don't have any of them on your property or nearby you may consider to build a nestbox for them. It takes about a 100 years for such tree hollows to develop naturally. The more thought you put into your design in this early planning stage the more likely you succeed. The planning process is summarized into the following steps:

- Connectivity (Consideration of the relationship of your site to the surrounding landscape)
- Purpose of the garden (A broad statement of the desired result)
- Objectives (the end towards which specific efforts are directed, for example a list of animals or organisms to be present)
- Actions (Specific efforts required, such as a list of plant species or materials)

When your vision of your garden is clear then it is time to sharpen the pencil and sketch out what goes where on a scaled map of your property. A garden designed for wildlife may superficially be similar to other gardens but would incorporate specific design solutions, the subject of the next chapter.

DESIGN PRINCIPLES OF ECOLOGICAL GARDENING

Urban areas are not completely devoid of suitable wildlife habitats and many residential suburbs provide significant areas of vegetation potentially available to birds, insects and other animals. The continuous forests with tall trees and a structurally complex understorey of shrubs and grasses interspersed with monsoon vine-thicket and paperbark forests originally found in the wider Darwin area have largely been removed during the early development of of the township and then again with the re-construction of Darwin following the extremely destructive cyclone Tracy in 1974. The now dominant vegetation of our suburban gardens and parks are sprawling lawns that require constant watering and mowing, tropical trees, both exotic and native, but also a plethora of exotic shrubs, in suburbs intersected with concrete, roads and houses. This 'urban habitat' bears little resemblance to the original forest cover. Even the species of plants are different; exotic and interstate (especially hybridized species and cultivars) and a select few natives mostly rainforest plants that have replaced the original local Savannah open forest or woodland. As a direct result of these major changes, our suburban gardens now support a wildlife community that is probably quite narrow and of a different species composition compared from those in the historic natural habitat. Suitable habitat for species with large habitat requirements cannot easily created at the garden level but needs to occur across numerous patches at the landscape scale, with structure as well as the variety of plant species taken into account. This means that there is a need for us to change the culture of gardening in Darwin at a community level in order to be able to make changes with real impact across the landscape. Individuals can make a start right now and the more people that create these floristically more diverse and wildlife friendly gardens, the richer the diversity of wildlife will be on the whole.

Here we consider a few design principles specific to sustainable gardens particularly with a view to improve and enrich interaction of animals and plants in your garden.

- Water: Replicate and promote processes of natural water systems including infiltration of rainfall and runoff, evaporation, transpiration and runoff that occur in undisturbed natural forested landscapes (more of that under the chapter design process - technique - water harvesting). In a natural forest precipitation moves 40 -50 % into evaporation, 20 – 40 % into the soil and then some from the soil into groundwater with the remaining surface runoff here being only less than 1 %. In contrast surface runoff in the typical suburban environment is 20 – 30 % with a sharply reduced evaporation share compared to forest. In other words development has increased runoff by 20 to 30 times compared to the historic landscape, the water being lost to urban drainage discharges. We aim to reverse this process in our garden for wildlife by gathering, absorbing, holding and releasing rainwater much like a sponge as natural landscapes do and so effectively controlling floods, recharging groundwater and sustaining diverse ecosystem. In the chapter design process I suggest some techniques to achieve that aim.

- Soil: Improve your soils based on a percolation testing, ph testing and soil texture test. Soil is the foundation that underpins the success of your garden. It is made up of mineral solids, water, air and organic matter. More broadly it supports vegetation that we rely upon for the air and breathe and the food we eat. Moreover soils protect water quality and supplies by filtering and retaining water, cleaning contaminated water, reduces runoff, erosion, sedimentation and flooding. Further, soils store carbon and support a healthy population of microorganisms. The chapter techniques will cover soil testing and soil amendments. Consider improving the cycle of organic matter in your garden. The primary consumers of organic matter are fungi and bacteria at the most basic level. Secondary consumers include protozoas, springtails, nematodes and mites. The next higher level incorporates earthworms, ground beetles, millipedes, centerpedes, ants and spiders. At each of these levels nutrients are released to build a healthy soil. The source of on-site generated organic material includes landscape trimmings and food scraps to be composted for soil amendments, large woody debris to be chipped and used as mulch and lawn cuttings to be left as clippings in situ. The principle here is to retain all organic waste and in-situ recycle into nutrients while providing the support for a diverse range of soil based microbes.

- Vegetation: Create diversification of vertical and horizontal structure and avoid over simplification. Planting for bird and wildlife biodiversity requires heterogeneity of structure of the species being planted, both applied to the smallest backyard and garden patch and right up to the scale of the re-vegetation of entire landscapes. (heterogeneous means composed of or part of different kinds, in this context meaning for example composition of different plant species in different spatial structures such as high canopy, understorey and groundcover, but also of different ages of plants, for example old trees have nesting hollows while young don't.)

- Birds do better in vegetation that is heterogeneous that is plantings of multiple different native species, with multiple age classed and varied patches. Classical formal garden structure and design may seem attractive to the human eye and human psychological need for order as well as perception of security but often also reduces the diversity of food and shelter niches especially for small animals. Aim to create or tolerate both unplanned and organized chaos in order to proliferate a diversity of small habitat niches.

- Create efficient shelter(s) by mass planting of shrubs. Closely planted shrubs form a dense protective thicket, great for small birds and other animals. Grow rambling, light climbers in amongst medium to tall shrubs and trees, to give extra shelter and possible nesting sites. To encourage a range of animals in domestic gardens, habitats need to be created that are similar to those in their natural environment. For the smaller animals most adversely affected by urbanization, this means creating dense, understorey vegetation in gardens as opposed to scattered trees and lawn. For example many small birds use vegetation up to a height of about 2 m for shelter, feeding and for nesting. By providing a diverse range of different shrubs and ground covers within gardens we not only replicate what is found in natural woodland and forest habitats but also provide a range of food sources (primarily nectar and insects) that can be used by birds. Insect pollinated plants encourage a greater diversity of insects, providing food for insectivorous species while also creating shelter. Pockets of dense shrubs can be achieved in two ways. Firstly, by growing plants close together in garden beds. (While plant mortality may be slightly higher due to increased inter plant competition, weeding is also reduced). Secondly, by pruning and shaping shrubs as they grow, allowing the gardener to have control over the shape of the shrub and encouraging dense coverage. Humans need shade and shelter just as animals do and we can provide for both by installing structures such as pergolas and trellises combined with climbing plants.

- Plant for food diversity, for example small birds eat nectar from native flowers and seed from native grasses, as well as associated insects. Mulch your garden to encourage insect life. Logs can make good edging around beds and also provide habitat. The use of mulch around plants and in garden beds encourages a range of invertebrates that not only improves the quality of the soil and reduces the amount of water needed in the garden but also provides food for many bird species. Gardens for wildlife accommodates access not only to live but also to dead vegetation such as snags, downed trees and leaf litter in order to provide precise needs of specialized native wildlife, the right cover, the right nest building materials and the right dietary nutrition such organism need for survival.

- Plant locals: Plants that grow naturally in your area are suited to local conditions. They will provide the right food shelter for local native birds, unlike some hybrids or plants from other parts of Australia, and are less likely to become weeds in adjacent bushland areas. If you can't get locally native plants grow them yourself by collecting seeds or cuttings.

- Create a garden with floristic diversity for different animals using ground covers, grasses, small, medium and large shrubs. Invertebrates are also found on grass so retaining some areas of grass is necessary for ground foraging species. Allowing patches of grass to grow and go to seed also provides food for a number of granivorous species, including parrots and finches. This can be done on a rotation basis so there is always some open short grass space available. Fallen wattle seed is also a potential food source for these birds. Understanding the micro-habitat needs of individual species may help in designing new habitats that will better cater for a given species or combination of species. The problem is that for many species these important characteristics are poorly known. In the absence of such information, maximizing the structural and floristic diversity of habitats is a good default and likely to result in a higher number of species resident being resident for longer period and perhaps breeding success.

- Use shade tolerant groundcover plant species under the canopy of larger trees to utilize space in a restricted area.

- Create a year round flowering calendar in your garden by you choice of flowering plants. Different plants will flower and fruit at different times of the year, thus providing food sources throughout the year. You can quickly check flowering periods using the plant chart of recommended plant species in the appendices,

- Reduce lawn area: Replace unused lawn areas with garden beds, native grasses and perennial herbs which produce attractive seed heads that provide food for finches and other seedeaters.

- Use small gardens effectively: With limited space, it is better to plant several plants of the same type, than only one of several types of different plants.

- Provide water: All animals need fresh water. This can be provided in a bird bath or garden pond but remember, birds are vulnerable when they are drinking or bathing and need to feel safe.
- Just like us, most animals including birds prefer to be active during the cooler part of the day. The early morning and later afternoon are often the best time when animals move about to feed or find water. In the Dry Season when most of the standing and running water in the Top End has dried out, life concentrates at the remaining waterholes when everyone is coming for a drink. The placement of water such as ponds and bird baths should be relatively close from where you can watch those areas easily without disturbing the wildlife that is using them.

- Research on the landscape scale suggest that around 30 – 35 % of the landscape of each habitat type needs to be covered by relatively natural vegetation for this type to maintain sustainable populations of most animal species. Other factors such as vegetation condition, diversity of vegetation types, inter-specific interaction (ie. exotic predators) and habitat connectivity will also influence the abundance of individual species and of species richness, but the overall amount of wooded habitat appears to be the driving factor. Transferring this principle from landscape to the garden scale suggests that wildlife friendly woody planting in backyards on average to cover at least 35 % of the share of total urban development including roofs, pools, roads, industrial areas, trimmed lawns and other infrastructure.

- Increase the amount of fallen timber, rocks and leaf litter. This provides habitat for insects, spiders, small reptiles and other small organisms. It also provides cover and nesting habitat for a range of ground-nesting birds.

- Connect with nature by incorporating your observation points into the design in a way that does not create disturbance to wildlife such as establishing viewing vistas into the remote corners of your garden, Experiencing urban biodiversity will be the key to lead to a change of attitude necessary to halt the loss of global bird diversity. This is because people are most likely to take action for biodiversity if they have direct contact with nature. A lack of early connection to nature in children might result in a lack of motivation to protect nature. For children, backyards seem particularly important in establishing a life long connection to nature. Much of the urban landscape consists of backyards such that people's primary experience of urban nature may be through their own gardens. This is why it is so important to ensure your backyard is as wildlife friendly as possible. Consider the view from your windows of activity (Kitchen, Living room, Study etc). Simply seeing trees, other plants and wildlife can have a positive impact on your health and well-being which in most persons is critical since we spend much of our lives indoor at home, work and school. It is important to maximize garden views from your room that be occupied the longest.

- Provide enclosures. For a space to have restorative quality it needs to have a sense of 'being away' that is a separation from noise, traffic, unsightly views and even surrounding buildings.

DESIGN PROCESS

The previous identified broad principles of design for a wildlife friendly garden and are now moving on to outline a proposed methodogical design approach.

The first step in the design process is to define your access and movement pattern in and out from the house and the regular activities that you conduct on your property such as working in a shed washing the car, growing vegetables in a greenhouse, using a swimming pool or spa, having a barbecue with family and friends and use of a children's play space if you have any of these. Ideally most of these activities should be concentrated into one or two areas in order to free up as much space as possible to the garden for wildlife. It is surprising how small your garden all of a sudden appears. Most of your paving and lawn should occupy this 'human' space and adjoin a terrace or deck as the main extension of your indoor living area. What wildlife don't needs are activities, pathways and structures criss-crossing your garden and reducing quiet space, all adding up to stress wildlife to retreat from noise and threatening movements of people. We must not forget wildlife is completely driven by instinct much more then humans and any moving object signals danger regardless of if it actual is.

In step two you determine the location of the largest trees you intend to plant. You need to take into consideration where these larger plants throw shade in addition to the shade existing large trees, the house and other structures create. Shaded areas reduce your options in the choice of plants dramatically since most plant species need a degree of at least partial sunlight. Lawns, native grasses and dry savannah species in particular are difficult to establish in shade and need full sun exposure for a good portion of the day. Also take into consideration shade created by your neighbors trees, houses and fencing, all constraints and/or opportunities to what you can do.

In step three you determine forage zones according to wildlife usage such as fruit eating zones, nectar zones, insect zones, shelter zones and nesting zones the size and location depending on your target species. Ideally you would have established a list of wildlife species at this stage and have a rough idea of where these animals are supposed to move about and what activities they undertake. Each feeding zone would ideally be adjoined by a shelter zone compatible with the size and habits of animal species that forages there. Don't complicate things too much with too long a list of many different types of animals but focus on the main animals first or try to group your species into like requirements such as according to food groups like nectar feeding birds. A garden is a living and growing entity. You start with a simple skeleton framework and refine and adjust in future years by taking out and introducing new elements. You aim to cater for year round feeding through your selection of flora in each area and that by selecting plant species according to flowering times. For example if you intend to plant Eucalyptus trees for animals that rely on their flowers as the main feature of your garden, you may need at least four species that flower at different times such as Corymbia bella (Ghost Gum) Aug-Dec or Eucalyptus herbertiana (Herbert's Gum) May-Dec, Corymbia ptychocarpa (Swamp Bloodwood) Oct-Jun and Eucalytus phoenicia (Scarlet Gum) Apr-Jul, Eucalyptus alba (White gum) Jul-Sept or Corymbia polycarpa Mar - Jun, in order to stretch out flowering times but be aware that many eucalyptus take many years before developing flowers. Even though in this case you chose eucalypts on flowering period you would also get other benefits with them because eucalypts in general accommodate a wide variety of insects, manna and lerp and potentially provide a niche for many other wildlife as they age. The eucalyptus species mentioned above have different water requirements which you need to take into account when determining their placement. Print out and use a paper copy of the quick reference charts for animals and plants (appendix A) to assist you in such considerations during this phase of design. By the end of the design phase three you should have a rough bubble diagram map of functional areas and zones of your property together with a list of species for each zone. This initial sketch concept plan considers the relationships with each zone between the human functional structures and movement patters from step 1, the location of large canopy trees from step 2 and wildlife forage, shelter and nesting zones from step 3.

Step four is the creation of the final scaled landscape plan that will show the detailed position of plants and other landscaping elements such as irrigation, mounds, mulched areas, rock placement, grassed and paved areas, garden pond and any other built structures. Such a plan is necessary if you intend to use contractors to implement your vision but it may also help to extract a schedule of plant and material quantities and estimate costs. You may need to prepare several maps to show different aspects such as plants, irrigation and built elements. With your plan move on to the consideration of the practical stuff.

GARDENING TECHNIQUES

SOIL – THE MISUNDERSTOOD FOUNDATION OF THE GARDEN

Many people take soil for granted and look at it as some kind of a thing and solid earthy, sandy, gravelly or rocky mass of dirt under your feet. However what we found through science, soil is much more, a complex living entity made up of a huge amount of interacting organisms. A teaspoon full of fertile garden soil contain a billion bacteria alone. In the past the focus has almost exclusively been on the non-living facets of soil: What is the acidity (pH)? What are the hydrological qualities? What is the status and chemistry of the nutrients in the soil? What is the soil structure and make-up? We now know there is so much more to it, soil is home to a truly staggering diversity of organisms, ranging from minuscule bacteria and archaea, nematodes, earthworms and up to vertebrates such as rodents. A typical single gram of healthy soil holds thousands of species. They all act to together in unison to make nutrients go around for all of them, keep the soil aerated and friable and provide the basic requirements for plants to flourish.

It has long been established that soil organisms are largely responsible for the processing of dead organic material, and therefore, nutrient cycling in ecosystems. In that sense, the soil community has been a recognized factor in ecological productivity. Furthermore new research has discovered many relationships among plants and soil biota that stretch above moving nutrients around. There are various groups of bacteria that stimulate plant growth by changing the production of plant hormones. Other soil dwellers can greatly extend a plant's ability to scavenge for nutrients on poor soils. There are fungi living in plants (endophytes) that allow them to grow in normally unsuitable habitat and also protect plants from pathogens. Indeed, the presence of particular soil organisms can be crucially vital from the plant's perspective.

Soil communities are not only incredibly diverse in terms of species and functions, they also develop over time. As with plant communities, there are distinct changes in below ground species composition over time. Although this depends on the local conditions, soil communities in (semi-)natural systems frequently become more complex over time and shift from many bacteria to relatively more fungi. The soil of your garden too has a history. It is likely somewhat degraded and would probably not much resemble what it once was before clearing and development. Some urban soils are severely degraded through years of punishment and compaction and are bare of the microbes compared to a undisturbed natural system. So how can we use improve relationships and processes in ecological gardening? For a start it is best not to further mechanically disturb the soil. If the soil is tilled or otherwise worked, many soil animals and fungi are damaged and killed, which will revert soil succession. Although we know relatively little about how mobile soil biota are, chances are that over time all the right species will establish for succession to proceed. However, as with plant succession, this can take several decades too long for us to wait. However we can immediately improve microbes in our soils by inoculating the soil with soil improvers such as compost or with live topsoil transfer from natural areas. If the soil community is essential for the establishment of specific vegetation communities, then we speed up succession and improve the quality of biodiversity by bringing in a natural soil into the area to be restored. The appropriate plant seeds or vegetative material can also be introduced with the soil to produce the desired vegetation.

A simple way to check the state of your soil is to dig a few holes and examine its contents spread over a tarp. If there are no earthworms that is bad news because they are one of the best indicators of a fertile garden soil. Other items to look for are the any moving organisms and the relative content of sand, gravel and organic substrate (dark colors) and evidence of mycorrhizal tissues (white webbings). \

SOIL, FUNGI AND OTHER MICROORGANISMS

For many years, scientists believed that mycorrhizal fungi were ubiquitous, and that the spores of all fungi traveled around the world in wind and air currents, so they didn’t need to be added to soil. Now we know that arbuscular mycorrhizal spores are large and relatively heavy, unlike the spores of ectomycorrhizal fungi. They don’t travel that far. We also recognize that, under the right circumstances, mycorrhizal fungi need to be added to garden soils and managed to benefit vegetation. Study after study has demonstrated that plants inoculated with mycorrhizal fungi show superior growth and health. Perhaps in the future, the use of arbuscular mycorrhizal fungi in gardens will become as widespread as the use of fertilizers today. Propagules of mycorrhizal fungi may be also absent from soils where severe soil disturbance has resulted in topsoil loss, or where host plants are limited by adverse soil or site factors such as salinity, aridity, waterlogging, or climatic extremes. Most studies of mycorrhizal associations in highly disturbed habitats such as mine sites have found reduced levels of mycorrhizal propagules. Less severe forms of soil disturbance, including agricultural tillage, soil animal activities, fire and erosion can also reduce levels of mycorrhizal fungus propagules. However spores and other propagules of mycorrhizal fungi can introduced to new sites by wind or water erosion, or by the activity of animals which feed on fungi. In a disturbed habitat, the effectiveness of natural vectors will depend on the proximity of undisturbed habitats containing suitable fungi (and their associated animals) as well as the phenology of fruiting of fungi. Effective colonization of disturbed habitats, such as minesites in Australia, by mycorrhizal fungi has been observed, but there is as yet insufficient information about the time required for this process to occur.

Arbuscular mycorrhizae can also enhance the uptake of phosphorus, nitrogen, sulfur, copper, zinc, boron, iron, magnesium, and manganese for their hosts. These nutrient metals are relatively immobile in the soil and must attach to anions in clay and organic matter before they can be absorbed by roots alone. Mycorrhizal fungi venture out and get them, sometimes releasing them from their substrates and always increasing the absorption of these ions, sometimes up to 60 times. Considering the cost of fertilizers, fungi are clearly a viable alternative.

Another important nitrogen impact results from arbuscular mycorrhizae: the establishment of mycorrhizae increases the activity of nitrogen-fixing nodules in leguminous plants. Phosphorus is needed in the nitrogen fixation process, and its increased presence, thanks to mycorrhizal fungi, increases the amount of bacterial colonization in the root nodules of legumes. In fact, when arbuscular mycorrhizal fungi colonize legume roots, the very number of nitrogen-fixing nodules increases.

Establishing arbuscular mycorrhizae in garden soils can reverse the damage caused by incorrect gardening methods. Glomalin, the sticky, carbon-based glycoprotein (part sugar, part protein) secreted by arbuscular mycorrhizal fungi, helps strengthen hyphal walls and seal gaps, but its most important attribute is the amount of carbon it contains. Glomalin contributes almost a third of the soil's carbon where mycorrhizal fungi are present. The carbon in glomalin molecules far surpasses the amount present even in humic acids, which weigh up to 20 times more. Glomalin's stickiness helps bind soil particles together, adding structure. As a result of the presence of arbuscular mycorrhizae and glomalin, soil aggregation, aeration, and drainage are greatly improved.

Arbuscular mycorrhizae also add organic matter to the soil as the fungi die and decay. These fungi can make up as much as 50 percent of the microbial mass in a given volume of soil. While the fungi are alive, they provide habitat for all manner of organisms that are attracted to their exudates or the protection they afford. These organisms tunnel and burrow through the soil, contributing to soil structure and aeration. When they die, the end result is a stable, carbon-rich agricultural soil that is more resistant to wind and water erosion.

The amount of phosphorus or nitrogen in the soil greatly affects the germination and formation of arbuscular mycorrhizal fungi. With too much of either nutrient in the soil, mycorrhizal spores are less likely to germinate and mycorrhizae growth is hindered. To compensate for the unavailability of phosphorus, many growers saturate soil with synthetic chemical phosphate fertilizers, because once all the soil exchange sites are full of phosphorus ions, any excess nutrients will be more readily available to the plants. This practice results in a huge excess of phosphorus in the soil, which inhibits mycorrhizae from forming, and it can take decades for phosphorus levels to reduce to the point where the arbuscular mycorrhizae can thrive again. Excess phosphorus can be problematic for traditional organic farmers as well, who amend soils with animal manures that contain high levels of phosphate salts, often more than 1000 parts per million (which is so high that under natural conditions, soil amended with manure will still result in excess phosphorus 100 years from application). The use of phosphate fertilizers, manure-laden compost, and direct use of manures must be carefully managed to realize and maintain the maximum benefits provided by arbuscular mycorrhiza.

Inoculating seed and/or soil with mycorrhizal fungi can be a cost-effective and conscientious way to minimize potentially polluting nutrients such as nitrogen and phosphorus in runoff water. Adding mycorrhizal propagules to soils greatly increases the uptake of water and mineral nutrients, and mycorrhizae can protect plant roots from attack by pathogens. Despite these and other practical benefits of mycorrhizal inoculation, however, many nursery-grown seedlings are planted in sterile media that is heavily fertilized.

Most blends of mycorrhizal fungi are available as spores or hyphal fragments mixed with various media such as sand, peat, clay, gel, or water to ensure delivery to the plant's root system. Many potting mixes and composts also add mycorrhizal fungi to their formulations. A list of mycorrhizal species and their concentrations is usually included on the packaging of products containing propagules.

The upshot of these considerations is my recommendation to stop using fertilizers in your garden and instead inoculate it with mycorrhizal fungi. I suggest the use of 'Mycogold' distributed from Brisbane to give you an example of such a product. Mycogold contains a mix of four Endomycorrhizal species (see fungi and microorganism list in the appendix, chart item 1.86 – 1.89), four Ectomycorrhizal species (see chart item 1.90 – 1.94) as well a range beneficial bacteria (see chart item 2.01 – 2.07). The practice is to mix some of this powder into the potting mix and also to spread the mix on top of the soil around established trees at the onset of the wet season which allows you to use natural rainwater rather than townwater in irrigaton. The chemicals in town water in my experience may restrict the germination of spores.

How much to use? A fungus can regenerate from just a tiny amount of a hypha. Determining the appropriate number of propagules to apply is not easy, though some manufacturers do offer recommendations. It depends on the plant, the fungi, the soil conditions, the delivery media, and other factors. Experiment and review the literature. Fortunately, it seems that you cannot apply too many mycorrhizal propagules to plants. If you use a commercial product such as mycogold simply follow manufacturers recommendations in the Mycogold case usually 5 grams per planted tree. Any inoculation need to be watered in preferably by rain water to ensure the propagules or spores reach the root zone and germinate readily.

The timing of inoculation is important to the fungi's effectiveness. Apply the inoculant too late, and its benefits are lost. It is best to inoculate as early as possible in the plant's life to ensure that it gets the maximum benefits from the mycorrhizal association. Roll or spray seeds in mycorrhizal formulations before they germinate. Establishing mycorrhizae in planted containers can take up to two month, a lot less time than it can take to colonize an agricultural field. This is because the conditions in pots are usually far more ideal and controllable than those in the field, and propagules are applied in much greater concentrations in pots. Container-grown mycorrhizal fungi also produce spores much more quickly. Sporulation is usually triggered by crowding in the pot as mycorrhizae develop. As soon as the pot becomes full of fungi, they begin the reproduction process. Container-grown mycorrhizal fungi can begin reproducing via spores within a year of inoculation.

Mycorrhizal fungi spores will not grow and thrive and hyphal fragments will not develop if they do not come in contact with the proper root exudates. To ensure proper propagule placement, make sure they are in physical contact with plant roots. The standard is to roll the roots of transplants in mycorrhizal mixes or sprinkle the mix directly on exposed roots. Once the roots are inoculated and the plant is transplanted, the extracellular hyphae grow from the roots and into the soil in the container. Studies have shown that it is also good practice to mix propagules throughout the potting mix before transplanting. The spores in the soil will germinate, grow, and increase, and more mycorrhizae will form as they become exposed to the expanding network of roots. A larger mycorrhizal network results, with increased nutrient uptake and other benefits. As plants are transplanted to larger pots, the existing fungal network comes along, though adding more fungal spores to the transplant mix continues to increase the number of mycorrhizae. Finally, when potted plants are transferred to the garden, gardeners can again supplement the mycorrhizal fungi at the grow location to bolster the plant and surrounding soils.

Studies have shown that soil containing ectomycorrhizal fungi taken from a forest at one location can be successfully used to associate with host trees at another. One such study used soils taken from New Zealand, India, Italy, Wisconsin, and the Alaskan tundra to establish successful mycorrhizal associations with the same tree hosts in one plot. Conifers and deciduous trees respond equally to these treatments. Collect the fruiting bodies (such as mushrooms) of ectomycorrhizal fungi to use as propagules. This takes some preparation and a bit of knowledge, based on the season and conditions as the appearance and thus availability of fruiting bodies can vary. The sporocarps are loaded with spores.

Experienced mushroom hunters know how to make a spore print to identify a mushroom by removing the stem and placing the cap, spore side down, on a piece of paper or glass for 24 hours. Spores will be deposited onto the paper or glass and can be collected. To establish ectomycorrhizal colonies, add propagules directly adjacent to plant roots or spray seeds with spore suspensions. For the home gardener and small grower, a much easier method is to cut the fruiting bodies into small pieces and mix them into potting soil. You don't need more than a few spores to inoculate the soil, and it is impossible to use too much. This is a great way to grow a single strain or to make your own mix. Ideally you would collect such soil from under the same species of established trees in natural areas in order to improve your chances of getting the right mycorrhizal fungi for the species of trees you intend to plant.

Grasses and arbuscular mycorrhizae:

Many grasses too benefit from inocculating soils with arbuscular mycorrhizae. These include commonly used lawn species such as:

Bahiagrass (*Paspalum notatum*)
Bermuda grass (*Cynodon dactylon*)
Centipedegrass (*Eremochloa ophiuroides*)
Kentucky bluegrass (*Poa pratensis*)
Perennial ryegrass (*Lolium perenne*)
Red fescue (*Festuca rubra*)
St. Augustine grass (*Stenotaphrum secundatum*)
Zoysia (*Zoysia* spp.)

Associations with arbuscular mycorrhizal fungi benefit grass plants in the same ways they benefit trees, shrubs, and most other colonized plants: Grasses inoculated with mycorrhizal fungi are generally healthier. Tests show that lawn grasses inoculated with mycorrhizal fungi contain more chlorophyll with improved photosynthesis. Root systems grow larger, denser, and faster as a result of mycorrhizal association, which can mean total coverage, without the need to replant. Mycorrhizae improve soil structure as fungal hyphae extend and explore surrounding soils. Mycorrhizae bind soil particles, allowing for better air and water movement throughout the soil. Mycorrhizae improve soils damaged by compaction, particularly soils supporting grass on playing fields and parks. Mycorrhizae improve drought resistance by reaching deep into the soil to access water resources. Mycorrhizae lessen infection rates from bacterial wilt, parasitic nematodes, and other pathogens. Grasses with mycorrhizal associations are also better able to resist the ravages of drought. Arbuscular fungi form tremendous extraradical networks in the soil that increase grass roots' access to water, especially in response to drought. Healthy mycorrhizal grasses with extensive root systems are better equipped to face the stresses of drought, and grasses bounce back much faster when water again becomes available. The complex mantle formed around roots by ectomycorrhizal fungi holds water, which enhances storage and the plants' ability to interact withsurface water. Arbuscular mycorrhizal fungi also form abundant vesicles within grass roots that stay hydrated and spongy to protect roots from desiccation during drought. Endomycorrhizal fungi deposit sticky glomalin into the soil, improving soil structure. Glomalin-enriched soil particles stick together, creating pores, tunnels, and reservoirs for greater water retention. Mycorrhizal colonization also increases the number of root aquaporins, the embedded cell membrane protein channels that transport water. Mycorrhizae benefit grasses in other ways as well. For instance, they impact gas exchange in plants, helping them expel oxygen and take in carbon dioxide for photosynthesis. Mycorrhizae impact the hydraulics of the host grass plant as it balances the water absorbed through its roots and released through its stomata. Stomata pores open and close to regulate the amount of gas and water vapor that are expelled from or held within the plant; the stomata close as water becomes scarce and open again to allow respiration.

You can use commercial propagule mixes with sufficient mycorrhizal fungal material and appropriate strains to match the specific crops for which the inoculum will be used. You can also gather your own propagules from soil collected from a field or from areas adjacent to a field, such as fence rows or woodlots. After you collect soils from several areas, mix them together and use a sieve to remove sticks, rocks, and other debris. This soil should contain a large and diverse population of indigenous mycorrhizal fungi to use as an inoculant; some studies suggest that indigenous mycorrhizal fungi perform better for their host plants than introduced species.

SOIL AMENDMENTS

A healthy soil is high in organic material both living and inert that together provide nourishment for microorganisms that break down the components and so create nutrients. Above all it is organic matter that improves soil structure, water infiltration, water holding capacity and creates new soil. The top 30 cm of healthy soils should contain at least 3 -5 % of organic matter. Before we can consider the need for soil amendments we need to know the proportion and structure of the soil particularly sand, clay, silt and organic matter. A simplified soil texture test can provide a rough estimate. To take a soil sample scrape off surface debris until soil layer is reached. Dig a hole preferably with an auger to desired depth of potential planting and take a vertical slice of the sample. Mix a handful of this soil sample with water, shake and let it settle in a glass jar. Sand and gravel will settle an the bottom in distinct layers and so silt, then clay and organic matter the latter some of which may float. This layering allows you to measure the approximate volume of a soils components. A good soil roughly consists of up to half of sand and equal amounts silt and clay with at least 5 percent of organic matter. If any of the components differ more than 30 %, your soil may benefit from amendments with the component in short supply. If your soil contains more than 70 % sand it is usually classified a sandy soil and with more than 40 % clay it would be considered clay soil. Soils that have a more balanced distribution of sand, clay and silt are classified as loams.

While it is important to know what your soil consists of it is equally important to know the degree of compaction which influences drainage capability. While drainage is related to the soil structure it can also indicate compaction. You can implement a percolation test on the same hole you dug for the soil sample in order to assert the degree of compaction and soil drainage. More than any other physical attribute, highly compacted soils will limit plant growth. Compacted soils are damaged soils with sharply reduced macro and micropore space necessary for water infiltration, air exchange and biological activity. Such soils must be rebuilt by ripping, cultivation and soil amendments. For the soil percolation test fill your excavated hole with water and time the amount of drainage for an hour. One inch per hour constitutes extremely poor drainage, one to four inch per hour is considered poor with four to eight inch per hour good and above that excessive.

The pH of the soil determines nutrient availability and the ability of the soil to retain those nutrients is related to soil texture. Most vegetables, annuals and grasses prefer nitrogen in nitrate form and do best in bacterially dominated soil in higher pH > 7 whereas most trees, shrubs and perennials prefer the nitrogen in ammonium form and do best in fungally dominated soils in lower pH < 7. Within the values of 6 to 7.5 most plant nutrients are sufficiently available for most species. Very high pH levels can lead to Iron (Fe), Manganese (Mn) copper and Zinc deficiencies. Soil pH can easily measured with a low cost moisture/pH/light gardening probe.

Having analysed soil type, soil drainage and pH you can now make an informed decision on how to remedy imbalances through soil amendments. In most cases it would probably mean the need to add organic matter.

Organic matter to amend soil in most scenarios leads to better soil health. This does not change the texture of the soil itself but it will in the long run increase waterholding capacity, drainage, number of microorganisms and available nutrient in the soil. Organic matter may be incorporated into the soil at a rate of up to 25% for sandy soils and up to 50% by volume for clayey soils. Types of suitable organic matter include shredded composted leaves, composted animal manure (can increase NPK), green manure as a cover crop, sphagnum Peat Moss, potting mix and composted woodwaste. All organic matter should be well composted or it can potentially immobilize nitrogen while it decomposes and/or release toxic compounds. If the pH of the organic matter is different from that of the soil it may alter the soil pH. Properly made compost also contains the entire complement of soil food microrganisms: fungi and bacteria, protozea and nematodes and containing lots of organic matter to keep the microbes going. Topical organic mulches combined with compost support all members of the soil food web over a longer period of time as it decays. The restored soil food web then comes with benefits such as less water because of the improved water and air holding capacity of the soil. Your gardens will have no need for fertilizer because these are recycled naturally in the soil. There will be fewer pant health issues because pathogens and parasites are held in balance. Per teaspoon, compost contains up to a billion bacteria, 150-300 meters of fungal hyphae, 10,000 to 50,000 protozea and 30 – 300 nematodes.

To make compost use grass clippings, leaves, wood chips, straw and kitchen scraps. Use both brown and green raw materials: Aged, brown carbon (C) material support fungi while fresh, green nitrogen (N) materials tend to support bacteria. The ideal C : N ration for a balanced compost is 25 – 30 : 1 you need some judgement to mix sources for the desired outcome.

Paper 170 : 1
Grass clippings 19:1
Tree leaves 40-80 : 1

An alternative to compost is the use of organic mulch on its own to amend soils. Although considered a maintenance tool, mulch will rehabilitate soils in the long term. Organic mulch can be created from landscape debris such as fallen leaves or pruned and shredded branches thus creating an on-site management for these items. Organic mulch generally facilitates water retention, temperature regulation, weed control and erosion control. Unlike inorganic mulches it also provides an added bonus of nutrients, improves soil structure, creates biotic activity, increases soil volume and adds organic matter to the soil.

Organic mulch reduces evaporation, prevents weed growth and insulate plants and recycles nutrients back into soil, prevents soil compaction by heavy rain. Suitable mulches include leaves and leave mold, grass clippings, bark and woodchip, straw, well rotted manure shredded plants and paper. All manner of micro and macro arthropods are able to live in mulches and speed decay. Although mulch has not quite the diversity of microbes compared to good compost because the decay process has not started yet in full, but if the right kind of mulch is used you can establish a proliferation of fungi or bacteria very quickly. Repeating, a mulch of aged brown, organic materials supports fungi, a mulch of fresh green organic materials supports bacteria. Either will in time attract micro-arthropods, arthropods, worms and other soil food web participants and slowly evolve a soil food web by drawing bits into deeper soil through tunneling and movement. Leaves and grass clip mulch lasts 6 months, while shredded woodchips last up to three years perhaps a little less in the tropics and where exposed to irrigation. Do not apply mulch more than 10 cm in thickness and be careful to keep mulches clear of the plant base. Mulches excel when they are used in conjunction with compost. Put the compost down first and then cover with mulch. The compost organisms will inoculate the mulch and speed up decay as well. To accelerate the breakdown of the mulch you can also grow protozea by soaking fresh grass clippings in water for three days and pour the soup over mulched areas

Another alternative option for improving soils in some situations is to use sand amendments on the premise that sandy soils are less susceptible to compaction and better drained compared to clayey soils. In practice this idea only works if a well graded sand is used coming at a cost of reduced nutrient an water holding capacity. Sand amended soils tend to require more irrigation and fertilization and sand amendments are therefore only recommended if the sand amendment is used in conjunction with organic matter amendment. In any case never use sand if it contains a high level of soluble salt.

Modification of soil pH (the degree of acidity or alkalinity) is difficult especially in fine textured soils or where the parent material contains much calcium. A better solution is to select plants that tolerate the existing pH instead of trying to change it. Soil pH is best lowered by applying elemental sulfur while ground limestone can be applied to raise pH.

Unless soil tests find the soil to be nutrient deficient there really is no need to add nutrients to it through fertilization contrary to general advice in Darwin and elsewhere. While the argument that our wet season excessively leaches nutrients from the soil that need to be replaced would appear to be sensible on the surface you would also have to consider that our local native plants are adapted to leached soils with poor nutrient status and any fertilization may cause toxic reactions. Adding organic matter such as stable compost is the most sustainable way to add nutrient to the soil particularly in the form of slow release type nitrogen. However supplementation of nutrients may be warranted if plant show specific mineral deficiencies that are not related to pH levels. In this case seek expert advice and apply targeted fertilizer or missing trace elements in several small applications during the wet season to avoid nutrients being wasted or leached into the groundwater.

WATER HARVESTING

Undisturbed natural landscapes provide clean freshwater, infiltrate rainfall and prevent excessive erosion. In sustainable gardening for wildlife we aim to replicate such processes here summarized under the umbrella term 'water harvesting'. This includes the promotion of on-site infiltration of rainfall and runoff as well as the capture and reuse of rainwater, graywater and treated blackwater. Rainwater can be captured from the roof into ponds and tanks and/or directed into your 'wetlands' while stormwater from impermeable surface can be directed into absorption trenches (backfilled with rock or sand) effectively harvesting water. Onsite infiltration and bioretention, such as with 'rain gardens/rain pockets', allows the soil and plants to naturally filter stormwater as it percolates into and through the ground, thus controlling surface non-point pollution. If the soils in your garden are overly compacted you will need to improve infiltration capacity by rip-planting methods and through additives all determined by soil testing as explained previously.

Rain gardens and rainpockets:

A rain garden/rain pocket unlike bio retention areas, do not contain an underdrain, but consist of a small shallow (up to 200 mm deep) depressed area that encourages water to briefly pond and infiltrate within a day. These areas should infiltrate more than 10 mm per hour and should be landscaped with suitable species tolerant of short term inundation. Most of our Top End floodplain species are adapted to both, seasonal inundation and also periods of drought. Larger areas should be covered by herbaceous plants and larger areas by trees such as Banksia dentata, Paperbarks and Swamp Mahagony. You may have to test the water percolation rate of your soil and if necessary work in additives such as sand to improve infiltration. Many smaller rain gardens or rain pockets and are preferable to a larger one.

Bogs:

A bog is a pond that is almost completely filled with soil or other material and maintains moisture all year. It will provide a great habitat for many species of frogs and can be linked to large logs and rock piles that also provide great hiding places for frogs and other animals. In Darwin a bog may be a good alternative to a natural pond avoiding mosquito breeding and Cane Toad spawning. Don't use pine-bark near your bogs because it can be too acidic for frogs. Likewise don't use treated pine or other treated timbers to build edges because the chemicals can be harmful to frogs. Keep grass and other vegetation long and thick near the bog. Both rain gardens and bog could be planted along their edges with native sedges. Sedges have not been used extensively in gardening and landscaping but they would be worth trying. The NT records 271 species out of 731 sedge species in Australia but very few locals would be familiar with any other than Cyperus bulbosus (Bush Onion), Eleocharis acuta (Sharp Spike Sedge), Eleocharis dulcis (Water Chestnut) and Fimbristylis spp. Some grasses would also be suitable in this situation such as Oryza rufipogon (Wild Rice) to name but one. As with local sedges the use of native grasses in Darwin residential gardens is largely untried mostly because of unavailability.

PLANTING

The source of plants matter. If you have the skills, the preference is to propagate your own plants from seeds or cuttings that are locally sourced. The recommended plants shown in the charts at the back of this book contain references on propagation to give you a hint and the reference on fruiting period show when viable seed is available. A few seeds can easily be sampled along popular bushwalks in the

Darwin area or from other lands with the permission of the land holder. Propagating your own plants has big benefits such as for example being able to inoculate your potting mix with mycorrhiza thus improving the odds of optimal growth and development. It is also a great way to get to know your plant more intimately and get greater satisfaction when you put your plant into its final place. My preferred seedling substrate are the Natural Coir Seed Raising Mix enriched with a small quantity of fresh moist local natural top soil (10 to 20 %) containing fungi spores and fragements of the mycellium of fungi. You only need a sprinkle of soil which can be collected together with the seed. Collect fresh viable seed some of which may also need be treated in some species to break dormancy. For example many berries are eaten by frugivorous birds and other animals and so undergo acidification in the animals digestive system which breaks down the protective coating thus initiating germination. Most frugivores have a very short period of digestion as little as 15 minutes. You can simulate such acid treatment by exposing seeds to acids like vinegar for 15 to 30 minutes. Other seeds will only germinate if mycorrhizal propagules are present in the seed raising substrate. Yet other seeds such as woody and hard coated Acacias for example need heat treatment to initiate germination. They are usually savannah species that germinate after fires. This treatment can be simulated by putting this type of seed into boiled water for a brief period usually a few minutes. There are no hard fast rules and in any case many seeds, especially very small and fine seeds, easily germinate without any treatment at all. In any case it is always a good idea to soak treated seeds in water for up to 24 hours prior to seeding. To be sure to apply the right treatment it is best to obtain advice from an experienced local nurseryman or propagator. When not sure why not experiment and try a range of methods.

Many seedlings as well as cuttings are sensitive to sun exposure even though the advanced plant may be quite hardy. In this case you are advised to raise your plants under protective cover such as a shadehouse or under established trees that provide filtered shade.

Planting a tree, shrub or grass is not rocket science but it helps to follow a few basic recommendations. The size of your plant determines the size of your tree planting hole and should ideally be three times the size of your container plant but be at minimum the volume of a 10 liter bucket for even the smallest seedling plant. There is a need to improve backfill, if the excavated material doesn't quite suit the requirements of the plant species. As a general rule, I have had good experiences with adding fifty percent potting mix to the excavation. Potting mixes tend to have added water holding elements and balanced fertilizer added so there is generally no need to add fertilizer to the bottom of the planting hole which is commonly practiced. The plant must be level with the natural ground level after planting so it doesn't drown and rot if too deep or dry out if too high. To make sure it is level, partially backfill your planting hole, thoroughly wet the soil and compact using soft pressure with your hands, then place the container to see if it is level taking into account a little settlement of backfill later on. When you are satisfied gently take the plant out of the container and place it into the hole and backfill, followed by watering and slightly compacting the backfill to ensure there is a good bondage of soil and roots. Depending on your irrigation system particularly if it is hand watering you may want to form a water-holding saucer with the excess backfill. Finish off with mulching but not too close to the base of the plant stem in order to avoid it to rot. You can help the plant through its initial establishment period with a light pruning (only for species that respond positively to pruning) in order to reduce its evaporation load especially when planting outside the wet season. In Darwin, the best time for planting is generally during December at the onset of the monsoonal rains. However planting is also successful outside that period if you use fully containerized advanced stock which can be slightly trimmed prior to planting. If you have scrubfowls in your garden or dogs you will need to protect your newly planted trees with placed rocks and/or stakes to prevent them to be dug up or run over.

ROCK RETREATS

In the wild natural formations of loose rocks suitable for animals to shelter beneath takes hundreds of thousands of years to establish. For gardens use natural rocks as they look authentic if well placed and so provide a higher level of amenity. If you don't have natural rocks, artificial retreats or refuges for reptiles can also be created from materials as a substiture such as artificial rocks made of concrete or broken rocks, concrete pavers or corrugated iron sheets, or through purposely created burrows. Earth burrows can be made simply by hammering a steel rod into the ground or more elaborately, for example, by using a wooden box connected to the surface via two PVC ringed pipesiles use retreats for protection against predators and buffering of environmental conditions, such as thermal extremes. An arrangement of rocks can be a heaven for lizards. Place them overlapping on top of each other to create small spaces and overhangs. If located at the edge of a pond they will also be attractive as shelter for frogs. As a substitute for natural rocks you can also use pavers slightly raised from the ground with spacers attached at the corners. Rocks or pavers, purposefully positioned form crevices and may be used by insects, spiders, geckos and skinks.

LOGS AND OTHER WOOD

Placed logs are a stylish multi functional feature such as borders of planting beds, informal seating or a habitat for timber dwelling insects and other animals or animals that feed on them. If you prefer you can choose durable hardwood and termite resistant plant species such as eucalyptus. However logs with cavities or hollows are preferable. Don't apply treatment unless the log is used for seating.

For wildlife habitat enhancement any wood from a tree including logs, branches and roots can be laid on the ground as a retreat for invertebrates and reptiles, among other species. Such wood also serves as a beautiful substrate for colorful and photogenic saprobic fungi.

In a similar way old timber fence posts that are no longer useful can be laid on the ground for some frogs, geckos, lizards and skinks. Natural logs can also be placed vertically when partially buried with holes drilled at various heights to attract certain species of native stingless bees or other insects.

NESTING OPPORTUNITIES

Artificial tree hollows (e.g. nest or roost boxes) can be provided as a habitat resource for hollow dwelling fauna if hollow-bearing trees are to be, or have been, removed from your garden or neighboring area. By substituting an otherwise lost habitat resource, you can encourage hollow-dwelling species to continue to live and reproduce in otherwise suitable habitat in the local area. Without such action, the removal of hollow-bearing trees will likely result in a loss of diversity of hollow-dwelling species, with some species at risk of becoming locally extinct. It's a huge problem in Australia because for example, eucalypts generally don't develop hollows suitable for vertebrate fauna until they are between 120 and 180 years old, and larger hollows are rare in eucalypts less than 220 years old. We are loosing our hollows rapidly from many areas including in the Top End. In newly established gardens and urban parklands that are almost always deficient in hollows, artificial tree hollows can be used as a temporary habitat resource while such an area is maturing. Although it takes many years, the saplings in the rehabilitated areas should eventually mature and develop natural tree hollows, so artificial hollows will no longer be required. Artificial tree hollows for bats do not always need to be attached to a tree. They can be attached to buildings and other structures, even at the end of poles concreted into the ground. If artificial tree hollows are to be attached to living trees, the method used to attach them should not harm the tree. It is preferable to attach artificial hollows to trees using a loop or strap that is capable of expanding automatically or being expanded manually as the tree grows

Artificial tree hollows constructed for birds and non-flying mammals are generally a rectangular hollow wooden box with a hole for fauna to enter. There are countless variations of this basic design, and they can be built from a range of materials. The specific dimensions of a nest box varies according to the species. Birds and non-flying mammals use artificial tree hollows for nesting and roosting. These artificial tree hollows can also be used by tree frogs and reptiles. Artificial tree hollows with side openings should be directed away from prevailing winds and shaded from direct sunlight. The orientation should favor protection from weather. Most artificial tree hollow studies have installed the boxes between 3 and 8 m from the ground, but further resolution is needed on ideal height for particular species. It is important that bat boxes are not installed above any obstructions (e.g. tree branches), so bats are able to drop before flight.

Nest boxes provide you with an opportunity to learn a lot more about the birds or other animals by facilitating breeding in residence in your garden and closer observation of how, in case of birds they cycle from egg to hatchling to fledgling to juvenile and finally into adulthood all in the knowledge that it wouldn't happening at your location without you. However all custom tailored nest boxes need to be correctly managed so as not to simply provide a nest site for unintended animals or allow predators access to the birds. Create or erect nest boxes according to the shape and dimensions required by the individual species.

As an alternative to nest boxes you can also try to construct a range of natural nesting sites in your backyard. This can be through growing a range of trees, shrubs, vines and tall grasses at different heights. By providing a range of places to build their nests, you may attract different types of birds to your garden. Eucalypts are ubiquitous across Australia's landscapes bu they are declining in urban environments. The physical structure of eucalypt trees- the dense foliage, bark crevices, hollows and cavities – together with fallen limbs (logs) and foliage (leaf litter) on the ground, means shelter, refuge or breeding sites for larger number of birds. So if you have a dead trees or tree limbs, don't be so quick to remove them. You can even create nesting holes using a brace to enlarge existing holes. The holes should face away from the sun and direct cold wind.

Natural hollows form after an aged tree has been subjected to physical injury from natural forces (e.g. rain, wind or fire). Fungi, bacteria and termites assist in decay of the heartwood (i.e. the inner core), thus forming a tree hollow. By understanding the way in which hollows form naturally, we can start to look at ways to artificially assist the formation of more hollows. There have been various ways suggested to accelerate hollow formation. You may experiment with constructing a cavity by drilling holes into the tree, inoculating decay-causing fungi, deliberately killing the tree and cutting the branches off the tree trunk. Although artificial tree hollows may have a limited life span (e.g. 10 years, depending on environmental conditions), a single artificial tree hollow has the potential to enable a breeding pair of birds to raise 10 clutches of offspring or house a whole bat colony. Species generally show a preference for artificial tree hollows with an entrance hole just wide enough to enter. Tight entrance sizes could be preferred because it would exclude larger predatory species and help to reduce competition for hollows by making them unsuitable for larger species. Premature decay of the artificial hollow and the probability of its collapsing can be reduced by ensuring that high-quality materials have been used in its construction. Stainless steel and galvanized fixings provide rust resistance, while hardwood, polyvinyl chloride (PVC) or plastic hollows will last longer than softwoods such as pine. Applying a non-toxic paint to the exterior of wooden artificial hollows will increase its lifespan.

While nest boxes are generally aimed at mammals (primarily possums) and birds such as Lorikeets, owls and a range of parrots, sugarbag bees but also feral bees also use them readily. On private property, householders can monitor the usage of the nest box and remove nesting material of undesirable species.

Here are suggested dimensions for selected local animal species:

Red-collared Loriket:

5 m high on a shady tree out of direct sunlight with a 23 cm long x 23 cm wide floor and 25 cm high with a 7 – 15 cm diameter entrance hole located near the top of the box. Place a perch just below the entrance hole and a small wire ladder inside

Pardalote:
5 m high on the shady side of a tree with a 12 cm x 50 cm floor and 12 – 15 cm height. Install a 3 cm diameter and 10 cm long plastic tube projection entrance.

Gallah:
6 m above ground out of direct sunlight with a 20 cm x 20 cm floor and 70 – 75 cm height with a 8 – 10 cm diameter entrance hole

Lizards:

Use large placed rocks to create habitat for lizards

To deter ants from nesting boxes use talcum powder applied to the entrance and edges of the nest box, sprinkled inside of box incites ants to leave and lanolin grease around edges of the box prevents them from returning. Ring of grease around trunk of smooth-skinned eucalypt encourages colony to leave the box. Open bottom prevents ant infestations in bat boxes.

To deter feral bees from nesting boxes, line the ceiling of the nest box with carpet before installation as this may thwart attachment of wax comb to ceiling. Grease the underside of the lid and top of the walls with marine grease or lanolin to prevent bees from attaching honeycomb.

PROVIDING WATER FOR WILDLIFE

All living creatures need water to drink, aquatic animal live in it and many others use it for bathing. In the Darwin Region, where we have a severe and prolonged annual dry period between May and November with virtually zero rain, the natural sources of water diminish incrementally with most animals finding water difficult to access as waterholes and streams run dry during this period. The irrigated urban environment dotted with hundreds if not thousands of swimming pools may seem like, an oasis, a magic magnet to creatures living in the drier surrounding woodlands and further out. It is of no wonder then that we observe local seasonal movement patterns in the late dry season leading to a concentration of wildlife in the urban environment including our backyard gardens particularly where water is made available. Our climate is warming, 2 degree Celsius so far and with every degree of warming evaporation increases by 7 % thus drying out the landscape even faster and making it tougher on animals. We can help a little to provide clean fresh water to them in our garden.

Birds bathe and preen in order to keep their feathers in perfect condition for flying and to maintain their waterproofing and insulating properties. The individual feathers are made of the same substance as human fingernails, keratin, and become bent and disarranged with daily activity. The feathers are repositioned and straightened by preening. The bird usually bathes and then passes the individual feathers through its bill, oiling them and snapping them back into position. Place such water sources in the shade near sheltering vegetation relatively secure from the intrusion of predators that try to sneak up on unsuspecting drinking birds. Birdbaths are particularly attractive to birds before sunset and are best placed close to where you can watch the spectacle of them bathing. Water for wildlife can also be provided by natural ponds if you want to attract frogs, dragonflies and butterflies in addition to birds, lizards and mammals.

The waterer or bath should be placed in a relatively open space such as suspended from a tree branch with a perching spot nearby so birds can observe the bath before using it and be able to see approaching threats. Of course you may also want the placement in view from of your favorite veranda rocking chair. Pedestal bird baths should be stable and high off the ground. The bath should be in dappled shade so the water does not become too hot during the day. Water must be replaced daily in order to remove contaminating droppings from the water and the bath scrubbed out regularly (don't use a detergent). Dense shrubs should be available nearby in the garden to allow the birds to escape if threatened or disturbed. Under no circumstances place the waterer or birdbath near any windows as many birds, when disturbed panic and subsequently may crash into the reflected sky of the window. The bath should be shallower than five centimeter deep with a rough base and sloping edges so birds or other animals are not at risk of drowning. If you have birds and animals such as lizards that forage or live on the ground provide an additional shallow bowl of water on the ground in an open space under a shade tree unless you also have a natural pond installation.

The design and construction of ponds require careful considerations to stop them from overheating and going foul or becoming a breeding ground of mosquitoes. A garden pond, constructed for wildlife need not more than 900 mm in Diameter or 500 mm at its deepest level. Varying the depth of the water will provide opportunities for greater biodiversity. Locate the pond so that most of he surface area is shaded. Too much sunshine may create excessive algae growth, heat up the water very quickly and so create unsuitable condition for most of aquatic wildlife. Avoid placing plants with excessive leaf or fruit drop near the pond. Transition the depth of water towards a shallower edge. Lillies preferably require sections of pond 500 – 750 mm deep while most other plants grow at 300 mm. Place flat rocks at the pond edge to provide perch for birds, butterflies and dragonflies. Leave a gap of 15 – 25 mm under the rocks for frogs and lizards to hide from predators. Use rainwater to fill you pond. Add small fish to your pond to control mosquitoes. Plant aquatic plants in terracotta pots before placing in the pond for ease of maintenance and to control growth when plants have matured, Plant foliage should cover a quarter to one half of the water surface to adequately oxygenate the water and provide shelter for pond life. Install a solar powered re-circulating pump to help distribute the water temperature and oxygen.

IRRIGATION

There are many ways and technical devices to irrigate your garden ranging from watering by handhold hose to fully automated drip, spray and sprinkler irrigation systems. If you want a no hands on system you will need to invest in an irrigation controller (usually battery operated) a system of solenoid valves and extensive network of underground polythene piping connected to sprinklers, sprayers and drippers. To have it work properly you may need to get an irrigation professional to design and install your system. Fully automated systems usually work fine for a while but need constant maintenance to clean clogged outlets, fix leaking pipes, clean the control box , replace batteries and replace faulty components. You also have to guard your irrigation system against being compromised by invasive roots or damaged by animals. The program may have to be re-adjusted for dry and wet season usage. Smaller gardens are probably better off in the long run to keep irrigation simple and get a plumber to install a series of water taps spread out in the garden and connect these to semi automatic hose and sprinkler outlets with a manual timer. This simplifies adjustment of water applications on a as needs basis. In windy conditions you simply shift the sprinklers or perforated hose to adjust for wind drift or move a single sprinkler to cover an area of grass larger than the throw of your sprinkler. If you are like me and enjoy watering the garden by hand, all you need is a hose and perhaps 3 or 4 smaller sprinklers. There really is no need to water the garden during the wet season other than during extreme dry spells and an expensive automatic sprinkler system would lay waste for this period. Depending on your planting layout some elements of the garden such as dense groups of shrubs along the fence perimeter may be economically watered with a polythene dripline and drip emitters connected to a tap with a manual timer. Most gardens in Darwin are over rather than under watered. If you have established native plants for your wildlife friendly garden you can rest assured that such plants are well adapted to withstand dry spells in any case. However even natives adapted to dry conditions need to be watered regularly during their establishment phase in their first year, the time they take to develop deep roots.

Read more on irrigation timing and watering under the chapter maintenance.

FENCES AND OTHER BUILT HAZARDS

Fencing is a standard component of residential and agricultural developments and often impedes fauna movement in a hazardous manner. Consider fauna inclusion fencing techniques to allow animals, generally smaller animals, to move freely from one side of the fence to the other. This improves their opportunities to access habitat resources and other individuals in related populations. Such inclusion fences can be designed to enable fauna to pass through, over or under the fence and are usually applied in situations where human access is to be restricted (e.g. property boundaries), but where native animals do not need to be excluded from the site. Fauna inclusion fences can also be incorporated into housing developments where domestic animals are not permitted to provide some connection of wildlife and people. They are less likely to sustain damage by animals trying to break their way through than a standard fence. Before replacing an existing standard fence with a fauna inclusion fence, it should be considered whether the existing fence is protecting fauna from an existing threat such as a road or domestic animals. For example, if a rural property has a border with native bushland on one side and a busy road on the other, it may be better to use a fauna inclusion fence adjacent to the bushland and a standard fence or fauna exclusion fence on the other side, adjacent to the road. The optimal design of a fauna inclusion fence will depend on the habits and abilities of the animals that will pass through, over or under it, Chain wire provides a medium that can be climbed by most agile climbing animals. However to enable fauna to crawl along or stand on top the fence should be made from a ridged material. While fauna inclusion fences can be made from many different materials desirable design features include: low overall height of the fence (approximately 1200 mm), the bottom of the fence offset at least 300 mm above the ground and the top of the fence allows climbing animals to freely pass. If the fence is also the property boundary you will need to discuss the proposition with your neighbor taking into consideration the type of animals it is aimed at. In the Darwin context we look at mammals such as possums as well as ground foragers such as lizards and monitors as well as quails and scrubfowls. Gaps in the bottom of the fence can be intermittent rather than continuous and be placed where animals are likely to cross properties such as in shrubby borders..

Barbed wire fences often cause fatalities in birds, arboreal mammals, ground mammals, reptiles and bats. Fauna that become entangled is likely to be injured or experience a slow and painful death. Such fences are often not necessary and should alternatively be substituted with high-tensioned plain wire successfully used to contain sheep and similar livestock. Fences made from high-tensioned plain wire are in many ways a better choice to barbed wire fences because they are comparatively cheaper, easier to install, reduce the risk of injury to livestock and require less maintenance.

Hazardous structures for wildlife include windows. They are particularly dangerous if feeding of birds occurs in the vicinity. Birds tend to panic at the sight of a predator and instantly bolt into all directions often crashing into windows at high speed with fatal consequences such as broken beaks, headtrauma or instant death. UV-reflecting and UV-absorbing window coverings are designed to prevent birds from flying into windows. The films allow one-way viewing, so do not obstruct the view from within the building. The windows appear opaque from the outside and so birds adjust their flight behaviour. Window markings (such as vertical dark stripes) have also been used with the intention to reduce bird collisions with glass.

MAINTAINANCE

PRUNING

In their natural environment plants are 'pruned' by grazing wallabies, insects, heavy winds and wildfires. Pruning helps some plants to induce strong, healthy growth and more attractive bursts of flowers and to encourage a more balanced root system. Some species will withstand heavy pruning, such as species with lignotubers (for example bottlebrushes) and with epicormic shoots (eucalypts). Prune the whole plant behind the flowers close and parallel to the existing branch, angled away from the buds, using clean, sharp secateurs to prevent damage and tearing. Some plants do not tolerate pruning and these include Acacia and Allocasuarina. Some species, including Leptospermum and Melaleuca flower on old wood, so removal of it can result in the loss of next seasons flower. Other plants such as Lilly Pilly and Grevillea should be only be given a regular light pruning to promote grown and retain shape.

Substantial and repeated pruning of trees is also advocated where you want to limit the height of trees in favor of lateral branching lower to the ground and in situations where invasive roots pose a potential problem. Many trees can intentionally be 'miniaturized' this way to about half of their natural mature size. If unsure you can do a test prune on one branch to find out how a particular species reacts.

Some trees, such as eucalyptus have a natural tendency to shed branches particularly during storms, a factor you should take into account when using or placing such trees. Put them where falling branches pose little risk or prevent the problem by cutting off suspicious branches. In Darwin removing branches is best done before a cyclone or storm approaches in conjunction with other cyclone preparations.

When cutting down or clearing advanced trees that have become to big, invasive or have to make way for something else, it is a good practice to leave the stump to a height of 1 – 1.5 m. Such a stump may not only provide a sculptural aesthetic feature in he garden but also be a potential home form many organisms such as insects, birds and fungi. In time the wood will break down naturally and its nutrients returned to the soil. You can drill holes into the wood to facilitate habitat for native bees and wasps.

<u>FEEDING WILDLIFE</u>

The issue of whether or not to provide food for wildlife is extremely divisive in Australia, despite it being a popular practice particularly elsewhere in the world. The supplementary feeding of birds during the harsh winter period in Europe and North America in particular has long been encouraged by conservation agencies in order to help birds to overcome food shortages during this time. In Australia, the extreme climatic conditions generally do not exist in the same way, although in Darwin, the extremes of dry and wet season tend to result in food shortages during the end of the dry season. Feeding may make sense during the period just before monsoon rains even though it may not be recommended by conservation agencies. As a consequence of a long prolonged dry, wildlife is generally starved and contracting from surrounding natural areas into the lush irrigated Darwin and Palmerston. This is the case of Magpie Geese often descending on Darwin by the thousands to feed on anything edible, mostly herbs and grasses they find on ovals, parks and school grounds. If you decide to feed your backyard animals I advise to do so sparingly and only during the end of the dry season until a few weeks into the arrival of the monsoon rains. When seeding grasses and fallen seeds have been diminished during the build up period and so putting many granivorous animals into starvation mode the situation can be helped by providing supplementary grains during this period.

In my observation the types of food provided by feeders is often inappropriate for many of the animals being fed. Bread has been associated with digestive and intestinal problems in birds, yet was the most common food provided in several Brisbane studies and I have seen many people in Darwin do so that is feeding dry white bread. In the case of carnivorous birds and animals when used as the primary part of an animals diet, low-grade meat with high fat content has been shown to cause calcium deficiencies and cause changes to the blood chemistry. Seeds such as uncooked white rice never forms a part of the natural diet of the native birds yet I have seen people feeding it. Honey and water is frequently used to attract lorikeets and does not provide all of the requirements necessary for the health of nectarivores, as the complex sugars found in native flowers are missing. It is not only the food itself that may be harmful to animals, unhygienic food stations have been shown to encourage the spread of a number of infectious diseases. For example the spread of mycoplasmal conjunctivis among House Finches (Carpodacus mexicanus) in eastern North America appears to be associated with bird feeders. This concern is important for Australia as unhygienic practices such as feeding waste seed from aviaries to wild birds and feeding on unclean stations have been found to be common practices among suburban feeders. So if you decide to feed only use quality fresh foods and offer them sparingly.

Finally, there is concern that feeding animals can result in these to become dependent on the supplementary food source. Most people that feed wild animals do so on a regular basis, with many feeding daily. However, while this is a major concern among both opponents and proponents of feeding, there has been remarkably little research examining this topic; currently, no evidence of dependency has been found. In my observation wild animals adapt very quickly to the cessation of feeding especially if they are mobile species such as birds and are quick in finding alternate food sources. Research found that in birds visiting feeders only a tiny fraction of their daily diet came from feeders and the rest mostly from natural sources. It means birds tend to use feeders as a supplement rather than their main source of food. When natural sources are in abundance, birds don't bother with feeders at all. Unlike humans who reason based on memory, animals live in the here and now by instinct, they don't judge or reminiscence, if there is no food they register the fact and simply move on.

A wildlife-friendly garden can provide food that is natural and beneficial for a diverse wild animal community. I consider that creating such a garden should be the primary means of forage, rather than supplementary feeding. Potential benefits to the animals from feeding can be outweighed by the damage done by attracting unwanted feeders such as rats or aggressive birds, feeding incorrectly and using unhygienic practices. Education is needed to inform people of the potential harm of incorrect feeding and highlight the benefits that can be gained through garden design. Feeders should also consider that providing food in one place may do harm to wildlife at another. For example if you feed a commercial grain mix, with the grains grown somewhere else (turning wildlife habitat there into agricultural land), then processed, transported and stored in an air-conditioned sales house. (greenhouse gas footprint that damages the environment for all), it will result in more harm than good on balance.

There is not much solid advice on how to stop feeding when it has got out of control such as when feeding draws too many animals or the wrong kind of animals. I now ever fed birds during the buildup at the end of the dry season and in my experience it is best to stop abruptly so the birds get a clear message and react quickly. Gradually reducing the feed over time does not work because the birds will stay longer so not to miss the next feed if there is less food or less frequent feeding and as a result the birds seemingly swell in numbers. With the abrupt method there may still be a lot of birds on the first day, then a markedly reduced number on the second day and very few or none on the third day. It can be helped by dispersing the birds into nearby parks by putting out feed there as an interim weaning off measure. The best time to stop feeding in Darwin is a few weeks into the first rains of the wet season when grasses and vegetation are bursting out with life. It is also during this period that insectivorous birds encounter and feast on huge numbers of flying termites. Don't worry too much about the birds being potentially starved when suddenly food is withdraw. Fluctuating fortunes of food availability and how to deal with it, is deeply incised in their DNA, after all they are able to fly and so move quickly to alternate sources. Most birds get by seemingly with very little and do so by adjusting their behavior and metabolism. They also have the flexibility to change over to foods they would normally not eat but these foods still provide nutrition. In my personal view, the value of feeding is to help them out over a periods of extreme scarcity and to draw them into your garden. However we should avoid turning wild animals into 'outdoor wild pets' for our entertainment.

Creating suitable habitat is the preferred way of maintaining native birds in urban areas. Providing artificial food sources is not necessary for most of the year or even desirable, although it should be recognized that some people derive great fulfillment from feeding wildlife and feel that they can gain a greater understanding of wildlife through feeding. In some situations feeding in times of crisis may contribute positively. In any case there are issues with feeding the incorrect food, encouraging the dominance of large and aggressive species and the spread of disease. If you choose to provide food for birds I encourage you to take the following steps to minimize threats to the health of individual birds as well as to the broad bird community:

• Avoid concentration of wildlife through the use of feeders, rather distribute foods over several areas in order to help 'social distancing' of animals and so avoid feather picking.

• Provide high quality food. Do not provide bread, fatty meat or honey and water mixes. Instead use nectar mixes, good quality wild bird seed mixes, fruit or insects.

• Vary the type of food provided and when it is available. Alternate between nectar mixes and seed for example. Set it out at different times and not every day.

• Monitor the types of animals using the feed areas. If numbers of Black Rats are turning up to visit your feeder intended for birds, you know you have a problem and must take a break from feeding for a while and then recommence with a different food type or in a different location. If you plan to stop feeding choose your timing well such when benign weather conditions occur.

• Always provide water with food.

PROTECTION WILDLIFE FROM PREDATION

Predation of wildlife species by pets is a huge problem in the Darwin residential areas because pet ownership especially dogs is hugely popular here. Cats are difficult to contain on the property and can become feral, potentially killing an enormous number of wildlife. The most vulnerable animals are bird fledglings and many are maimed or killed by cats or dogs running wild of the leash.

We know from global research that a great deal of urban wildlife is killed by cats although it is not quite clear whether cats prey on individuals that would have died in any case (from other predators, old age, injury or disease), the 'doomed surplus' hypothesis, or whether cat predation is indiscriminative, the 'hapless survivor' hypothesis. Certain bird species in Darwin such as ground foraging doves and young birds in generally are more vulnerable. The mere presence of cats can lead to animals avoiding otherwise preferred habitat and in this way reduce breeding. Birds may make a decision to frequent a garden as a trade-offs between survival in the presence of predators and acquiring forage and other materials for long-term survival or reproduction. Personally I'm against pet ownership, particularly birds, cats and dogs, but if you must have a pet consider the following guidelines.

• Keep cats indoors as much as possible and/or create a cat-proof outdoor enclosure, not allowing a cat access to potential prey is the only way to completely stop it hunting. This also keeps the cat safe from potential dangers. Special cat netting placed on fences and walls can also stop the cat escaping from the yard but will not stop it taking prey.

• Provide refuge in the yard for birds and reptiles, create locations in the garden for animals to retreat to that are out of reach of cats.

• Nest boxes should be high in trees inaccessible to cats with metal collars placed around the base of trees.

• Bird baths should be beyond the reach of cats, hanging from a tree is ideal. They should have good visibility all around it and a perch nearby so birds can observe the area before using the bath and also be able to retreat quickly.

• Prevent neighboring cats from spending time in the garden, a spray of water from a water bottle is a great deterrent and will not harm the cat although the owner of the cat may resent you for it.

• Predation is a fact of life for most animals and in Darwin that occurs surprisingly frequently through birds of prey, reptiles and lizards such as large monitors. Who needs cats to catch mice or black rats if you have a monitor, goshawks and Carpet Phytons in your garden? Predation is usually a rather benign method in natural systems to eliminate the diseased and old, a kind of quick mercy killing which reduces needless suffering. It also maintains the balance in the web of life and improves the fitness of the evolution of species. Animals are on the constant lookout for predators and have many adaptions to evade them successfully. Its natures way to improve each species while maintaining balance.

FERTILIZER

“No one ever fertilized and old growth forest”

How much of a need you have for fertilizer depends on a number of factors such as the type of soil, the type of plants, your watering routine and nutrient recycling through leaf drop and mulches. Darwin soils are notoriously nutrient poor because of the repeated leaching events of up to two meters of rainfall during the few months in every wet season. Using an irrigation system for the remainder of the year exacerbates this problem particularly if you waste water by over watering as many people do. Removing grass clippings and leaf drop ultimately removes even more nutrients from your soil which often results in poor and nitrogen starved yellowed and stunted foliage or growth patterns. Although chemical lawn fertilizers work well by feeding the roots directly, they at the same time kill off many soil food web microbes. Since most of these fertilizers are salts they cause osmotic shock to organisms, that is the water within organisms flows to the higher concentration outside the cells. Once the microorganisms are gone your grasses rely on constant further applications of fertilizer to keep them going, particularly in the tropics where fertilizer leach quickly from the soils. With the natural buffering action of bacteria and fungi gone, the soil pH is thrown off the kilter too made worse by the absence of the breakdown action for grass clippings which in a fertilized lawn have to be removed. By removing clippings and leaves the destruction of the soil food web is compounded. Earthworms too leave the area when salts are applied since the gut microbes within worms are irritated by the salts. When all bacteria and fungi are gone the soils loose structure and with it their ability to hold air and water. Earthworms are a good indicator of the health status of your lawn, If there are no birds hunting for earthworms or a lack of visible worm castings on the lawn the soils are in bad shape. Therefore leave grass clippings on the lawn, all season as a bacteria favoring mulch. The sugars in the grass will attract a healthy population of bacteria. Clippings also foster populations of protozoa which ensure nutrient recycling.

Not only are chemical fertilizers harmful to the environment because of their contribution of greenhouse gases in their production and distribution, they are also unnecessary when you adopt a system of recycling organic waste into a garden that is designed to be sustainable. You need to look at how the water flows through your garden and how this flow can be slowed, reduced and stored. Ideally in a sustainable garden you will have water intercepted by four layers, first by a high tree canopy, then again by mid-storey shrubs and again by groundcover vegetation or mulches and finally be stored in the soil itself. If the soils are too sandy or gravelly and rapid draining you may be able to improve their water-holding capacity by the addition of organic materials.

The only fertilizer I have ever used in Darwin is mulch and compost. In combination they provide a huge reservoir of slow release nutrients and at the same time habitat for a wide variety of microbes and other organisms. The outcome is a natural system in balance and operating just fine without interference from man-made fertilizer, herbicides and pesticides.

MULCHING

Check the source of mulch and make sure it comes from a known source and is not contaminated with weed seeds or sourced from plant species with growth prohibiting substances. Consult your provider of the mulch. The thickness of the mulch should be sufficient to suppress the growth of weeds usually 75 mm or more. Mulch tends to be acidic forming leading to a proliferation of saprobic fungis and this will favour trees, shrubs and perennials that generally grow better on fungal soils. Therefore you are best advised to apply thick mulch and compost around all your trees and shrubs plantings up to their dripline. Apply your mulch during the wet season in order to get the breakdown by bacteria, fungi and other microorganisms going before the dry.

WEED CONTROL AND FIRE MANAGEMENT

Although fire management does not really apply to home gardens in Darwin it is touched on here as crucially important tool for larger properties on the outskirts of Darwin. In this situation fire management would normally be considered in conjunction with weed control.

Methods for weed control include manual (dig, hoe and grub), herbicides, mechanical control, plant competition, mulching, grazing, fire and biological control. In the smaller home garden only three of these techniques realistically apply that of manual, competition and mulching.

Manual control is the best and most direct method for home gardens, sensitive ecosystems on larger properties and for follow-up control in both and is best timed after rain or irrigation events when the soil is friable and the entire plant pulls out more easily.

Herbicides should not be used in the home garden since they normally require careful adherment to the label in order to ensure the correct and safe method of application. Herbicides often come with unexpected and negative impacts on wildlife such as bees and insects, but also on human, impacts which sadly are widely under-researched. For example some well known herbicides legal in Australia have now been banned in overseas countries. Herbicides only have a place in larger properties where alternative methods such as the spraying of fire breaks are too costly or unfeasible.

Mechanical control is used to kill weeds by burying, slashing or uprooting. Again this is not for the home garden but can be used in large rural blocks. Selective slashing in particular is very useful to isolate fire sensitive areas and then apply a controlled burn away from these areas. The timing of slashing operations should be aimed at preventing weeds to seed.

Plant competition is the preferred long term method for weed control in the home garden as well as for smaller rural landholdings with access to some form of irrigation and consists of establishing dense shrub or small tree canopy to suppress the establishment of weeds. This works extremely well in combination with the application of mulching and water harvesting. The mulching prevents weeds to take a hold while your plants establish.

Mulching not only suppresses weeds but also at the same time improves the retention of soil moisture to help the establishment of native vegetation as well as providing nutrients by natural biological mechanisms such as decomposition of organic matter and by the effects of microorganisms in the mulch and soil beneath the mulch. I recommend the purchase of a small household wood chipper. They come in all sizes and are a fantastic investment, taking care of garden waste by recycling organic material into nutrients. Alternatively if you have time on your hand and want exercise you can cut small quantities of waste down to size manually with a secateur and axe.

Grazing as a form of weed control is realistic only for larger properties but comes with the probability to worsen weed problem worse by dispersing seed through attachment to fur and in dung. The grazing animals also often forages on your native vegetation and not just the weeds.

Biological control involves the introduction of organisms such as insects, fungi and microbes in order to reduce significant infestations by weakening the weed. Landholders need to contact their local government pest control for more information and availability of control agents.

Fire can be an effective tool for weed control. Of course we don't use fire in suburbia. In contrast larger properties in Darwin's rural outskirts often contain undisturbed savannah woodland and such areas may rely on fire every so often to regenerate and keep fuel loads to low levels. The response of fire on a particular species of weeds varies considerable, depending on the fire regime (frequency and timing) used, fuel moisture content, fuel load and the slope of the land. In 2007 there were over 6,000 bush blocks of less than 1.000 ha and totaling an area of over 3,600 sqkm in the northern NT, mainly in the rural fringe around Darwin of which over 2000 were between 2 and 8 ha in size. Since then the number of rural blocks would have somewhat increased given a tendency of larger properties subdividing. Part of the natural savannah landscape that contains those rural holdings burns every 1 – 2 years on average. The active use of fire in controlled low intensity burns early in the Dry in these properties can be a useful protection from hot wildfires. Strategically slashed firebreaks around infrastructure and important habitat patches allow safe low intensity burning away from fire sensitive areas such as dry rainforest (vine thickets) riparian forests which should not be burned. Properties need to be considered case by case because there are often unique accentuating features in relation to fire hazards and weed status thus there are no prescriptions that fit all.

One aspect that is often overlooked when considering weed control and fire management is the effect such operations have on wildlife. Open Eucalypt Forest predominantly made up of Woolybutt and Stringybark and dominating rural outskirts becomes alive in the late Dry Season when flower and seeds attract black cockatoos, lorikeets and honeyeaters. Seedeaters and ground dwelling birds are affected strongly by fire regimes which are more and changing from traditional mosaic burning to hot fires of highly flammable African grass infestations. The response and ability of animals to cope with fires is species dependent. Some species such as Northern Brown Bandicoots and Pale Field Rats that both feed on green stems and seeds thrive on frequent fires while others such as Brushtail Possums and Black Footed Tree Rats that feed on fruit such as Green Plums and Billygoat Plum in mid storey trees decline. Heavy rains at the beginning of the wet season make many grains and seeds germinate thus leading to a supply crunch of seed for granivorous birds and many of them die as a result. Relief usually comes with the seeding of early flowering grains such as Cockatoo Grass. Mosaic patch burning helps to improve access to the fallen seeds and enables them to detect predators. more easily. Broadscale fire reduces hiding spots for small mammals such as quolls, bandicoot and rockrats so predation by owls, cats and dingoes tends to be higher. A reduced food supply can also affect populations. Fire regime for your rural block will depend on objectives, vegetation level of weed infestation and fuel loads.

PROTECTING CROPS

Use only wildlife-safe netting and fencing material or even better build a small low cost shade tunnel to grow your vegetables. A tunnel will allow you to grow more crops as they are better protected from extreme weather such as sun, precipitation and wind while offer complete exclusion of wildlife. Don't use chemicals or pesticides in your garden because if native animals eat poisoned snails or insects they can be affected as well. Therefore use only safe, natural, non-chemical alternatives for pest control. For example you may fight a mealy bug infestation with a thinned rubbing alcohol solution. For cleaning of tools and structures use white vinegar and baking soda. Personally I have no problem of some sharing of crops with wildlife, Permaculture methods are of help as they make it more difficult for infestations or forage damage to blow out. For example a good strategy is to mix planting small patches of food crops with other plants that are not or unlikely to be attacked by insects. In the long term predatory animals will help to neutralize populations of plant pests.

WATERING

Most of Darwin's backyard gardens rely and have some form of watering to sustain a leafy green biomass throughout the dry season between May and November when there is little or no rain. It makes sense to do so because of the need to protect properties from fires, suppress dust and to provide cool comfort and shade in a hot and high UV radiation environment. Although humidity and temperatures tended to drop a little compared to the wet season this is now changing because of climate change and as a consequence we may have to face uncomfortable hot conditions throughout the year. Irrigation of gardens is a key to ameliorate the micro-climate in your backyard. Considering the likelyhood of increased future demand for irrigation, water resources are getting tight worsened by a growing population and higher evaporation rates (every degree Celsius warming increases evaporation by 7 %) and the limited resources of existing ground and surface water resources. We need to irrigate on the one hand but safe water on the other. The key to this growing problem lies in improving soils so they are holding more plant available water, more efficient and smarter irrigation that cuts waste of water, the adoption of native plants that cope with dry spells and the application of water harvesting all helping to take pressure off public utilities.

As a rule of thumb it takes an average of 100 mm of water a month to maintain active growth of vegetation in hot environments which would equate roughly to a calculated consumption of up to 2000 – 3000 ltr per day for the average sized suburban house block. A daily watering regime during the dry as commonly exercised in most local gardens however encourages shallow roots and so may lead to increased water consumption above what is really needed because plants without a deep moisture reservoir get stressed easier and then as a result are watered even more frequently. The shallow rooting habit in case of trees also leads to increased wind damage because of reduced resistance against cyclonic winds that Darwin is exposed too. Deep rooted plants are healthier and are more forgiving when a scheduled watering is skipped. Therefore recommendations are for a deeper watering regime limiting irrigation of lawns to only two to three times a week rather the daily routine, mulched garden beds twice a week and natives once a week. The recommendation of irrigating lawns three times a week during the dry season to a total of at least 100 mm per month would roughly equate to about 10 mm per watering. If you water only twice you could increase that to 15 mm per watering without increasing monthly consumption and at the same time achieve a deeper penetration into the topsoil.

There is a relationship between soil texture and plant available water. Sandy soils hold very little water while clay holds most but to the detriment of air. Roots need both air and water and loam soils constitute a happy medium in between. Sandy soils can be improved by adding organic materials and clay. There is no point of deep watering sandy soils as excess water is simply leached away.

INTEGRATED PEST CONTROL

Integrated Pest Management (IPM) is a sustainable approach to managing garden pests (ie. unwanted vegetation, insect species or diseases), which combines a suite of biological, cultural, physical and chemical tools in a way that minimizes economic, health and environmental risks, by emphasizing the reduced use of pesticides in favor of preventive measures and alternative control techniques such as:

- preventive measures to reduce the attractiveness of the site to pests
- establishment of a 'tolerance threshold'
- monitoring mechanism to identify pest presence
- consideration of treatment options such as biological, cultural, physical and chemical

Preventive measures for me more often than not arise out of trial and error after problems have been encountered. For example I protect plants from being dug up by scrub fowls with sticks and rocks. I found rocks have to be a certain size and sticks are more effective than rocks. Black Rats or mice too are present in our garden at times but they often get wiped out by a range of predators such as monitors and raptors. It is better to tolerate their presence rather than overreact and become heavy handed with poisonous chemicals. Better measures here include maintaining diligence with minimizing access to food sources, such as closing lids on refuse bins after each use, minimizing areas that may be used for nesting (e.g. restricting entry to the space beneath raised buildings) and especially encouraging efficient native predators such as for example the Northern Carpet Python (Morelia spilota) the latter which potentially can consume one rat a week.

My monitoring mechanism for pests is simply to look at every plant visually on a 'daily garden inspection walk'. Sometimes I intervene such when I find an excessive amount of butterfly eggs on a young growing tree. On others I may tolerate caterpillars and eggs and trust to let nature sort it out. Often after a insect invasion that seemingly wipe out plants, natural predatory insects also appear and get damage under control. For example white fly is being reduced by the Great Green Longlegged Fly.

WILDCARE

When you have a garden teaming with wildlife you may occasionally be confronted with a dying, orphaned or injured animal. The caring for native wildlife is licensed by Government in order to ensure suitable experienced carers and rescuers deal with such a problem. You should either contact the local wildcare institution (look up the yellow pages) or contact the wildlife officer in the Parks and Wildlife Department. If the animal is in distress and you can safely catch it and hold in a suitably sized cardboard box it may be faster to transport the animal to the closest local vet which have an agreement with the government to assess and care for such wildlife free of cost.

In many cases for juvenile animals that appear lost the problem does not exist because the parents often leave juveniles unattended for brief periods or perhaps because your presence has scared them away. The juvenile in this case only apprears helpless and lost. In this situation it is better to just step back and wait for the parents to return. In other cases many nestlings or baby animals prematurely fall out of the nest and are then abandoned by the parents as is often the case with Tawny Frogmouths for example. Yet in other cases often the nest itself including baby birds falls out of the tree because of strong winds or other causes. If the baby birds are well just secure the nest as close as possible to its original location and watch the parents return and take care.

This concludes the main text of the book. It has been a journey of learning for myself and this journey is not over rather the learning will continue for my lifetime because there are infinite things to learn and discover. This first edition of the book will be revised every year as I learn and progress and better understand the ecological connections of the web of life through observation. Additionally I will also endeavor to include photography documention for all organisms described in this book.

A final word:

“Land, even more so 'Wildland' is alive, it feels you, it knows you, walk on it softly with a sense of wonder and respect.”

APPENDIX (CHARTS & PHOTO PLATES)

There are three charts that support the main text of this book and consist of the Animal Chart, the Plant Chart, the Fungi and Microorganism Chart and are followed by some sample photos of species, the Bibliography of recommended source reading and the index.

The Animal Chart contains essential information about the size of the adult form ot the animal, habitat, feeding, breeding and nesting for each organism and is presented in broad categories of birds, butterflies, beetles, bees, spiders, other insects, reptiles and mammals. The item number is cross referenced throughout the main text. The scientific name and common name assist in finding information from the internet or bibliography for a more detailed description and photos of the animal.

Key to abreviated habitats in the animal list:

W	Wetland
M-Rf	Monsoon-Rainforest
P	Parks
G	Gardens
Gl	Grassland
Wl	Woodland
Sl	Sedgeland
Est	Estuaries
M	Mangroves
Scl	Scrubland
For	Forests
Ow	Open Woodland
Riv-f	Riverine Forest
Owd	Open Woodland

ANIMAL SPECIES CHART

ITEM	SCIENTIFIC NAME	COMMON NAME	SIZE	HABITAT	FOOD TYPE	BREEDING	NESTING	COMMENT
1. BIRDS								
1.1	Anseranas semipalmata	Magpie Goose	70-90 cm	W	Herbivore	Feb-May	Reeds, float,	DWN Sep-Dec, roost in trees
1.2	Megapodius reinwardt	Orange-footed Scrubfowl	45 cm	M-Rf, P,G	Granivore	Aug-Apr	Ground-mound	Roost in trees
1.3	Coturnix ypsilophora	Brown Quail	20 cm	Gl, Wl, Sl	Granivore	Feb-May	Ground-scrape	Roost on ground
1.4	Threskiornis molucca	Australian White Ibis	70 cm	W. Est. M	Insectivore	Mar-Jul	Platform	Roost in trees
1.5	Threskiornis spinicollis	Straw-necked Ibis	65 cm	W, Wl, P,G	Insectivore	Sep-Oct	Platform	Flocks roost in trees
1.6	Burhinus grallarius	Bush Stone Curlew	57 cm	Wl, Sl, Gl	Insectivore	Jun-Mar	Ground-scrape	Nocturnal, roost standing/sit
1.7	Vanellus miles	Masked Lapwing	34 cm	Open areas	Insectivore	Any time	Ground-scrape	Roosts on ground, defensive
1.8	Accipiter fasciatus	Brown Goshawk	30 – 45 cm	For, plains	Carnivorous	Jul-Sep	Twigs in tree	Eats small birds and mammals
1.9	Geopelia placida	Peaceful Dove	22 cm``	For., Gl	Granivore	Any time	Twigs in shrub	Roost in tree or shrub
1.10	Geopelia humeralis	Bar-shouldered Dove	28 cm	For.,M	Granivore	Any time	Twigs in shrub	Roost in tree or shrub
1.11	Ptilinopus regina	Rose-crowned Fruit Dove	23 cm	M-Rf, W,G	Frugivore	Sep-Feb	Twigs in tree	Roost high in canopy
1.12	Ducula spilorrhoa	Torresian Imperial Pigeon	31 cm	M-Rf, W,G	Frugivore	Aug-Feb	Twigs in tree	Roost in trees
1.13	Chrysococcyx minutillus	Little Bronzecuckoo	16 cm	M. M-Rf, F	Insectivore	Feb-Apr	Brood parasite	Mainly in Mangrove
1.14	Cacomantis variolosus	Brush Cuckoo	21 cm	For.	Insectivore	Oct-Apr	Brood parasite	In dry moves to wetter areas
1.15	Ninox connivens	Barking Owl	32 cm	Riv-f, OW	Carnivorous	Jul-Sep	Tree hollow	Hunts from perch nocturnal
1.16	Podargus strigoides	Tawny Frogmouth	40 cm	Riv-f, OW	Insectivore	Jul-Feb	Twigs in tree	Hunts from perch nocturnal
1.17	Todiramphus macleayii	Forest Kingfisher	20 cm	Riv-f. OW	Insectivore	Sep-Feb	Termite mound	Hunts from perch by day
1.18	Eolophus roseicapillus	Galah	35 cm	OW, Gl	Granivore	Feb-Jun	Tree hollow	Roosts at nest hollow
1.19	Cacatua galerita	Sulphur-crested Cockatoo	55 cm	For.,Gl, P	Granivore	May-Oct	Tree hollow	Roosts communally in trees
1.20	Trichoglossus rubritorquis	Red-collared Lorikeet	30 cm	For.,Sl, P,G	Nectarivore	Any time	Tree hollow	Roosts communally not brdg
1.21	Aprosmictus erythropterus	Red-winged Parrot	32 cm	Riv-f, OW	Granivore	Any time	Tree hollow	Moving with food
1.22	Pitta iris	Rainbow Pitta	17 cm	Riv/M-f,	Insectivore	Oct-Mar	sticks-dome	Roosts in trees, forage ground
1.23	Chlamydera nuchalis	Great Bowerbird	36 cm	For., Sl	Frugivore	Sep-Jan	Bower/bowl	Nest in tree, bower on ground
1.24	Malurus melanocephalus	Red-backed Fairy Wren	11 cm	OW, Gl	Insectivore	Jan-Apr	Dome spdweb	Neg effect of fire on grass
1.25	Myzomela obscura	Dusky Myzomela	14 cm	Riv/M-f	Nectarivore	Apr-May	Cup g/spdweb	Similar to Brown Honeyeater
1.26	Lichmera indistincta	Brown Honeyeater	14 cm	For., Sl, G	Nectarivore	Apr-Sep	Cup g/spdweb	Common in Dwn gardens
1.27	Philemon buceroides	Helmeted Friarbird	34 cm	For, G	Nectarivore	Aug-May	Cup of sticks	Congregates at food sources
1.28	Philemon argenticeps	Silvercrowned Friarbird	30 cm	For.,	Nectarivore	Sep-Mar	Cup of sticks	Congregates at food sources
1.29	Entomyzon cyanotis	Blue-faced Honeyeater	30 cm	For., G	Nectarivore	Apr-Dec	Use old nests	Small flocks
1.30	Melithreptus albogularis	White-throated Honeyeater	13 cm	Riv-f, OW	Nectarivore	Apr-Oct	Cup b/spdweb	Prefers forage in Euc. canopy
1.31	Conopophila albogularis	Rufous-banded Honeyeater	13 cm	Riv-f, M	Nectarivore	All year	Cup b/spdweb	Pairs occupy territory all year
1.32	Ramsayornis fasciatus	Bar-breasted Honeyeater	14 cm	Riv-f.,OW	Nectarivore	Sep-May	Suspend. dome	Prefers close to paperbarks
1.33	Stomiopera unicolor	White-gaped Honeyeater	20 cm	Riv/M-f	Nectarivore	Sep-Mar	Cup b,g,spdw.	Prefers dense high canopy
1.34	Pardalotus striatus	Striated Pardalote	11 cm	For, Sl	Nectarivore	Mar-Nov	Nest tunnel 1m	Prefers canopy, lerp

1.35	Smicrornis brevirostris	Weebill	11 cm	For, Wl,Sl	Insectivore	May-Sep	Round spdweb	Suspended nest often Euc.
1.36	Lalage leucomela	Varied Triller	19 cm	Riv/M-f	Frugivore	All year	Cup spdweb	Adaptable with broad diet
1.37	Sphecotheres vieilloti	Australasian Figbird	28 cm	Riv/M-f,	Frugivore	Sep-Feb	Bowl of sticks	Commonly in small flocks
1.38	Oriolus flavocinctus	Green Oriole	28 cm	Riv/M-f	Frugivore	Sep-Mar	paperb,spdweb	Nest suspended below fork
1.39	Dicrurus bracteatus	Spangled Drongo	28 cm	For, G	Insectivore	Sep-Oct	Basket, vines	Usually alone
1.40	Rhipidura rufiventris	Northern Fantail	17 cm	For, Riv-f	Insectivore	Sep-Apr	Cup bark/spdw	Usually near water
1.41	Grallina cyanoleuca	Magpie Lark	28 cm	For, Gl,	Insectivore	Aug-Apr	Cup, mud,grass	Likes open habitats
1.42	Dicaeum hirundinaceum	Mistletoe Bird	9 cm	For, Sl	Frugivore	Nov-Jan	Pear, spdw,	In Dwn Milkwood/Cheesewd
1.43	Neochmia phaeton	Crimson Finch	13 cm	Wd, Pand.	Granivore	Dec-Jul	Spherical, Pand	Prefers to be in Pandanus
1.44	Peophilia acuticanda	Long-tailed Finch	16 cm	OW,	Granivore	May-Jun	Grass, in Euc.	Pairs sleep in roost nests
1.45	Taeniopygia bichenovii	Double-barred Finch	11 cm	OW, Sl	Granivore	Jan-Jun	Dome, grass	Pairs sleep in roost nests
1.46	Lonchura castaneothorax	Chestnut-breasted Mannikin	11 cm	Gl, sedl,	Granivore	Nov-Apr	Dome, grass	Roosts in dense grass or reeds
1.47	Merops ornatus	Rainbow Bee-eater	25 cm	Wl, For	Insectivore	Sep-Oct	Nest tunnel	Non-breed. in group treeroost
1.48	Eurystomus orientalis	Oriental Dollarbird	28 cm	OW, Riv-f	Insectivore	Oct-Jan	Tree hollows	Leave feb-apr return sep
1.49	Corvus orru	Torresian Crow	49 cm	Wl, dumps	Omnivorous	Jan-May	Bowl of sticks	Kills Cane Toads
2. BUTTERFLIES								
2.1	Tirumala hamatus	Blue Tiger	7 cm	M-rf, vine	Nectar, LFP,	Wet Season	na	Disperses in pre-wet
2.2	Cethosia penthesilea	Orange Lacewing	6.5 cm	M-rf	Nectar, LFP	na	na	Fly in sunlit gaps of canopy
2.3`	Hypolimnas bolina	Varied Eggfly	6 cm	broad	Nectar, LFP	Not in dry S	na	LFP variety of herbal plants
2.4	Hypolimnas alimena	Blue-banded Eggfly	7 cm	M-rf	Nectar, LFP	Na	Na	LFP variety of herbal plants
2.5	Euploea corinna	Common Crow	7 cm	Broad	Nectar, LFP	Not in dry S	Na	LFP may types of plants
2.6	Mycalesis sirius	Cedar Bush-brown	4 cm	Pb-f, Ow	Nectar, LFP	2 generations	Na	LFP mainly grasses
2.7	Danaus petilia	Lesser Wanderer	6 cm	Broad	Nectar, LFP	2+gen	Na	LFP wide variety of plants
2.8	Junonia villida	Meadow Argus	4 cm	broad, Ow	Nectar, LFP	Not in dry S	Na	LFP many herb + shrubs
2.9	Acraea andromacha	Glasswing	5 cm	M-rf, OW	Nectar, LFP	Na	Na	LFP vines + forbes
2.10	Eurema hecabe	Large Grass-yellow	4 cm	OW, Gl,	Nectar, LFP	2+gen	Na	LFP range of plants
2.11	Catopsila pomona	Lemon Migrant	6 cm	Broad, Ow	Nectar, LFP	Wet Season	Na	LFP cassia and senna
2.12	Delias argenthona	Scarlet Jezebel	6 cm	Ow, Pb, G	Nectar, LFP	Na	Na	LFP includes mistletoe leaves
3. BEETLES								
3.1	Gnathaphanus philippensis	Common Black Ground Beetle	7 mm	In debris	seeds	na	Na	Often at margins of water
3.2	Cicindela semicincta	Emerald Tiger Beetle	1 cm	various	insects	na	na	Active day and night
3.3	Lasioderma serricorne	Cigarette Beetle	3 mm	Near foods	grains,wood	Na	Na	Lays eggs into dry substances
3.4	Bostrychopsis jesuita	Large Auger Beetle	2 cm	Near trees	wood	Na	na	Lays eggs into bored tunnels
3.5	Prosopocoilus bison	Bison Stag Beetle	6.5 cm	forests	Wood	Na	Na	Lays eggs in wood cracks
3.6	Dilochrosis brownii	Brown's Fruit Chafer	2.5 cm	Near trees	Nectar	Na	Na	Active by day, near flowers
3.7	Xylotrupes ulysses	Rhinoceros Beetle	6 cm	forests	Bark, fruit	Na	Na	Larvae in nests of scrubfowl
3.8	Merimna atrata	Fire Beetle	2 cm	Near trees	Wood	Na	Na	Larvae laid into burnt bark
3.9	Coccinella transversalis	Transverse Ladybird	5 mm	In any veg	Aphids	Na	Na	Also eats insect eggs/pollen

3.10	Poneridia semipullata	Figleaf Beetle	1 cm	Forests, P	Fig leaves	Na	Na	Larvae feed on fig leaves
4. BEES								
4.1	Amegilla aeruginoses	Copper Rust Bee	1 cm	For., Sl	Nect/Pollen	Na	Ground tunnel	Female dig nest tunnel
4.2	Amegilla chlorocyange	Blue Banded Bee	1 cm	For., Sl, Gl	Nect/Pollen	Na	Ground tunnel	Female dig nest tunnel
4.3	Apis mellifera	European Honeybee	12 mm	flwrs+water	Nect/Pollen	Na	hives/hollows	“Dance” communications
4.4	Megachile aethiops	Northern Purple-winged Bee	16 mm	unknown	Nect/Pollen	Na	Cavity	solitary
4.5	Trigona mellipes	Northern Sugarbag Bee	4 mm	OW	Nect/Pollen	Na	Tree cavity	Colony of thousands
4.6	Xylocopa paryula	Large Carpenter Bee	7 mm	OW	Nect/Pollen	Na	Dead wood	Females bore nest into wood
5. SPIDERS								
5.1	Pholcus phalangioides	Daddy Long Legs	6-8 mm	OW, sheds	invertebrates	All year	Web, logs,rock	Active day and night
5.2	Argiope aetherea	St Andrews Cross Spider	5-18 mm	For., P+G	invertebrates	Na	X-web	Egg sacs
5.3	Eriophora biapicata	Garden Orbweaving Spider	15-22 mm	OW, P+G	Invertebrates	Na	Large web	Sits in center at night for prey
5.4	Nephila edulis	Edible Golden Orbweaving S.	5 - 40 mm	OW, P+G	Invertebrates	Na	Huge web	Female sit in web day + night
5.5	Nephila pilipes	Giant Golden Orbweaving S.	4 – 50 mm	Riv-f, M-rf	Invertebrates	Na	Huge web	Elaborate courtship rituals
5.6	Nephilengys papuana	Australian Hermit Spider	5 – 18 mm	For., P+G	Invertebrates	Na	Surface web	Active at night
5.7	Latradectus hasselli	Redback Spider	3 – 15 mm	OW, G	Invertebrates	Na	Funnel web	Dangerous venom
5.8	Thomisus spectabilis	White Crab Spider	3 – 12 mm	OW, P+G	Invertebrates	na	Sits on flower	Does not build web
5.9	Cosmophasis bitaeriata	Green Ant Scent-mimicking S.	1 cm	For., P+G	eggs/larvae	na	GreenAnt nest	GreenAnt eggs and larvae
5.10	Mopsus mormon	Green Jumping Spider	12 – 15 mm	For., P+G	Invertebrates	Na	Silk home	Active day and night
6. OTHER INSECTS								
6.1	Eurycnema osiris	Darwin Stick Insect	14 – 26 cm	For., P+G	Foliage	Na	Na	Often on Eucalypts/Acacias
6.2	Oecophylla smaragdina	Green Ant	1 cm	Forests	insect/nectar	Na	Nest of leaves	Colony may contain ½ million
6.3	Calephorops viridis	Lesser Buzzer	1.5 – 2 cm	OW, Gl, L	Grass ?	Na	Na	Makes buzzing flights
6.4	Froggattina australis	Froggatt's Buzzer	2 – 3 cm	OW, Gl, L	Grass ?	na	na	5 sec buzz flight to attract fm
6.5	Gastrimargus musicus	Yellowwinged Locust	4 – 5 cm	Grass areas	Grass ?	Multi per yr	Eggs on soil	Eggs viable for 10 months
6.6	Valanga irregularis	Giant Grasshopper	6.5 – 9 cm	For, Sl, P,G	leaf tree+shr	Na	Eggs in hole	Hides when spotting predator
6.7	Periplaneta australasiae	Australasian Cockroach	5 cm	Many, HH	All organic	All year	Na	Active at night
6.8	Periplaneta americana	American Cockroach	5.5 cm	Many, HH	All organic	All year	NA	Active at night
6.9	Coptotermes acinaciformis	Tree-piping Termite	6.5 mm	For, Sl, Gl	Wood	Na	Domes, cones	Colonies at trees
6.10	Macrotristria doddi	Darwin Whiner	5 cm	For, P, G,	Na	Na	na	Droning sound
6.11	Rhyothemis graphiptera	Graphic Flutterer	3 cm	Near water	Invertebrate	Na	Na	Yellow/black stripes on wings
6.12	Culex annulirostris	Common Banded Mosquito	4 mm	Near water	Blood	Peak in wet	Eggs on water	Transmits range of viruses
6.13	Ochlerotatus vigilax	Saltmarsh Mosquito	4 mm	Salt marsh	Blood	Peak in wet	Eggs on water	Transmits range of viruses
6.14	Nala lividipes	Black Field Earwig	11 mm	Vegetation	Na	Na	Na	Inhabits loose soil, crop pest
7. REPTILES AND MAMMALS								
7.1	Lophognathus temporalis	Northern Water Dragon	Sv 10 cm	For, Sl, P,G	Invertebrates	Na	Ground dwell.	Sleeps perched on tree
7.2	Litoria bicolor	Northern Dwarf Tree Frog	3 cm	Riv-f, OW	Invertebrates	Na	Na	Perched on grass + near water

7.3	Litoria caerulea	Green Tree Frog	to 10 cm	For, swamp	Invertebrates	na	na	Up to 4000 eggs on surface
7.4	Rhinella marina	Cane Toad	14 cm	For, Sl, Gl	Invertebrates	Wet season	na	Up to 20000 eggs, toxic
7.5	Tiliqua scincoides	Northern Blue-tonged Lizard	Sv 30 cm	OW, Sl, G	Invertebrates	Na	burrow	Live bearing
7.6	Trichosurus vulpecula	Brushtail Possum	40 cm	OW	Leaves, fruit	All year	Tree hollow	In NT in decline
7.7	Nyctophilus walkeri	Pygmy Long-eared Bat	4 cm	Riv/M-For	invertebrates	Early wet	Veg + hollows	Hunts flying low to ground
7.8	Macroglossus minimus	Northern Blossom Bat	5-7 cm	For, coastal	Flowers, fruit	Na	caves/hollows	Important pollinator
7.9	Pteropus alecto	Black Flying Fox	23-28 cm	Forests	Flowers, fruit	Wet season	Comm/camp	Travels up to 20 km to forage
7.10	Pteropus scapulatus	Little Red Flying Fox	20 – 24 cm	Forests	Flowers, fruit	Nov-May	Comm/camp	Travels far to forage
7.11	Rattus tunneyi	Pale Field Rat	12-30 cm	For, Gl	Plant matter	Jan-Apr	Burrow	Prefer near water
7.12	Rattus rattus	Black Rat	19 – 25 cm	Riv/M, Wd	Omnivorous	All year	Burrow, cavity	Common in Darwin
7.13	Chlamydosaurus kingii	Frillneck Lizard	26 cm	OF, Wl	Insectivore	Nov-Jan	burrow	Gender by temperature
7.14	Morelia spilota	Northern Carpet Phyton	2 m	Forests	Carnivorous	Sep-Nov	Hollows	Prays on the Black Rat
7.15	Dendrelaphis punctulatus	Golden Tree Snake	1.2 m	Forests	frogs,lizards	Na	Tree foliage	Abundant near water
7.16	Varanus panoptes	Yellow-spotted Monitor	1.4 m	Owd, Sl, Gl,	Small animal	Wet season	burrow	Vulnerable (Cane Toad)

The following Plant Chart contains information on recommended and commonly occuring plant species presented in broad categories of Monsoon Vine Thicket, Wetland, Riverine, Coastal, Sandstone Escarpment, Woodland, Exotic plant species (not naturally occuring in the NT) and Weeds. As with the Animal Chart it includes the item's cross reference, scientific name, common name and a size attribute but also information on light and water requirements, flowering period and fruit type. Detailed habitat classification however is not presented in the chart as they are covered in more detail in the main text. Light and water requirements, size and flowering period need to be taken into consideration when designing your garden and having these attributes in condensed form facilitates quick comparisons to find like requirements and a consideration of flowering sequence. While the list of recommended plants is based on proven species performance, availability in local nurseries and suitability to support a broad spectrum of wildlife, it is by no means comprehensive. I strongly recommend the richly illustrated book 'Top End Native Plants' by John Brock which is available in local book shops and the Darwin libraries.

PLAND SPECIES CHART BY HABITAT								
ITEM	BOTANICAL NAME	COMMON NAME	SIZE	LIGHT	WATER	FLOWERING	FRUIT	COMMENT
1. MONSOON VINE THICKET								
1.1	Acacia auriculiformis	Black Wattle	20 m`	Sun	Medium	Apr-Jul, (Y)	pods	P (Treated seed), fast
1.2	Allosyncarpia ternata	Allosyncarpia	30 m	Sun/Semi	Low	Oct-Dec (C-W)	capsule	P (Fresh seed), adapts
1.3	Alphitonia excelsa	Soap Tree	5-15m	Sun	Medium	Jan-Apr (C)	capsule	P (seed) native bee nectar, med
1.4	Alstonia actinophylla	Milkwood	10-20 m	Sun	Medium	Aug-Oct (C)	follicles	P (seed/cuttings), slow
1.5	Antidesma ghaesembilla	Black Current	<15 m	Sun/Semi	Medium	Aug-Dec (C)	Edible	P (seed/cuttings) m+f diff. tree
1.6	Breynia cernua	Bird Apple	1-4 m	Sun	Medium	Periodic (C)	e. berry	P (seed/cuttings) m+f same tree
1.7	Cupaniopsis anacardioides	Tuckeroo	5-10 m	Sun	Medium	Jul-Sep (W)	capsule	P (fresh seed)
1.8	Diospyros maritima	Aus. Ebony	3-6 m	Semi	Medium	Jan-Mar (W)	e. birds	P (seed), m+f on different trees
1.9	Diospyros compacta	Aus. Ebony	3-6 m	Semi	Medium	Oct-Dec (W)	e. birds	P (seed) m+f on different trees
1.10	Albizzia lebbeck	Albizzia	10-15 m	Sun	Low	Sep-Oct ©	Pods	P(seed) good source of nectar
1.11	Ficus scobina	Sandpaper Fig	4-8 m	Sun	Low	Oct-Jun (flesh)	edible	m+f flowers on separate trees
1.12	Flueggea virosa	White Current	2 m	Sun	Medium	Oct-Feb (C)	edible	P (seed) leaves medicinal
1.13	Leea rubra	Leea	1-3 m	Sun/Semi	High	Sep-Apr (R)	edible	P (seed/cuttings) pot plant
1.14	Leea novoguinensis	Leea	1-3 m	Sun/Semi	High	May-Jul (R)	edible	P (seed/cuttings) pot plant
1.15	Maranthes corymbosa	White Cloud	10-25 m	Sun	Medium	May-Sep (C)	Big seed	P (seed/cuttings) firewood
1.16	Micromelum minutum	Lime Berry	<20 m	Semi	Medium	Periodic (C)	Big seed	P (seed) good nectar for bees
1.17	Milletia pinnata	Pongamia	5-10 m	Sun	Medium	Sep-Dec (C-P)	Pods	P (seed) all parts are toxic
1.18	Mimusops elengi	Red Condoo	10-15 m	Sun	Medium	Nov-Jan (C)	edible	P (seed) adapts but slow
1.19	Morinda citrifolia	Cheese Fruit	3-8 m	Sun	Medium	Periodic (W)	edible	P (seed) young leaves edible
1.20	Murraya paniculata	Orange Jasmine	2-10 m	Sun/Semi	Medium	Nov-Dec (W)	Big seed	P (seed/cutting)
1.21	Myristica insipida	Native Nutmeg	8-14 m	Sun/Semi	Medium	Feb-Mar (C)	edible	P (seed) m+f on different trees
1.22	Peltophorum pterocarpum	Yellow Flame	10-15 m	Sun	High	Aug-Jan (Y)	capsule	P (treated seed), fast
1.23	Pleomele angustifolia	Native Dracaena	1-5 m	Semi	Medium	Jun-Oct (G-Y)	berry	P (seed)
1.24	Sterculia quadrifida	Peanut Tree	5-15 m	Sun	Medium	Feb-Nov (G-Y)	Edible	P (seed), seeds edible
1.25	Syzygium fibrosum	Red Bush Apple	5-8 m	Sun	High	Apr-Oct (C)	Edible	P (seed), keep well drained
1.26	Syzygium nervosum	River Apple	15-20 m	Sun	High	Sep-Nov (C)	Edible	P (seed) keep well drained
1.27	Tabernaemonlana orientalis	Iodine Plant	1-3 m	Semi	Medium	Nov-Feb (W)	seeds	P (seed)
1.28	Terminalia microcarpa	Damson Plum	15-30 m	Sun	High	Sep-Dec	Edible	Deciduous, P (seed)
1.29	Vitex glabrata	Vitex	3-6 m	Sun	Low	Jun-Dec (W-P)	Edible	P (seed)
1.30	Wrightia pubescens	Wrightia	3-12 m	Sun/Semi	Medium	Oct-Jan (W)	follicles	P (seed)
1.31	Aidia racemosa	Archer Cherry	4-10 m	Sun/Semi	High	Feb? (C)	Edible red	P (seed), fragrant,
1.32	Ipomea abrupta	Bush Yam	Vine	Sun/Semi	Medium	Nov-Mar	capsule	Tuber/Roots are eaten raw or cooked
1.33	Ampelocissus acetosa	White Grape	Vine	Sun/Semi	Medium	Sep-Feb	Edible	P (Seed) Fruit and roots are edible
1.34	Flagellaria indica	Bangle Vine	Vine	Sun	Medium	Jan-Dec	Berry	P (Seed) flesh is edible not seed

1.35	Gymnanthera nitida	Gymnanthera	Vine	Sun/Semi	Medium	Dec-Jul	Capsule	
1.36	Hoya sp	Waxplant	Vine	Sun	Low	Dec-Mar	Pods	P (Cuttings) make good rockery plants
1.37	Jasminum aemulum	Native Jasmine	Vine	Sun/Semi	Medium	Oct-Dec	Berrry	P (Seed or cuttings)
1.38	Opilia amentacea	Opilia	Vine	Sun/Semi	Meduum	Aug-Oct	Fruit	Edible when peeled and eaten with seed
1.39	Parsonsia velutina	Parsonsia	Vine	Sun/Semi	Low	Jan-Apr	Follicle	
1.40	Smilax australis	Sarsaparilla	Vine	Sun/Semi	Medium	Nov-Mar	Berries	Edible
1.41	Ziziphus oenoplia	Wild Jujube	Vine	Sun/Semi	Medium	Feb-Mar	Edible	Thorny shrub and vine,
2. WETLAND								
2.1	Lophostemon lactifluus	Swamp Mahagony	7-10 m	Sun	Medium	Sep-Dec ©	Capsules	P(hardwood cuttings and seed)
2.2	Asteromyrtus symphyocarpa	Liniment Tree	4-10 m	Sun	Medium	Periodically (O)	woody	P (seed)
2.3`	Banksia dentata	Banksia	3-8 m	Sun	Medium	Dec-Apr (Y-O)	woody	P (seed) tolerate waterlogging
2.4	Corymbia bella	GhostGum	8-15 m	Sun	Medium	Aug-Dec (C-W)	capsules	P (seed) good bee nectar
2.5	Grevillea pteridifolia	Fern Grevillea	5-10 m	Sun	Low	MayOct (O)	woody	P (seed?tip cuttings) edible flwr
2.6	Nymphaea violacea	Water Lily	water	Sun	submerge	Jan-Jul (W-B-P)	Edible	Roots, stalk, seed head edible
2.7	Nymphoides indica	White Snowflake	water	Sun/Semi	submerge	Apr-Jul (W)	Edible	Tiny seeds
3. RIVERINE								
3.1	Carallia brachiata	Bush Currant	5-12 m	Sun	High	Jul-Sep (C-G)	Edible	P (seed)
3.2	Carpentaria acuminata	Carpentaria Palm	15 m	Sun	Med/High	Sep-Dec (C)	Edible	P (seed) young shoot edible
3.3	Chrysopogon elongatus	Tamil Grass	grass	Sun	High	Apr-Sep, Dec-J	seeds	P (seed/rhizome) 3-5 years
3.4	Corymbia ptychocarpa	Swamp Bloodwood	8-12 m	Sun	Med/High	Feb-Jun (R)	woody	P (seed)
3.5	Cyclophyllum schultzii	Canthium	2-8 m	Sun	High	Sep-Nov (W)	Edible	P (seed to 60 d to germinate)
3.6	Fragraea racemosa	Woodland Coffee	4-10 m	Sun	High	Periodic (W)	berries	P (seed/cutting) pendulous
3.7	Helicia australasica	Helicia	10-15 m	Semi	High	Aug-Nov (C)	edible	P (seed)
3.8	Hydriastele wendlandiana	Wendland's Palm	palm	Semi	High	Sept-Dec (C)?	edible	Growing shoot eaten
3.9	Leptospermum madidum	Weeping Tea Tree	3-8 m	Sun	Medium	Jul-Nov (C)	woody	P (seed/cutting)
3.10	Livistonia benthamii	Fan Palm	palm	Sun/Semi	Medium	May-Aug (C)	berry	P (seed 3-4 months to germinat)
3.11	Melastoma malabathricum	Native Lasiandra	<2 m	Sun	Medium	Periodic (P)	Edible	P (seed/cutting) Pollen for bees
3.12	Nauclea orientalis	Leichardt Tree	10-20 m	Sun	Medium	Sep-Dec (Y)	Edible	P (seed) medical
3.13	Syzygium armstrongii	Bush Apple	8-12 m	Sun	High	Sep-Dec (C)	Edible	P (seed) fruit eaten raw
3.14	Timonius timon	Timonius	5-15 m	Sun	Medium	May-Nov (W)	drupes	P (seed) medicinal
3.15	Melastoma polyanthum	Lasiandra	<2m	sun/semi	High	Periodic (P)	Edible	P (seed/cutting) Pollen for bee
3.16	Themeda triandra	Kangaroo Grass	grass	sun	Medium	Nov-Mar	Seedheads	P (seeds) seeds eaten by several bird species
4. COASTAL								
4.1	Cordia subcordata	Sea Trumpet	7-15 m	Sun	Low	Feb-May (O)	edible	P (seed) well drained soil
4.2	Dillenia alata	Red Beach	5-10 m	Sun	High	Oct-Jan (Y)	edible	P (seed/cutting)
4.3	Ipomea pes-caprae	Morning Glory	GC	Sun	Low	Periodic (Pink)	Edible	P (seed/cutting) medicinal
4.4	Hibiscus tiliaceus	Beach Hibiscus	5-8 m	Sun	Medium	Periodic (Y)	woody	P (seed/cuttings) root/flw edible
4.5	Vitex trifolia	Blue Vitex	<3 m	Sun	Low	Jun-Jul (Lilac)	seed	P (seed up to 75 d), cutting

4.6	Vitex rotundifolia	Beach Vitex	<1 m	Sun	Low	Jun – Jul	Seed	P (seed_
5. SANDSTONE ESCARPMENT								
5.1	Asteromyrtus magnifica	Medicine Leaf	<3 m	Sun	Low	Periodically (W)	woody	P (seed)
5.2	Acacia mountfordiae	Mountford Wattle	2-4 m	Sun	Low	Jun-Oct (Y)	pods	P (treated seed) rock+sand
5.3	Eucalyptus herbertiana	Herbert's Gum	3-10 m	Sun	Low	May-Dec (C)	woody	P (seed) sugar-bag bees
5.4	Eucalyptus phoenicia	Scarlet Gum	7-12 m	Sun	Low	Apr-Jul (O)	woody	P (seed) good firewood
5.5	Gardenia fucata	Cape Jasmine	<4 m	Sun/Semi	Low	Sep-Feb (W)	seeds	P (seed) scented flowers
5.6	Grevillea formosa	Mt Brockman	1-2 m	Sun	Low	Dec-May (Y)	follicles	P (seed/tip cuttings) fast growth
5.7	Grevillea refracta	Silver-leaf Grevillea	<4 m	Sun	Low	Periodic (O)	follicles	P (seed)
5.8	Jacksonia dilatata	Jacksonia	2-4 m	Sun	Low	May-Nov (Y)	capsule	P (seed)
5.9	Pandanus basedowii	Sandstone Pandanus	3-5 m	Sun	Medium	Apr-Jul	woody	P (seed) m+f flw on diff trees
5.10	Acacia dunni	Elephant Ear Wattle	2-4 m	Sun	Low	Mar-May (Y)	woody	P (seed)
6. WOODLAND								
6.1	Acacia gonocarpa	Cloud Acacia	1-3 m	Sun	Low	Oct-Feb (C)	pods	P (treated seed) fast growth
6.2	Acacia nuperima	Acacia	1.5 m	Sun	Low	Periodic (Y)	pods	P (treated seed) fast growth
6.3	Gardenia megasperma	Gardenia	3-6 m	Sun/Semi	Low	Jun-Oct (W)	edible	P (seed)aboriginal uses
6.4	Eucalyptus alba	White Gum	10-16 m	Sun	Medium	Jul-Sep (C)	woody	P (seed) nectar for bees
6.5	Grevillea decurrens	Cloth Peg Tree	<4 m	Sun	Low	Dec-Apr (pink)	follicles	P (seed) adapts to soils
6.6	Grevillea dryandri	Dryander;s Grevillea	<2 m	Sun	Low	Nov-Apr (R)	Follicles	P (seed) nectar for bees
6.7	Melaleuca minutifolia	Paperbark	2-4 m	Sun	Low	Sep-Dec (C)	woody	P (seed/cuttings) papery bark
6.8	Pandanus spiralis	Pandanus	3-10 m	Sun	Medium	Apr-Jun (W)	woody	P (seed) m+f fw on diff trees
6.9	Petalostigma pubescens	Quinine Tree	<6 m	Sun	Low	Oct-Dec (C)	woody	P (seed) m+f fw on diff trees
6.10	Xanthostemon paradoxus	Bridal Tree	4-10 m	Sun	Low	Periodically (Y)	pods	P (seed) fragrant flowers
6.11	Calytrix estipulata	Turkey Bush	1 – 4 m	Sun	Low	May-Aug (P)	Small nut	P (seed) good nesting shrub
6.12	Buchanania obovata	Green Plum	4 – 10 m	Sun	Low	Jul – Oct	Edible	Decidious, Good bush tucker
6.13	Terminalia ferdinandiana	Billy Goat Plum	5 – 7 m	Sun	Low	Sep – Nov	Edible	Decidious
6.14	Ficus opposita	Sandpaper Fig	3-8 m	Sun	Low	Jul-Feb (flesh)	edible	m+f flowers on separate trees
6.15	Syzygium suborbiculare	Red Bush Apple	8 – 12 m	Sun/Semi	Low	Jul-Oct	Edible	Fire tolerant lignotuber, P (seed)
6.16	Corymbia polycarpa	Long-fruied bloodw.	5 – 15 m	Sun	Low/med	Mar-Jun (C)	capsule	P (seed) calender plant
6.17	Ficus aculeata	Sandpaper Fig	4 – 8 m	Sun	Low	?	Soft edible	m+f flowers on separate trees
6.18	Triodia epactia	Spinifex	< 1 m	Sun	Low		Seed	P (seed) perennial spinifex grass
6.19	Alloteropsis semialata	Cockatoo grass	Grass	Sun	Low	Nov-Dec	seed	P(seed) important for granivorous birds
7. EXOTIC								
7.1	Breynia 'Ironstone Range'	Nodding Breynia		Semi	Medium	Periodic (C)	e. berry	Pollinator*Epicephala* spp moths
7.2	Callistemon 'Wilderness”	White Bottlebrush	2.5 m	Sun/Semi	Medium	Spring (W)	follicles	P (cuttings half ripened tips)
7.3	Metrosideros collina	Little Ewan	<1 m	Sun/Semi	Medium	Periodically (R)	seed	P (cuttings)
7.4	Xanthostemon chrysanthus	Golden Panda	<5 m	Sun/Semi	Low	Autumn (Y)	pods	P (cuttings)

7.5	Syzygium australe	Lilly Pilly	3 m	Sun/Semi	Medium	Spring (W)	edible	P (cuttings hardened)
7.6	Psidium littorale	Cherry Guava	2-5 m	Sun	Medium	Periodically (C)	edible	P (cuttings)
7.7	Grevillea 'Sandra Gordon'	Grevillea	3.5 m	Sun	Low	Spring (Y)	follicles	P (cuttings half ripened tips)
7.8	Melaleuca linarifolia purple	Dwarf Melaleuca	1.3 m	Sun	Medium	Spring (W)	woody	P (cuttings)
7.9	Callistemon viminalis 'Rose'	Rose Opal	2 m	Sun/Semi	Medium	Spring (pink)	woody	P (cuttings)
7.10	Citrus japonica	Cumquat Nagami	3 m	Sun/Semi	Medium	Spring (W)	edible	grafted
7.11	Moringa oleifera	Moringa	< 12 m	sun/semi	Medium	May – Oct	pod	Medicinal flowers excellent source of nectar
7.12	Gardenia pisodiodies	Hann Gardenia	< 1 m	Sun/semi	Medium	Periodically ?	seeds	Prostrate ground cover P (cuttings)
8. COMMON WEEDS IN THE DARWIN AREA								
8.1	Alternanthera philoxeroides	Alligator Weed	GC/AQ	Sun	High	Jan-Mar	seeds	Both aquatic and landform
8.2	Baleria prionitis	Balerias	2 m	Sun/Semi	Range	Mar-Dec	capsules	Wide range of habitats
8.3	Jatropha gossypifolia	Bellyache Bush	3 m	Sun	Range	Jan-May	capsules	Forms thickets
8.4	Clitoria ternata	Butter Fly Pea	Vine	Sun/Semi	Medium	Feb-Jun	pods	Invasive in riparian systems
8.5	Calopogonium mucunoides	Calopo	Vine	Sun/Semi	Medium	Apr-Aug	pods	Invasive in moist habitats
8.6	Senna alata	Candle Bush	4 m	Sun/Semi	Medium	May-Jun extended	pods	Invasive in creeks, gullies, drainage lines
8.7	Centrosema molle	Centro	Vine	Sun/Semi	dry	Sep-Oct	pods	Disturbed areas
8.8	Ziziphus mauritiana	Chinee Apple	6 m	Sun	dry	Dec-Apr	fruit	Edible and spread by birds and animals
8.9	Leucaena leucocephala	Coffee Bush	6 m	Sun	dry	All year	pods	Forms dense thickets in disturbed sites
8.10	Antigonon leptopus	Coral Vine	Vine	Sun/Semi	Medium	All year	Seeds	Seeds dispersed by birds
8.11	Eulophia graminea	Exotic Grd Orchid	Orchid	Sun	Medium	Jan-Mar ?	Seeds	Invades mulched areas
8.12	Sida cordifolia	Flannel Weed	< 2 m	Sun/Semi	dry	Dec-May	Seeds	Invades disturbed areas
8.13	Panicum maximum	Guinea Grass	Grass	Sun	Medium	Feb-Oct	Seeds	Forms dense stands, displaces native grass
8.14	Hyptis suaveolens	Hyptis	1.5 m	Sun	Range	Feb-Aug	Capsule	Invades most soil types except waterlogged
8.15	Rottboellia chochinchinensis	Itch Grass	Grass	Sun	Range	Jan-Sep	Seeds	Dispersed by animals including birds
8.16	Lantana camara	Lantana	4 m	Sun	range	All year	seeds	Dispersed by birds eating the fruit
8.17	Lantana montevidensis	Lantana	GC	Sun	range	All year	Seeds	Dispersed by birds eating the fruit
8.18	Cenchrus polystachios	Perennial Mission G	Grass	Sun	range	Mar-Jun	Seeds	Easily spread by wind
8.19	Azadirachta indica	Neem	15 m	Sun	Medium	Jul-Sep	Seeds	Dispersed by bats and birds eating the fruit
8,20	Annona glabra	Pond Apple	6 m	Sun	High	Oct-Mar	fruit	Dispersed by animals and forming stands
8.21	Cryptostegia grandiflora	Rubber Vine	Vine	Sun/Semi	High	Feb-May	pods	Invades riparian fringes strangling natives
8.22	Senna obtusifolia	Sicklepod	2 m	Sun	Dry	Feb-Aug	pod	Dense stands displacing native vegetation
8.23	Stachytarpheta spp	Snakeweed	2 m	Sun	Medium	All year	Seeds	Invades riparian and monsoonal forest
8.24	Sida acuta	Spinyhead Sida	2 m	Sun	Low	Apr-Sep	Seeds	Invades disturbed area
8.25	Cenchrus pedilatus	Annual Mission G	Grass	Sun	Medium	Apr-Jun	Seeds	Invades roadsides and wet margins
8.26	Andropogon gayanus	Gamba Grass	Grass	Sun	Medium	April	Seeds	Invades wet margings and pastoral areas
8.27	Passiflora foetida	Wild Passionfruit	Vine	Sun	Range	All year	Fruit	Birds disperse seeds
8.28	Spathodea campanulata	African Tulip Tree	20 m	Sun	Medium	May-Aug	capsule	Fruit is poisonous

8.29	Caryota mitis	Fishtail Palm	10 m	Sun	Medium		fruit	Dispersed into rainforests and drainage lines
8,30	Cassia fistula	Golden Rain Tree	8 m	Sun	Medium	Jul-Feb	pod	Seeds dispersed by birds
8.31	Delonix regia	Poinciana	15 m	Sun	Range	Nov-Dec	pods	
8.32	Thunbergia grandiflora	Blue Trumpet Vine	Vine	Sun	Medium	All year	seeds	Seeds dispersed by birds

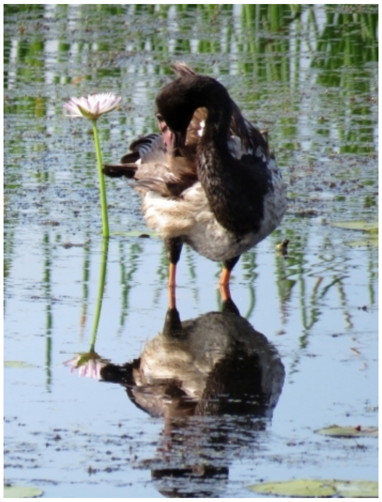
The following chart on Fungi and Microorganisms contains a fair portion of publically available information on fungi in the NT, but is by no means exhaustive or complete. There are many gaps in our knowledge and it is no wonder that this table contains blank spaces. We don't know what we have here in the NT and the little we know remains barely researched. As we are just getting to know that the world of fungi, bacteria and other microorganism is crucially important to the health of the web of life particularly the soil food web we simply can't any longer be ignore it. Not only do we not know what is out there in terms of these microscopic species and how they interact with plants and wildlife, we also have very little clue on how these organisms will fare in the face of climate change, chemical pollution, global warming and when confronted with development. As with the animal and plant charts I have included a cross reference number and a scientific name but in addition to this also a family reference. Hints on the habitat are followed by information on body and form, spores and type. The column 'photos' refers to availability of reference source photos (W = wiki, AA = Australian Atlas, F = Fuhrer field guide page number, Y = Young field guide, PW = Parks and Wildlife of the NT). This reference will help you locate photos of the specimen. While this first edition of the book contains no photos of specimens of plants and animals other than a few examples shown in the appendix, I'm planning to add several hundred photos in the second edition. This may take a couple of years.

FUNGI AND MICRO ORGANIMS CHART								
ITEM	SCIENTIFIC NAME	FAMILY	BODY/FRUIT	HABITAT	FORM	SPORES	PHOTO	BEHAVIOR
1. FUNGI		(E = edible,T = toxic, P = pathogenic)				in micrometer		
1.1	Candida glabrata	Saccaromycetaceae	P	Human tissue	Microscopic	Asexual	W (wiki)	Yeast
1.2	Camarophyllpsis darwiniensis			Rainforest			AA (atlas)	
1.3	Oxyporus latemarginatus			Rainforest				
1.4	Candida parapsilosis	Debaryomycelaceae	P	Animals, soil	Microscopic	Asexual		Yeast
1.5	Candida albicans	Saccaromycetaceae	P	Human gut	Microscopic		W (wiki)	Yeast
1.6	Leucocoprinus birnbaumii	Agaricaceae	T, gilled, 60 mm d	On soil in litter	Bell cap	10x7, white	F166, AA, Y	Saprotrophic
1.7	Chlorophyllum molyblites	Agaricaceae	T, gilled, 40 mm d	Lawns, parks	Flat cap, stipe	Green, 10x7	W, AA, Y	Saprotrophic
1.8	Lycoperdon perlatum	Agaricaceae	E, 60 mm dia	Leaf litter, ground	Puffball	4, brown	F 329, AA	Saprobic
1.9	Cavalium cyathiformis	Agaricaceae	5-20 cm,high	Grass, paddock	Puffball	3.5-7.5,	W, AA	Saprobic
1.10	Leucoprinus fragilissimus	Agaricaceae	45 mm, gilled	Decaying plants	Cap, ringstipe	White print	W, AA	Saprotrophic
1.11	Lycoperdon scabrum	Agaricaceae	40 mm	Woodland, OF	Puffball	5, brown	F 331, AA	
1.12	Coprinus sterquilinus	Agaricaceae	60 mm	On animal dung	Ovoid cap	17-26x10-15	AA	
1.13	Coprinus cyanescens	Agaricaceae						
1.14	Amanita hemibapha	Amanitaceae			Giled cup, stipe	White print	AA, T, W	Mycorrhizal
1.15	Arthonia cinnabarina	Arthoniaceae					W	Lichen ?
1.16	Auricularia cornea	Auriculariaceae	E, 100 mm	Dead wood	Yelli fungi	20x9, white	F 449, AA, Y	Saprotrophic
1.17	Bolbitius titubans	Bolbiiaceae	T, 50 mm	Manure, grass	Giled cap	12X8, brown	F 25, AA	
1.18	Boletellus emodensis	Boletaceae	100 mm	Forest, on wood	Fleshy pore	22x10, brown	F 286, W, Y	Mycorrhizal?
1.19	Austroboletus lacunosus	Boletaceae	150 mm	Eucalypt fores	Fleshy pore	15x8, brown	F 283, AA	
1.20	Botryosphaeria rhodina	Botryosphaeriaceae	P		canker			Pathogenic
1.21	Descolea recedrens	Cortinariaceae	40 mm	Rainforest litter	Giled cap	12x7, brown	F 81, AA,Y	ectomycorrh.
1.22	Formitopsis feei	Formitopsidaceae	Woody	Rotten wood	Polypore bracket	White to pink	P (parks)	Brown rot
1.23	Laetiporus sulphureus	Formitopsidaceae	Woody	Fallen wood, logs	Polypore bracket	7x4, white	W, AA, Y	Brown rot
1.24	Gloeophyllum concentricum	Glocophyllaceae	Shaggy leathery				AA	Brown rot
1.25	Glyphis cicatricosa	Graphidaceae	Brown	On wood			W	Lichen
1.26	Chapsa indica	Graphidaceae						Lichen
1.27	Graphis vinosa	Graphidaceae						Lichen
1.28	Graphis subrelata	Graphidaceae						Lichen
1.29	Fuscoporia senex	Hymenochaetaceae	bracket	On wood	Polypore		W	Saprotrophic
1.30	Phellinus gilvus	Hymenochaetaceae	bracket	On wood	Polypore	5x4,hyaine	AA, Y	Saprotrophic
1.31	Trichoderma viride	Hypocreaceae	Fungal control	On soil & wood	Mold		AA, W	Parasite
1.32	Lecanora helva	Lecanoraceae	Circular disk		Rim Lichen			Lichen
1.33	Lecanora achroa	Lecanoraceae	Circular disk		Rim Lichen			Lichen
1.34	Coniothyrium olivaceum	Leptosphaericaceae						

1.35	Marasmius elegans	Marasmiaceae	40 mm, gilled	Eucalypt litter	Redish cap	10x5, white	F 180, AA, Y	Saprotrophic
1.36	Marasmius haematocephalus	Marasmiaceae	gilled		Pinkish cap		AA	saprotrophic
1.37	Rigidoporus undatus	Meripilaceae	P		Bracket			Saprotrophic
1.38	Anisomeridium subprostans	Monoblastiaceae					W	Lichen
1.39	Filoboletus manipularis	Mycenaceae	30 mm	Decaying wood	Cap + pores	7x5, white	F 89, AA, Y	Saprotrophic
1.40	Fusarium heterosporum	Nectriaceae	Some P					saprobes
1.41	Varicellaria velata	Ochrolechiaceae						
1.42	Relicinopsis malaccensis	Parmeliaceae						Lichen
1.43	Peltigera rufescens	Peligeraceae			Foliose			Lichen
1.44	Phallus indusiatus	Phallaceae	E. 25 cm tall	Mulch, litter	Stinkhorn	4x2, none	W, AA, Y	saprotrophic
1.45	Phallus multicolor	Phallaceae	180 mm high	Mulch, litter	Stalked puffballs	4x2, none	F 362, W, Y	saprotrophic
1.46	Dirinaria picta	Physciaceae	Greenish				W	Lichen
1.47	Dirinaria applenata	Physciaceae						Lichen
1.48	Pyxine cocoes	Physciaceae		On bark, rocks	Foliose	15-22 by 6-8	W	Lichen
1.49	Dirinaria aegialita	Physciaceae						Lichen
1.50	Hyperphyscia adglutinata	Physciaceae					W	Lichen
1.51	Setospheria rostrata	Pleosporaceae	P				W	parasistic
1.52	Cochliobolus eragrostidis	Pleosporaceae	P					
1.53	Curvularia clavata	Pleosporaceae						Mold
1.54	Pleurotos djamor	Pleurotaceae	E				W, AA	
1.55	Ganoderma sp	Ganodermaceae	conk	soils	Polypore			saprophytic
1.56	Hexagonia tenuis	Polyporaceae	100 mm	On dead logs	Pored bracket	6-7, white	F 399, AA	Saprotrophic
1.57	Coriotopsis aspera	Polyporaceae			bracket			saprotrophic
1.58	Polyporus grammocephalus	Polyporaceae			bracket		W	saprotrophic
1.59	Trametes marianna	Polyporaceae			bracket		W, AA	saprotrophic
1.60	Panus fasciatus	Polyporaceae	50 mm	On dead wood	Gill cap	4-7.5, white	F 231, AA, Y	saprotrophic
1.61	Pycnoporus coccineus	Polyporaceae	9x7x2 cm	Fallen logs	Red orange,	3-6x4-6, whi.	W,AA, Y	saprotrophic
1.62	Daedaleopsis confragosa	Polyporaceae			bracket	brown		saprotrophic
1.62	Enterographa subserialis	Roccellaceae						
1.63	Schizophyllum commune	Schizophyllaceae	30 mm	On dead wood	Split gills, fan	6.5-2.5, white	F 261, AA, Y	saprotrophic
1.64	Sebacina incrustans	Sebacinaceae	Coral jelly	On soil surface	Jelly	white	W	ectomycorrh.
1.65	Serpula similis	Serpulaceae	Flat brown	On surface		Spore formng	W	Brown rot
1.66	Strigula orbicularis	Strigulaceae						
1.67	Cryptococcus gattii	Tremellaceae	P	In soil		Inhale spores	W	Yeast
1.68	Cryptococcus neoforman	Tremellaceae	P	In soil		inhalespores	W	Yeast
1.69	Polymeridium quinqueseptatum	Trypetheliaceae						
1.70	Anhracocystisandropogronis-	Ustilaginaceae						

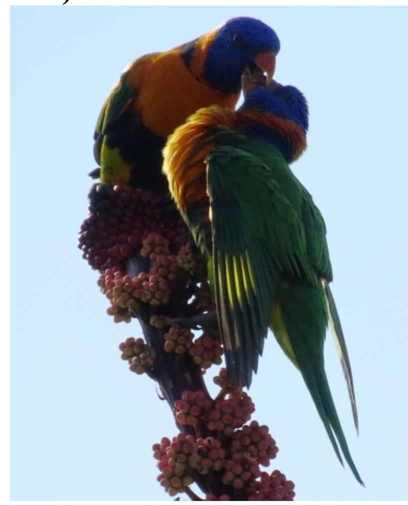
	aciculati							
1.71	Daldinia caldariorum	Xylariaceae					W	saprotrophic
1.72	Xylaria polymorpha	Xylariaceae	80 mm high	On dead wood	Club shaped	10x5.5. none	F 535, Y	saprotrophic
1.73	Cordiceps cicadae	Cordicipidaceae	P				W, PW	parasitic
1.74	Cortinarius sp purple	Cortinariaceae				Rusty brown	W, PW	mycorrhizal
1.75	Favolusemeric	Polyporaceae					W, PW	
1.76	Beastrum relutinum						W, PW	
1.77	Gymnophyllus sp						PW	
1.78	Hygrocybe sp red	Hygrophoraceae		Mostly soil		white	W, PW	Symbiotic
1.79	Microporus xanthopus	Polyporaceae	Cap 60 mm dia	Dead branches	bracket	4x2.5, white	P, AA, Y	saprophytic
1.80	Phaeoclarulina sp				coral		W, PW	
1.81	Phallus atrovolutus						PW	
1.82	Pycnoporus sanguineus		Red orange		bracket		PW	saprophytic
1.83	Solioccasus polychromus	Boletaceae					PW	mycorrhizal
1.84	Tylopilus sp.						PW	
1.85	Fuliga septica	Physaraceae	Sporangium phase	Leaf litter, grass	Scrambled egg	6 – 8 black	F538, RM, Y	Slime mould
1.86	Glomus inraradices	Glomeraceae	arbuscular	soil/roots	Hyphae/arbusc.			endomycorrh.
1.87	Glomus mosseae	Glomeraceae	arbuscular	soil/roots	Hyphae/arbusc.			endomycorrh
1.88	Glomus aggregatum	Glomeraceae	arbuscular	soil/roots	Hyphae/arbusc.	40-85,Yellow		endomycorrh
1.89	Claroideoglumus etunicatum	Claroideoglomeraceae	arbuscular	soil/roots	Hyphae/arbusc.			endomycorrh
1.90	Pisolithus tinctorius	Sclerodermataceae	4-12cm, clubshp	Under trees	puffball	7-12, brown		ectomycorrh
1.91	Scleroderma cepa	Sclerodermataceae	6-10 cm, poisons.	woodland	puffball	brown	W	ectomycorrh
1.92	Rhizopogon roseolus	Rhizopogonaceae	3 cm truffle,edible	Woodland soil	False truffe,	7-16, ochre	W	ectomycorrh
1.93	Laccaria laccata	Hydnangiaceae	6cm gilled cap	Wooded areas	Convex or flat	7-10, white	W	ectomycorrh
1.94	Trichoderma harzianum	Hypocreaceae	Fungal control	All soils	Mold			Parasite
2. BACTERIA								
2.01	Bacillus subtilis	Bacillaceae	Bacterium	soil/human gut	bact/endospore	4-10, rodshp	W	immunisation
2.02	Bacillus licheniformis	Bacillaceae	Bacterium	soil/bird feathers	bact		W	
2.03	Azospirillum brasilense	Rhodospirillaceae	Bacterium	soil/rhizosphere	bact			Nitrogen fixer
2.04	Azospirillum lipoferum	Rhodospirillaceae	bacterium	soil/rhizosphere	Bact			Root hormone
2.05	Pseudomonas fluorescens	Pseudomonadaceae	bacterium	soil	Rod shaped			Bio control
2.06	Pseudomonas putida	Pseudomonadaceae	Bacterium	Soil	Rod shaped			Bio control
2.07	Streptomyces cellulosae	Streptomycetaceae	Bacterium	Soil				fungichromin

SAMPLE PHOTO PLATES 1 (BIRDS) AND 2 (PLANTS & FUNGI)



Anserana semipalmata

Ducula spilorrhoa

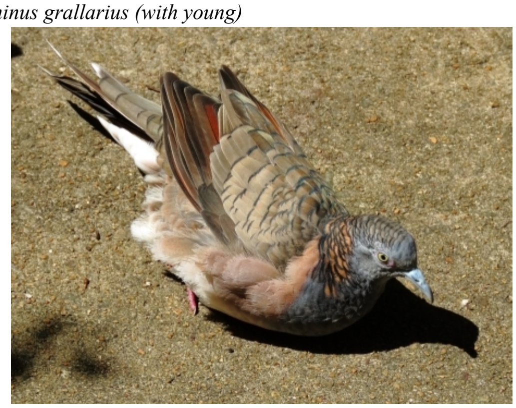


Trichoglossus rubritorquis(feeding young)

Sphecotheres vieilloti (female)

Burhinus grallarius (with young)

Lichmera indistincata



Geopelia humeralis sunbacking

Geopelia placida

Taeniopygia bichenovii teamwork


Aidia racemosa


Metrocideros collina

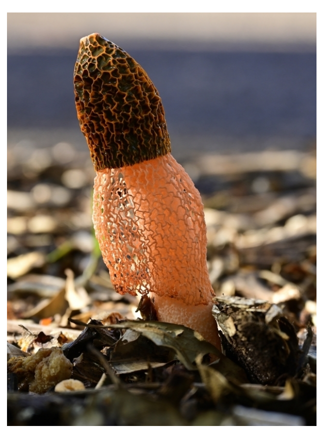

Fuligo septica


Vitex rotundifolia


Cordia subcordata


Corymbia ptychocarpa


Micromelum minutum


Phallus multicolor


Schizophyllum commune

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The titles listed below are a selection of published books and reference documents drawn on in the preparation of this book, all highly recommended reading. In addition a considerable amount of information came from web sources such as the Wikipedia online encyclopedia, the online living atlas of Australia, the online Fungi and Lichen sites of the Australian National Botanic Gardens and Australian National Herbarium, the CSIRO Mycorrhizal fungi site by Mark Brundrett, the Northern Territory Insect CD by G. Brown, Darwin City Council reports on East Point Reserve, numerous Parks and Wildlife publications and other NT government webpages on land and vegetation, all accessible online. After many years of reading and nature study I have to admit that I still know next to nothing on the subject of the incredible complexity of ecological relationships between the diverse world of organisms in the Top End. What I did come to understand in the process of study however is the wonder and preciousness of nature in its raw natural condition and that we must do everything in our power to safeguard it. It requires more study, love for nature and will.

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ALPHABETICAL INDEX SCIENTIFIC & COMMON NAMES