Preface

Northern Australia is a vast region that includes the Kimberley of northern Western Australia, the 'Top End' of the north of the Northern Territory, the 'Gulf Country' of central-eastern Northern Territory and western Queensland, and Cape York Peninsula of northern Queensland. Collectively, these areas make up the Australian Monsoon Tropics biome, a distinct geographical region renowned internationally for its large and relatively intact natural landscapes, high biodiversity and strong Indigenous culture. However, currently there is increasing pressure to exploit northern Australia's natural wealth, particularly through expansion of the pastoral, agricultural/horticultural and mining industries, all of which will inevitably result in substantial habitat loss and modification and erosion of biodiversity values. In addition, there is a multitude of other threats, including invasive species, inappropriate fire regimes, pastoral intensification and, of course, climate change. Hence, there is an urgent need to identify the region's biological assets, to inform policy and management agencies and to set priorities for biodiversity conservation.

This atlas deals specifically with the western portion of the Australian Monsoon Tropics—that is, the region west of the Gulf of Carpentaria (Kimberley, Top End, Northern Deserts and western Gulf Country). The main purpose is to compile a comprehensive inventory of the butterflies and diurnal moths (Insecta: Lepidoptera) of this region of northern Australia. In particular, we aim to answer the following questions regarding the entire fauna within the study region:

1. How many species occur in the region?
2. What kinds of species occur in the region?
3. What proportion of, and which, species are restricted to the region?
4. What is their geographical/breeding range?
5. What are their ecological requirements according to larval food plant specificity and habitat preferences?
6. What is the breeding status of those species?
7. When are they most abundant as adults, do they breed continuously or seasonally and what strategies have they evolved to cope with the adversity of the dry season?
8. What is their conservation status, and how well are they represented in the conservation reserve system?

Answers to such basic questions concerning the composition, distribution and abundance of the fauna are critical because they provide the baseline against which the extent and direction of change can be assessed in future.

Our dataset—comprising 23,885 records based on field observations (55 per cent), museum specimens (34 per cent) and literature (11 per cent)—represents 4,352 sites and spans more than 110 years of recording effort. These data indicate that 166 taxa representing 163 species (132 butterflies and 31 diurnal moths) have been recorded from the study region. The Top End appears to be substantially more diverse than the other subregions, with 150 species (122 butterflies and 28 diurnal moths, or 93 per cent of the total fauna) compared with 105 species (88 butterflies and 17 diurnal moths, or 63 per cent) from the

Kimberley, 82 species (74 butterflies and eight diurnal moths, or 51 per cent) from the western Gulf Country and 53 species (45 butterflies and eight diurnal moths, or 33 per cent) from the Northern Deserts (less than 700 mm mean annual rainfall). Surprisingly, a substantial number of species (37, or 23 per cent) recorded from the study region—including several that are yet to be scientifically described—have been detected only during the past four decades, highlighting that northern Australia is still a frontier for biodiversity discovery.

The fauna comprises seven (4 per cent) taxa of Papilionidae, 31 (19 per cent) Hesperiidae, 20 (12 per cent) Pieridae, 33 (20 per cent) Nymphalidae, 43 (26 per cent) Lycaenidae and 32 (19 per cent) diurnal moths representing eight different families. Thus, the lycaenids, nymphalids and hesperiids are the dominant components in the fauna. No genera are endemic to the study region. Available data indicate that 17 species (seven undescribed) and 35 subspecies (six undescribed) are endemic to the region. The level of endemism is relatively low at the species level (10 per cent), but rises to 31 per cent if all taxa (i.e. species and subspecies) are considered, suggesting differentiation of the fauna has been relatively recent. Most of the endemic species and subspecies have narrow ranges and are restricted to the Top End or to the Kimberley and Top End. Interestingly, all of the endemics, with one exception, are restricted to savannah habitats, especially woodland associated with sandstone or sandy soils derived from sandstone. Clearly, the Top End has been important as an area of endemism in the evolution of the butterfly and diurnal moth fauna.

Breeding habitats, or suspected breeding habitats, based on the presence of immature stages on larval food plants or other evidence have been recorded for 142 (87 per cent) species in the study region. More than 50 (31 per cent) species are dependent on various types of monsoon rainforest, of which 34 (21 per cent) are entirely restricted to these habitats, despite the fact that monsoon forests occupy less than 1 per cent of the landscape. About 60 (37 per cent) species are found only in savannah woodland (including eucalypt heathy woodland, eucalypt open woodland, *Acacia* woodland, riparian woodland and tropical grassland). At least 88 (54 per cent) species occur in savannah woodland, but a number of these species breed equally in both savannah woodland and monsoon forest or mixed monsoon forest, while others that are more typical of savannah woodland also breed along the edges of monsoon forest. Eleven of these woodland species are restricted to habitats associated with laterite or sandstone outcrops or sandy soil derived from sandstone/laterite, often with a heathy understorey or a hummock (spinifex) grass understorey. At least nine species are regularly associated with paperbark woodland, paperbark swampland or mixed paperbark–pandanus swampland and other damp areas, often adjacent to evergreen monsoon vine forest. Fewer species are associated with floodplain wetlands, mangroves and coastal saltmarsh.

Of the 166 taxa (i.e. species and subspecies), 151 (91 per cent) are resident (i.e. breeding regularly within the study region, with permanently established populations), three (2 per cent) are immigrant (i.e. breeding irregularly, with temporary populations) and 12 (7 per cent) are vagrant or infrequent visitors (i.e. not breeding, with nonresident populations). Although many species (at least 64, or 40 per cent) have been recorded in each month of the year, most show pronounced seasonal changes in relative abundance, with some appearing for just a few months of the year. We distinguished five broad seasonal patterns, with groups of species peaking at different times of the year: early wet season (late October – early January), mid wet season (late December – early March), late wet season and/or early dry season (March–May), mid dry season (May–July) and late dry season (August–October). Available data on the breeding phenology and seasonal abundance of adults indicate that about half of the species breed, or are suspected to breed, continuously throughout the year, while the other half breed on a more seasonal basis. The continuous breeders have multiple generations during the year, whereas those that breed seasonally usually have only one or a few generations

annually. Both groups have evolved a range of life-history strategies that enable them to either breed continuously or survive the long harsh dry season when their food plants are not available.

Of the 166 taxa assessed for their conservation status according to the International Union for Conservation of Nature (IUCN) Red List criteria, one (1 per cent) is categorised as Vulnerable (VU), four (2 per cent) as Near Threatened (NT), 131 (79 per cent) as Least Concern (LC), 16 (9 per cent) as Data Deficient (DD) and 14 (8 per cent) as Not Applicable (NA). No species from the study region are known to have become extinct since European settlement, although one species (*Pollanisus* sp. 7) has not been detected since it was first recorded 110 years ago. The taxa of most conservation concern are *Ogyris iphis doddi* (VU), *Euploea alcathoe enastri* (NT), *Hypochrysops apelles* ssp. 'Arnhem Land' (NT), *Idalima* sp. 'Arnhem Land' (NT) and *Hecatesia* sp. 'Arnhem Land' (NT)—all of which are endemic to the Top End. However, at least nine of the Data Deficient taxa—*Hesperilla crypsigramma* ssp. 'Top End', *Suniana lascivia lasus*, *Acrodipsas myrmecophila*, *A. decima*, *Ogyris barnardi barnardi*, *Nesolycaena caesia*, *Theclinesthes albocinctus*, *Pollanisus* sp. 7 and *Agarista agricola agricola*—are of conservation interest because they may qualify as Near Threatened (NT) once adequate data are available.

In terms of representation in the National Reserve System (NRS), most taxa are adequately represented to varying degrees, but 14 lack adequate representation. Populations of six taxa (*Suniana lascivia lasus*, *Acrodipsas myrmecophila*, *A. decima*, *Ogyris barnardi barnardi*, *Jalmenus icilius* and *Theclinesthes albocinctus*) are currently not represented in any conservation reserve, while a further eight (*Ogyris oroetes oroetes*, *O. iphis doddi*, *Nesolycaena caesia*, *Petrelaea tombugensis*, *Nacaduba kurava felsina*, *Theclinesthes sulpitius*, *Synemon* sp. 'Roper River' and *Agarista agricola agricola*) are each currently known from only a single conservation reserve.

Overall, the fauna may be considered in reasonably good health because there are apparently few threatened taxa with narrow geographic ranges. Most species, particularly those associated with savannah woodland, have large geographic range sizes across the study region. However, for species with such widespread distributions over relatively uniform landscapes, the loss of any local area/population will not necessarily be inconsequential. Many of the ecological processes that underpin the health and heterogeneity of the landscape—such as fire, flooding, pollination and seed dispersal—operate across large spatial scales such that loss of a subset of the range and disruption of natural processes may have far-reaching and unforeseen consequences.

A key issue that is likely to adversely affect those species with relatively small geographic range sizes is decline of ecological resources (larval food plants and/or habitat) through inappropriate fire regimes, especially an increase in the frequency and scale of dry season burns. At present, the interval between fires in many tropical savannahs of northern Australia is far too short, such that relatively long unburnt habitat (more than five years) is now rare in the landscape. Habitat loss and fragmentation are also a concern, and other threatening processes may become significant in future, such as invasion of grassy weeds (particularly gamba grass and mission grasses) and the concomitant grass–fire cycle affecting habitat specialist species inhabiting savannah woodland, riparian woodland/open forest and the edges of riparian monsoon forest. The long-term viability of monsoon forest patches and the disproportionally rich butterfly and diurnal moth assemblages they support may ultimately depend on reducing the frequency and intensity of fire in the surrounding matrix. High fire frequency may reduce both patch size and connectivity of monsoon forest, but the extent of connectivity between patches may also be adversely affected by any loss or decline of essential pollinators and seed dispersers.

Northern Australia is one of few tropical places left on Earth in which biodiversity—and the ecological processes underpinning that biodiversity—is still relatively intact. Moreover, scientific knowledge of that biodiversity is still in its infancy and the region remains a frontier for biological discovery. The butterfly and diurnal moth assemblages of the area, and their intimate associations with vascular plants (and sometimes ants), exemplify these points. However, the opportunity to fill knowledge gaps is quickly closing: proposals for substantial development and exploitation of Australia's north will inevitably repeat the ecological devastation that has occurred in temperate southern Australia—loss of species, loss of ecological communities, fragmentation of populations, disruption of healthy ecosystem function and so on—all of which will diminish the value of the natural heritage of the region before it is fully understood and appreciated.

This text is taken from *Atlas of Butterflies and Diurnal Moths in the Monsoon Tropics of Northern Australia*, by M.F. Braby, D.C. Franklin, D.E. Bisa, M.R. Williams, A.A.E. Williams, C.L. Bishop and R.A.M. Coppen, published 2018 by ANU Press, The Australian National University, Canberra, Australia.