A snapshot of diversity – a North Queensland BioBlitz exploring plant and animal diversity at a reforested urban park in Malanda, Atherton Tablelands

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Abstract

Bioblitzes are public events that engage the community and stimulate learning about the natural environment. On 9 November 2024, a bioblitz was held in Dungavel Park, Malanda, Qld, which is a public park with open areas and a narrow, revegetated riparian corridor replanted 20-25 years ago. During the event, which was attended by c. 300 people, experts and public participants were invited to make and submit observations of biodiversity over a period of 24 hours. A research team from the School for Field Studies and various specialists of different groups of biodiversity also conducted targeted surveys of plants, invertebrates, birds, reptiles and amphibians throughout November. We documented a total of 461 species, which included 262 species of plants including algae (1 spp.), bryophytes (12 spp.), ferns (11 spp.), gymnosperms (3 spp.) and flowering plants (235 spp.). Of the 249 vascular plants, 169 species were native, while 80 species were non-native. We also recorded 14 species of lichen, three of macrofungi, 107 of invertebrates, and 75 species of vertebrates. Although the sampling effort was intensive for only a limited time, the data collected should be considered a snapshot of the biodiversity of the site. Some groups of organisms, such as non-vascular plants, fungi, invertebrates, fishes and mammals remain underrepresented. Nevertheless, the plant and animal diversity documented is significant considering the highly modified environment at the bioblitz site and that most of the observations were recorded from the riparian strip. We conclude firstly that older revegetated rainforest patches, even when subject to heavy anthropogenic use, can provide important habitat for native biodiversity. Secondly, bioblitz events are useful initiatives for documenting local biodiversity, engaging the public, and promoting educational outreach about nature. Finally, we recommend organising similar events for other localities and habitat types within the Australian Wet Tropics to document and spread awareness about local biodiversity, and we hope that this work presents a useful example of how biodiversity data from future bioblitzes can be reported.

Handling editor: Donald Franklin

Citation: Heiser AG, McDowell SR, *et al*. 2025. A snapshot of diversity – a North Queensland BioBlitz exploring plant and animal diversity at a reforested urban park in Malanda, Atherton Tablelands. *North Queensland Naturalist* 55: 22-39.

Introduction

Over 55% of the global population now live in urban environments - a number that is projected to increase to 68% by 2050 (UN 2018). Many people have become estranged from the natural world through migration into urban areas, and this estrangement can lead to a multitude of negative effects on human physical, mental, and emotional well-being (van Den Berg 2007). In a study in the Netherlands on the impact of green spaces on childhood development, children and adolescents living in areas with better access to green space experienced a significantly lesser number of mental and physical health diagnoses relative to those living in more urbanised environments (Maas *et al.* 2009). As a restorative measure, public nature education at school and beyond can help foster an appreciation of nature and help maintain people's emotional and physical well-being (Gass *et al.* 2021). Engaging in nature-based citizen science projects can provide similar benefits (Williams *et al.* 2021).

The loss of global biodiversity and habitat degradation are also pressing issues. Species distributional data is fundamental for effective biological conservation, restoring degraded habitats, and ecological monitoring (Murphy & Smith 2021). The responsibility for collecting such data falls heavily on relatively few professionals such as botanists, zoologists and other specialists who often need to undergo years of training. Their assessments, though accurate, can be time-consuming and costly. Additionally, expert-led biodiversity assessments are subject to the availability of funding (Roger & Klistorner 2016).

Given these limitations, engaging the public to participate in citizen science to help generate species distribution data could be a useful way to fill data gaps in biodiversity knowledge. Provided that endeavours involving citizen scientists are well-planned and adequately supervised by biodiversity professionals, citizen scientists can significantly improve the spatial and temporal coverage of biodiversity projects (Roger *et al.* 2024).

Indeed, within the last two decades, citizen science has emerged as a powerful tool for informing biodiversity conservation (Pocock *et al*. 2018; Callaghan *et al.* 2024).

While citizen science initiatives vary depending on their objectives, bioblitzes are notable examples of citizen science projects or events that can fulfil multiple objectives of generating valuable biodiversity data while simultaneously helping educate the public and generating nature awareness. A bioblitz is a brief yet thorough field survey of flora and fauna by individuals and experts over a minimum of 24 hours that enlists the help of volunteers to document and identify as many species as possible (Ruch *et al.* 2010). The term “bioblitz”, shortened from biodiversity blitz, was originally coined by Susan Rudy in 1996 from the first such event, which took place in the Kenilworth Aquatic Gardens in Washington, D.C. in the USA (Ruch *et al.* 2010).

Bioblitzes are now held annually in various locations throughout the world (Leong & Kyle 2014; Tiago *et al*. 2024), and even though they represent only a biodiversity snapshot, case studies have reported highly positive outcomes for biodiversity conservation (Postles & Bartlett 2018; Tiago *et al*. 2024). For instance, the 48-hour Walpole Wilderness BioBlitz, 400 km southwest of Perth, led to the discovery of 10 new species, 15 species that were new to the region, and the documentation of 38 threatened species (Eacott 2023). It prompted extensive funding, mapping, and restoration of the peatland ecosystems found in the Walpole Wilderness and across Western Australia (Eacott 2023). Bioblitzes may also include experts providing educational talks and leading surveys (Meeus *et al.* 2023). Educating the public and local community about the biological diversity of the land around them fosters a stronger sense of place in the community, and bioblitz participants are more likely to take on the role of long-term stewards of their local area (Lowman *et al.* 2019).

In Australia, bioblitzes and similar citizen science activities have been popular and held in terrestrial and marine locations throughout the country (Walker 2011; Driscoll *et al.* 2019; Mesaglio & Callaghan 2021). These have occurred at spatial scales ranging from continent-wide (e.g. as part of the Great Southern BioBlitz, *https://www.greatsouthernbioblitz.org/*) to more localised or even urban areas. For instance, in 2014, the bioblitz held in Sydney Olympic Park in New South Wales involved school children, scientists, naturalists, and community members (Player 2014). Other bioblitzes have been held in school compounds and home backyards (Elwell-Gavins 2021). Some have also explored ecological themes, such as the Big Bushfire BioBlitzes held in 2022 in rainforest regions within New South Wales, in which data was collected on species that had returned since the 2019-2020 Black Summer bushfires (Roger 2022). Ecological-themed bioblitzes can generate valuable data that may serve as a baseline for ongoing environmental monitoring.

Despite the popularity of bioblitzes in Australia, there have been few such events in North Queensland. The examples we could find include two in the Cape York Peninsula Bioregion at the Laura Sandstone (Anon 2017) and at the Normanby Boulderfields (Ananda 2023), and one in the Wet Tropics Bioregion in Cloudland Nature Refuge (Commonwealth of Australia 2013). Given that the Wet Tropics is among Australia’s most biodiverse areas, and rainforest areas within it have been inscribed as a UNESCO World Heritage Area due to their significant biodiversity (UNESCO 2024), more bioblitzes are needed in the region.

Although much of the region’s tropical rainforest is now protected, many areas have been deforested and some are in a state of recovery. In the last two decades, significant effort has been made to revegetate clear-cut areas or abandoned pastures, especially in the upland regions of the Wet Tropics (Heise-Pavlov & Tng 2023) and also to monitor the recovery of biodiversity in revegetated areas (Lawes *et al*. 2017; Tng *et al*. 2023; Tucker *et al*. 2024ab). In early November 2024, the Malanda BioBlitz (*https://www.malandabioblitz.com.au/*), the first community-based event in the Australian Wet Tropics, was held in a public park in the rural town of Malanda on the Atherton Tablelands of far north Queensland. As the park contains revegetated areas of riparian forest which was planted 20 years ago, the Malanda BioBlitz provided an opportunity to survey and investigate the recovery of biodiversity of the restored riparian forest habitat. The event also coincided with plant ecology and invertebrate research activities being undertaken at the site by students and researchers at the Centre for Rainforest Studies, School for Field Studies (SFS), and it was deemed that the data collected from these research activities would complement community efforts.

Finally, although bioblitzes are now fairly common events in Australia, the species data collected during such events are woefully under-reported (although see Cameron 2015; Anthony *et al.* 2019). Many bioblitzes or bush blitzes lack follow up reports, or are only mentioned by participants as personal experiences in social media (e.g. a Facebook reel by Ananda 2023). Where they are reported, they are often part of the grey literature (e.g. Keighery & Keighery 2013), which may be hard to access, or in short website notices (e.g. McDonald 2015) that report general numbers or activities but do not provide compiled lists of species. The objectives of the current study are to collate the data collected during the Malanda BioBlitz and to provide a systematic report of the species observed. We hope that this article, along with other promotional material for the Malanda BioBlitz, will encourage future bioblitzes and serve as a template for reporting on such events.

Methods

Bioblitz location and vegetation

The bioblitz took place at Dungavel Park (17°20’59” S, 145°35’22” E, 731m a.s.l.; Fig. 1), a multiple-use park situated in the rural town of Malanda on the Atherton Tablelands, North Queensland. The town has a population of approximately 2,000 (Australian Bureau of Statistics 2022). Over the last 150 years, the broader Atherton Tablelands region underwent a period of intensive clear-cutting of forests on basaltic soils for dairy pastures and agriculture (van Oosterzee 2023), activities upon which the economy of the region is still based.

Prior to this deforestation, the native vegetation at Dungavel Park would likely have consisted of a wet rainforest type locally known as complex mesophyll vine forests (Tracey & Webb 1975; Sattler & Williams 1999). A *c.* 30 ha remnant of this forest occurs in Malanda Falls Conservation Park, which is *c.* 500 m southwest of Dungavel Park (Fig. 1).

The present closed-canopied vegetation at Dungavel Park consists of 20-25-year-old revegetated forest along the North Johnstone River riparian area (Fig. 1A). Unfortunately, records of what was planted at that time are not available, but a cursory assessment during reconnaissance for the bioblitz revealed that the plantings, now well established, included some typical tall pioneer trees such as Blue Quandong (*Elaeocarpus grandis*) and Milky Pine (*Alstonia scholaris*), later successional trees such as Red Cedar (*Toona ciliata*), and understorey shrubs such as the Red-leaf Fig (*Ficus congesta*) (Horner 2024). During the 1970s, a patch of Tallowwood (*Eucalyptus microcorys*) and scattered Camphor Laurel (*Cinnamomum camphora*) trees were planted to line the riverbank, and some of these trees persist within or at the edges of the revegetated forest (Horner 2024). Further revegetation efforts in 2024 and in 2013-2014 were undertaken by the local Malanda Landcare group, who planted native tropical North Queensland rainforest plants around the margins of previous revegetation (Horner 2024).

Organising the Malanda BioBlitz

Planning for the bioblitz began in earnest three months prior to the event. Following recommended steps for organising bioblitzes (Hepburn *et al.* 2015), the coordinator, Gemma Horner, obtained permission for use of the site, generated and published marketing materials, obtained collection permits (see Acknowledgements), and made contact with experts on various groups of organisms and experienced naturalists in the region. Consideration about how to sample or observe a broad variety of organisms (Leather 2008) was factored into the early planning. Some organisms, namely those collected using traps, were sampled by researchers prior to the event. We use the term “researchers” here as a collective term for plant and animal experts or specialists and a cadre of School for Field Studies (SFS) undergraduate environmental science students.

We therefore distinguish between “researcher only” and “public” phases of the Malanda BioBlitz. The researcher phase commenced up to a week before the public event, and continued until 30 November. In contrast, the public phase engaged both researchers and the public, with participants making ad hoc observations and taking part in specialist-led surveys on 9 Nov. 2024.

Sampling methods

We organised the data collection of the bioblitz into a number of themes as detailed below. The main observations for many of the following groups of organisms took place at focal observation spots (Fig. 1A), although researchers and participants alike were encouraged to

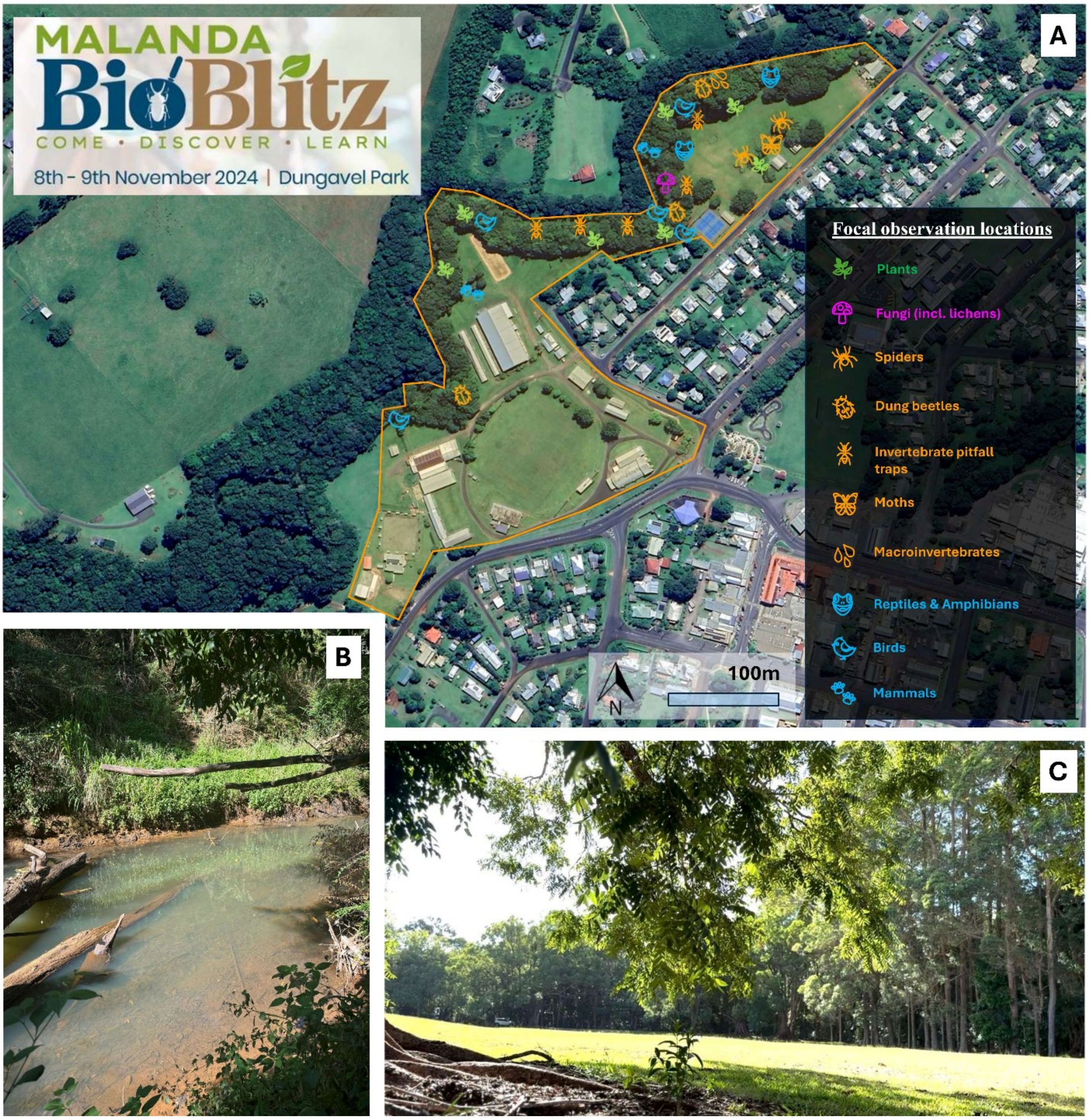

Figure 1. The BioBlitz site at Dungavel Park, Malanda, Queensland, Australia. The survey area (A) is outlined in orange, where there were (B) riparian environments along the North Johnstone River, and a mix of both (C) restored forest and open park habitats. The plant and animal symbols in (A) denote focal observation location spots where the depicted organism types were part of a targeted search, although observations of different organisms were made throughout the park. Photos: Dylan Berr.

contribute observations of any organism anywhere within the site.

Plants - Plant sampling took place from 3–9 November during two sampling sessions. To obtain quantitative data on plant species, on 3, 4, and 8 November, a group of four SFS researchers established six 50 m x 3 m belt transects within the re-vegetated riparian forest (Fig. 1A) within which the identities of all vascular plants were recorded on field sheets. During the public bioblitz day, the researchers conducted a brief but thorough search for plant species at a small replanting area behind the Girl Guide's hut (Fig. 1A), and throughout the day, both researchers and participants from the public made observations along the perimeter of the revegetated site, the open field and built up areas, with researchers and public participants submitting *ad hoc* observations to the iNaturalist platform or noting them on field sheets. In a few cases where plants could not be readily identified in the field, we collected cuttings to bring back to the School for Field Studies field laboratory, where we identified them using online identification keys for ferns (Field *et al.* 2022) and flowering plants (Zich *et al.* 2020).

Bryophyte samples were opportunistically observed in a multitude of microhabitats, such as on decaying logs and fallen twigs, the bark of the main stems, on the surface of leaves (i.e. epiphylls), and on earth banks. While some bryophyte observations were made only on-site and uploaded to iNaturalist, a few collections were taken back to the lab and identified later under a dissecting and light microscope.

Fungi (including lichens) - Fungi observations were made opportunistically and submitted to iNaturalist. At the time of the bioblitz and the weeks preceding it, there had been very little rainfall, so toadstools and fruiting bodies of macrofungi were not overtly present or conspicuous. On the other hand, lichens (or lichenised fungi) were frequently observed on the bark of trees in the revegetated area, and *ad hoc* photographic observations were made by researchers and submitted to iNaturalist.

Spiders - Spiders were collected opportunistically during the public bioblitz event between 1000 and 1600 hrs. Most specimens were collected at the small patch of plantings at the rear of the Girl Guides' hut (Fig. 1A). Collected specimens were euthanised, preserved in containers of 75% v/w ethanol solution, and examined and photographed back at the laboratory. Some identifications were made using field guides (Framenau *et al.* 2014; Whyte & Anderson 2017), and a few genus-level identifications were supplied by specialists (see later).

Lepidopterans (moths and butterflies) - To sample moths, we used a light sheet (Intachat & Woiwod 1999) in which a white projector sheet was suspended from a rope between two trees with two 1600-lumen LED portable work lights angled towards it. We conducted light sheeting activities on 9 November in two 5-hour sessions, the first from 0000 – 0500 hrs and the second from 1900 – 2359 hrs. Moth specimens that visited the light sheet were photographed *in situ* and then collected and euthanised in a jar with paper towel soaked in acetone. Moth specimens were identified to the genus or species using Richardson (2016) or by comparison with the image database on the Australian Lepidoptera website (Herbison-Evans & Crossley 2020).

Butterflies were observed opportunistically during the daytime on 8 and 9 November. On the first day, observers captured butterflies with nets for examination and identification and subsequently released the specimens. On the second day butterflies were observed and identified on the wing while observers walked along the North Johnstone River. A total of six hours over the two days was dedicated to butterfly observations.

Ants - Pitfall traps were deployed on 7 November and retrieved on 9 November to capture terrestrial ants. Two traps were positioned along the edge of the forest, while three traps were positioned within the revegetated area along the North Johnstone tributary (Fig. 1A). Pitfall traps were dug to be level with the ground, a small amount of water and dish soap solution poured into the bottom to prevent escape and preserve specimens, and a plastic shield angled over the top of each pitfall trap to prevent debris from accumulating inside (Grootaert *et al.* 2010). Specimens were stored in a 75% v/w ethanol-water solution and identified using an ant identification key (AntWiki 2020).

Dung beetles - Dung beetle trapping began on 6 November. Nine baited pitfall traps (Larsen & Forsyth 2005; Derhé *et al.* 2016) were deployed from 0900–1600 hrs in groups of three (at 0, 20 and 40 m) across three 40-meter transects in the revegetated strip (Fig. 1A). Two carrion, four dung, and three mushroom-baited pitfall traps were set up across the three transects. Each bait was wrapped and tied in cloth and hung from a grid overlaying a pitfall trap. Plastic shields were angled over each trap to prevent debris from falling in. A water and dish soap solution was poured into the bottom of the pitfall traps to prevent escape and temporarily preserve specimens (Grootaert *et al*. 2010). On 9 November, the traps were retrieved, and dung beetle specimens were first sorted and then transferred into containers of 75% v/w ethanol solution. Back at the SFS field laboratory, the beetles were examined under a dissecting microscope and identified using species identification keys (Matthews 1972, 1974, 1976; Storey & Weir 1990).

Other miscellaneous arthropods and invertebrates - Freshwater macroinvertebrates and shrimp were sampled on the morning of 9 November. The river was accessed at a point with acute riffles and heavy debris. Debris was scooped up and assessed for macroinvertebrates (Stark *et al*. 2001). All observed specimens were placed in a bucket. Each debris item was then held in a plastic tub for a period of at least five minutes to collect any species still present. A fine mesh net was also swept along the vegetated sides of the river to collect shrimp (Stark *et al*. 2001). Observations of other invertebrates were made opportunistically as bycatch in the pitfall and dung beetle traps, and also by researcher and public participants during the 24-hour observation period on 9 November.

To sample leaf litter-dwelling invertebrates, we opportunistically collected leaf litter along the tree line of the revegetated area on 6 November. In the lab, we placed the litter into a Berlese funnel (Macfadyen 1961) - an invertebrate collection setup that involves a lamp positioned above the funnel to illuminate and heat the top of the leaves, resulting in invertebrates migrating to the bottom of the funnel and falling into a receptacle containing a 75% v/w ethanol solution. The traps were checked after three days on the morning of 9 November, and the collected specimens were sorted and preserved in jars containing ethanol solution. Species were sorted and photographed under a dissection microscope.

Reptiles and Amphibians - On the mid-mornings of 8 and 9 November, aquatic reptile and amphibian observations were made in a 60-minute snorkel in the watercourse behind the Malanda showgrounds. Aquatic data was also collected using two BRUVs (Baited Underwater Remote Video Cameras, Willis & Babcock 2000), which were set in the mid-morning for approximately 60 mins in the watercourse behind the Girl Guides' and Scouts' huts.

Other reptiles and amphibian observations were made from 1930 – 2130 hrs on a researcher-led spotlighting session on 9 November. Experts and volunteers walked along the North Johnstone River tributary trail (Fig. 1A) with headlamps, looking for species eyeshine and listening for frog calls, identifying the species *in situ*. All headlamps were turned off every 15 minutes for approximately three minutes. Data of species observed were recorded on field sheets.

Birds - Bird species were recorded in three separate approaches. The first involved two systematic 20-min surveys (Loyn 1986) starting at 0801 hrs and 1615 hrs respectively. During these surveys, bird data was collected within a 2-hectare plot and in twenty-minute surveys at three transect sites along the river at Dungavel Park. The second approach involved recording birds within a 500 m radius covering the entire site and starting at 0645 hrs on 9 November. Finally, opportunistic bird sightings were also made throughout the day by researchers and public participants, and these observational data were recorded on field sheets.

Mammals - Two Anabat bat detectors were deployed from 31 October to 3 November from 1900 hrs – 0700 hrs the following morning along the riparian area of the bioblitz site. One detector was placed in the forest interior and the other closer to the river, 300 m apart (Fig. 1A). Anabat is a bat echolocation detection program that compares audio data with a database of identified bat echolocation calls (Titley Scientific 2024). We did not have a permit to conduct spotlighting surveys for mammals, so mammal observations were made opportunistically during surveys for other organisms on 9 November.

Recording observational data

To record observational data generated during the bioblitz, we chose the online platform iNaturalist to partially fulfil our needs. The platform is currently the largest and most popular online nature observation curation site in the world, with the total number of observations and species exceeding 150 million as of 2023 (iNaturalist 2023). The platform relies on the public to upload pictures of species, with subsequent forum-based identification of these species; it aims to connect people with nature and produce valuable biodiversity data (Mesaglio & Callaghan 2021). Detection can be the biggest challenge to the documentation of biodiversity, and iNaturalist has emerged as a powerful tool for collecting large quantities of data across many participants and on private land. As of 2020, 18,627 iNaturalist records of species with a conservation status of near threatened or above have been exported to the Atlas of Living Australia (Mesaglio & Callaghan 2021), which is a national database of biodiversity observations.

For the Malanda BioBlitz, we created an iNaturalist project entitled "Malanda BioBlitz" (*https://www.inaturalist.org/projects/malanda-bioblitz*). All observations within a delineated polygon specified for the site of interest (i.e. Dungavel Park; Fig. 1), and a specified time period (8 November 2024 to 1 January 2025) were uploaded and would automatically be registered under that project.

During the bioblitz on 9 November, SFS researchers ran short optional instructional workshops for registered participants to encourage use of the iNaturalist platform. We also provided field sheets to participants. For some groups of organisms where observations might be fleeting, such as butterflies, or some plants that were too tall to photograph, the use of iNaturalist was not feasible, so those observations were made almost entirely on field sheets. Bird survey data was contributed to the Birdata database (Birdata 2024).

Some observations were identified only to a higher-level taxonomic group (e.g. a species of *Hydra*, and a Myriapod) without photographs or a collection. When we refer to *species*, we may mean *morphologically unique taxa*. We have included these in our list as we are confident that they are unique species.

All records were evaluated for threatened or endangered species status. The final digital dataset and specimens collected will be curated as part of an ongoing natural history collection and database that is being established at the Centre of Rainforest Studies, School for Field Studies. For reporting purposes and to facilitate cross-checking, we organise the data by major groups of organisms, namely plants, fungi, invertebrates, and vertebrates. All species observations are tabulated in full in worksheets in the Supplementary Excel file, including those uploaded to iNaturalist for which we also include the URL. The species nomenclature for plants follows that of Laidlaw (2022), that of most animals follows that of iNaturalist, and bird nomenclature follows BirdLife Australia (2022).

Results

The event on 9 November was attended by approximately 300 people, of which 35 were researchers who also led walks or provided educational talks whilst making observations or collections.

Snapshot of the biological diversity at Dungavel Park

The Malanda BioBlitz documented a total of 460 species (Table 1). In descending order of the top four most species-rich higher-level groupings of organisms, we recorded a total of 262 plant species, including bryophytes and algae (Table 1, Supplementary Table A1), 17 fungi and lichen species (Table A1), 106 invertebrate species (Table A2) and 75 vertebrate species. (Table A3).

Plants were the most intensively surveyed group – with eudicots making up a large portion of the plants encountered (188 spp., 71.8% of plant species) (Fig. 2A). Among the 249 species of vascular plants (ferns, gymnosperms and angiosperms), trees were the most species-rich lifeform group (124 spp., 49.8% of vascular species) while mistletoes were the least represented (2 spp., < 1% of vascular species) (Fig. 2B). The majority of the native plants recorded are part of the original plantings and were found within the revegetated forest, in which species such as the Alexander Palm (*Archontophoenix alexandrae*), Brown Laurel (*Cryptocarya triplinervis*), Hairy-leaved Bollygum (*Neolitsea dealbata*), Brown Tamarind (*Castanospora alphandii*), Blue Quandong (*Elaeocarpus grandis*), Queensland Maple (*Flindersia brayleyana*), Umbrella Tree (*Heptapleurum actinophylla*) and Brown Bollygum (*Litsea leefeana*) were the most frequently occurring trees and were each present in at least five of the six vegetation plots (Supplementary Table A1). Significant observations were the Iron Malletwood (*Rhodamnia sessiliflora*, Myrtaceae, Endangered), and Hard Pink Elder (*Ostrearia australiana*) (Fig. 3A), which is a Near Threatened north Queensland endemic and a tropical member of the witch hazel family (Hamamelidaceae).

Among the most common native groundcover species which probably recruited naturally within the revegetated forest, were the Sword Fern (*Nephrolepis cordifolia*) and Wandering Jew (*Pollia macrophylla*). Likewise, a number of native vines, including Millaa Millaa Vine (*Elaeagnus triflora*), Cockspur Thorn (*Maclura cochinchinesis*), and Pepper Vine (*Piper hederaceum*), were common and appear to be colonizing the revegetated forest. Various mistletoes and epiphytes were observed on trees in the park, notably the Rock Felt-fern (*Pyrrosia rupestre*), which has a Special Least Concern status. The open field area consisted

Table 1. Breakdown of the number of unique taxa and families across all major taxonomic groups sampled at the BioBlitz at Dungavel Park in Malanda, Queensland.

Taxonomic groups	# Unique taxa	# Families distinguishable	# Genera distinguishable	# Species distinguishable	# only identified to genus level or higher
PLANTS	**262**	**92**	**210**	**246**	**16**
Algae	1	1	1	1	0
Bryophytes (mosses and liverworts)	12	9	6	2	10
Pteridophytes (ferns)	11	7	11	11	0
Gymnosperms (conifers and allied plants)	3	2	2	3	0
Angiosperms (flowering plants)	235	73	190	229	6
FUNGI	**17**	**7**	**8**	**5**	**12**
Macrofungi	3	2	3	2	1
Lichens	14	5	5	3	11
INVERTEBRATES	**107**	**43**	**73**	**57**	**50**
Cnidarians (Hydrozoa)	1	1	1	0	1
Gastropods (Gastropoda)	1	1	0	0	1
Crustaceans (Malacostraca)	2	2	2	1	1
Chilopods (Chilopoda)	1	1	1	1	0
Arachnids (Arachnida)	24	8	13	5	19
Insects (Insecta):	78	30	56	50	28
Lepidoptera	32	10	27	28	4
Hymenoptera	8	3	6	1	7
Coleoptera	16	3	7	13	2
Dung beetles	12	1	4	11	1
Other insects	22	14	16	8	14
VERTEBRATES	**75**	**44**	**69**	**74**	**1**
Amphibians	2	2	2	2	0
Reptiles	8	5	8	8	0
Birds	55	31	51	55	0
Fishes	1	1	1	1	0
Mammals	9	5	7	8	1
GRAND TOTAL	**461**	**186**	**360**	**382**	**79**

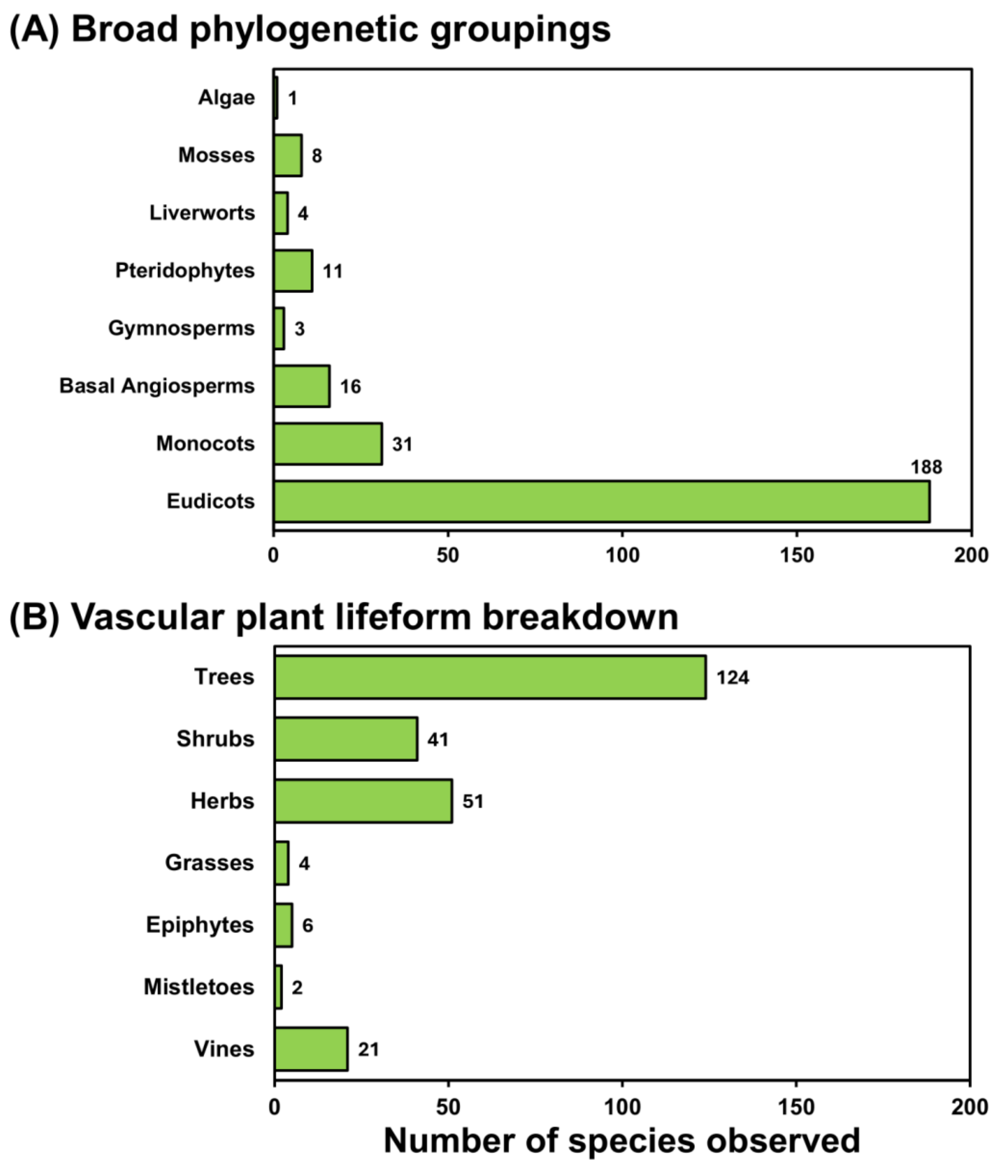

Figure 2. Composition of plant species recorded at Dungavel Park, Malanda, Atherton Tablelands, Queensland during the bioblitz: (A) broad phylogenetic groupings; (B) lifeforms of vascular plants.

mostly of non-native grasses (mostly Carpet Grass [*Axonopus compressus*] and Rhodes Grass [*Chloris guyana*]) and 20 herb species.

Seventy-seven (31%) species of the vascular plants were non-native or naturalised (Supplementary Table A1). A total of 61 naturalised plant species were observed on the margins (*Senna* spp., *Solanum* spp.) and/or also in the understorey of the riparian zone plantings, for example the shrubs Firespike (*Odontonema tubaeforme*), Mickey Mouse Plant (*Ochna serrata*) and Night-scented Jasmine (*Cestrum nocturnum*).

As a higher-order grouping of organisms, the invertebrates represented the next most species-rich set of observations (Supplementary Table A2). Among the invertebrates, butterflies and moths (Lepidoptera) were the group with the highest number of species (29.9%), followed by spiders (Arachnida: 22.4%) and beetles (Coleoptera: 14.0%). The majority of spiders were orb-weavers, but some free-ranging hunting spiders (Salticidae, jumping spiders), huntsmen (Sparassidae), and species associated with leaf litter were also observed. Among the beetles, dung beetles were the most represented group (73.3% of the beetles),

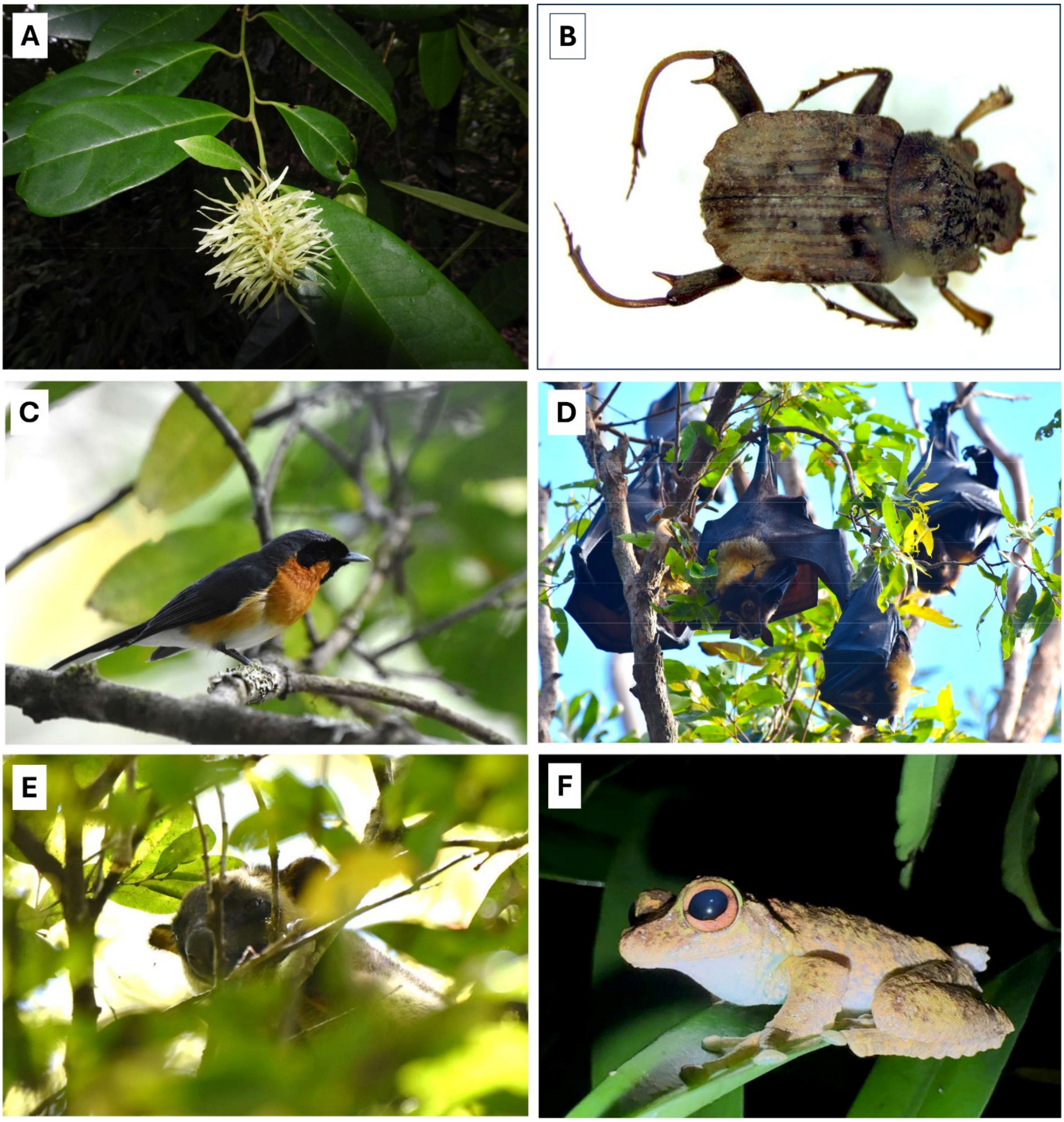

Figure 3. A selection of species of special conservation interest observed during the bioblitz at Dungavel Park, Malanda, Queensland. These include (A) Hard Pink Elder (*Ostrearia australiana*, Hamamelidaceae, endemic and Near Threatened); (B) a poorly known and yet to be formally named dung beetle, *Amphistomus* sp. NQ5 (Scarabeidae); (C) the Spectacled Monarch (*Symposiachrus trivirgatus*, Monarchidae which is listed as being of Special Least Concern); (D) the Spectacled Flying-fox (*Pteropus conspicillatus*, Pteropodidae, Endangered); (E) the arboreal Lumholtz Tree-kangaroo (*Dendrolagus lumholtzi*, Macropodidae, Near Threatened); and (F) the Green-eyed Tree-frog (*Ranoidea serrata*, Hylidae, Vulnerable). Photos: (A) Penny Taylor, (B) Mia Derhe, (C-F) Dylan Berr.

all of which were collected from baited pitfall traps. Most of the dung beetles were from the genus *Orthophagus*, although we also found a poorly known species yet to be formally described, *Amphistomus* sp. NQ3 (Fig. 3B). Other insects (20.6% of total) included representatives of the orders Trichoptera (caddisflies), Orthoptera (grasshoppers and crickets), and Phasmatodea (stick insects). Of the four phasmids recorded, one is undescribed (*Anchiale* sp.). Two crustacean species, the Australian Marmorated Reclined Woodlouse (*Cubaris marmorata*) and a species of freshwater shrimp (*Caridina* sp.) were recorded.

Among the vertebrates, birds (55 spp., 73.3% of the vertebrates) were the most species-rich group (Table 1). Among these, three species, the Black-faced Monarch (*Monarcha melanopsis*), Spectacled Monarch (*Symposiachrus trivirgatus*) (Fig. 3C), and Rufous Fantail (*Rhipidura rufifrons*), are of Special Least Concern. While the majority of birds were forest dwellers, two aquatic birds, the Australasian Darter (*Anhinga novaehollandiae*), and the Pacific Black Duck (*Anas supercilios*), were observed in the river. The Common Myna (*Acridotheres tristis*) was the only exotic bird observed.

The next largest group of vertebrates, the mammals (9 spp., 12% of the vertebrates), were mostly represented by bats (Chiroptera: 8 spp.). Two species of conservation interest, the Diadem Leaf-nosed Bat (*Hipposideros diadema*, Near Threatened) and the Spectacled Flying-fox (*Pteropus conspicillatus*, Endangered) (Fig. 3D) were observed using the revegetated riparian forest as habitat. There was also a sighting of Lumholtz Tree-kangaroo (*Dendrolagus lumholtzi*, Near Threatened) (Fig. 3E).

The remaining 11 species of vertebrates (14.7%) consisted of reptiles, amphibians and one fish species (Table 1). The Carpet Python (*Morelia spilota*), which is rare in the area, was spotted by the river, and several specimens of the Vulnerable Irwin's Snapping Turtle (*Elseya irwini*), as well as one Saw-shelled Turtle (*Myuchelys latisternum*) were caught while snorkelling. The Green-eyed Tree-frog (*Ranoidea serrata*, Vulnerable) (Fig. 3F) was also spotted by the river, as was the naturalised Cane Toad (*Rhinella marina*).

Most of the data submitted to the research team were in the form of field sheets. Eighteen participants of the Malanda BioBlitz submitted 343 observations to iNaturalist (Fig. 4), these belonging to 239 species which is 51.8% of our total species count. Identification of uploaded photographs was provided by 58 persons from the broader iNaturalist community.

Discussion

The bioblitz attracted public interest from residents of the locale, from the broader community in the Atherton Tablelands, and visitors from elsewhere. Overall attendance was estimated to be around 300. Of the public who attended the event, most visited booths with displays and listened to talks. Many also participated in guided walks through the site without necessarily contributing observations while others participated in surveys led by experienced observers. A cadre of experts or researchers with diverse expertise conducted surveys or collected specimens and provided field sheets of their observations, and some participants uploaded pictures of their observations for digital curation on iNaturalist.

Ecological and conservation relevance of a snapshot of biodiversity

Since plants were the most extensively surveyed, they are the group from which most inferences can be made. The majority of plants, and especially trees, recorded from the revegetated riparian area were planted as part of the restoration efforts over 20 years ago. The presence of a diverse mix of well-established and reproductively mature fleshy-fruited tree genera and species such as figs (*Ficus* – 9 spp.), native apples (*Syzygium* – 13 spp.), and members of the laurel family (Lauraceae – 7 spp.) is a positive indicator that the restored forest can serve as a good food resource for rainforest animals, although the majority of these trees are in the small-fruited category mostly used in restoration plantings (Engert *et al*. 2020; Tng *et al.* 2023). In contrast, conspicuously absent is a suite of rainforest trees with large, fleshy fruit such as Cribwood (*Corynocarpus cribbianus*, Corynocarpaceae), Poison Laurel (*Cryptocarya pleurosperma*), Hairy Walnut (*Endiandra insignis*) (the latter two in Lauraceae), and other rainforest understorey trees, shrubs and vines that are found in the nearby and contiguous Malanda Falls Conservation Area (D. Tng, personal observation).

While the flora of the riparian revegetation at Dungavel Park is not completely representative of the original forests, it has been shown that, with increased recovery time, recovering forests within Australia's Wet Tropics become more complex (Yeo & Fensham 2014; Mullin *et al.* 2020; Tng *et al*. 2023). Indeed, native epiphytes, herbs, forest dwelling grasses (*Oplismenus* sp.), and some vines have most likely colonised the site unassisted since the original planting. Likewise, the observation of bryophytes and lichens on diverse substrates provides a good indicator of the development of suitable microhabitat to support these lifeforms

Figure 4. Map of 343 photographed and geotagged observations submitted by bioblitz participants (both active researchers and public) and digitally curated in iNaturalist. URLs are listed in the Supplementary Tables.

(Rehm *et al.* 2019). Moreover, bryophytes and lichens warrant further collecting as they are under-represented in our record due to time constraints and limited expertise.

Despite the observable development of a closed canopy in the revegetated riparian zone, the substantial number of non-native plant species is noteworthy and of concern. Non-native plants on the edges of the forest consisted of various garden escapes, and some species such as Night-scented Jasmine (*Cestrum nocturnum*, Solanaceae), Mickey Mouse Plant (*Ochna serrulata*, Ochnaceae) and Firespike (*Odontonema tubaeforme*, Acanthaceae) appear to have formed localised infestations persisting under the shade of the canopy. Ongoing studies are further examining the demography of plants in the understorey of the riparian zone to determine the impact of these infestations on normal secondary succession (S. Sharp, M. Martin-Fuller, E. Garman, personal communication). Nevertheless, we recommend that management actions that discourage nearby residents from dumping garden refuse as well as some weed control may be beneficial for the long-term ecological integrity of the site.

Forests with developed canopies and understories have been shown to attract invertebrate diversity (Wardhaugh *et al.* 2012), and it is no surprise that the invertebrate fauna was the next most diverse group of organisms. For instance, the diversity of spiders of various ecological guilds is a good indicator of suitable habitat development (Churchill 1997). Nevertheless, we acknowledge that our sampling of invertebrates, more than of any other group, represents just a snapshot of the diversity of the invertebrate fauna at the site, as the majority of the sampling occurred over 24 hours. Most invertebrate groups are likely substantially under-represented by our data despite efforts to sample broadly across different microhabitats (leaf litter, foliage, aquatic habitats), and behavioural patterns (nocturnal, diurnal, etc.). We found only eight species of moths over ten hours of light sheeting, which likely reflects dry preceding conditions, as moth occurrences can be highly dependent on weather patterns (Butler *et al*. 1999). In marked contrast, Tng *et al*. (2021) noted over 1000 distinct moth species over two years at a single spot at the forest edge at Danbulla, 15 km northeast of the bioblitz site and at a similar altitude.

Expertise was a limiting factor in our invertebrate surveys, and most of the invertebrates collected, other than dung beetles, were identified to Order or Family level only. When a stick insect expert visited the site after the public phase of the event, he noted four species, including one unnamed, during a brief search along the forest edge. Other invertebrate groups such as cockroaches (Blattodea), and grasshoppers, katydids, and crickets (Orthoptera), are known to be diverse in the Wet Tropics region (Rentz 2014; Rentz & Su 2019), but were very poorly represented in our invertebrate surveys.

Vertebrate species were observed non-invasively during the bioblitz, with experts collecting data on birds, bats, and herptiles. Among the birds, seven species are rainforest-dependent (Kanowski *et al.* 2010), namely the Wompoo Fruit-dove (*Ptilinopus magnificus*), Double-eyed Fig-parrot (*Cyclopsitta diophthalma*), Orange-footed Scrubfowl (*Megapodius reinwardt*), Pied Monarch (*Arses kaupi*), Yellow-breasted Boatbill (*Machaerirhynchus flaviventer*), Pale-yellow Robin (*Tregellasia capito*) and Grey-headed Robin (*Heteromyias cinereifrons*). The presence of these rainforest birds highlights the significance of the revegetated riparian forest at Dungavel Park as bird habitat (Freeman *et al*. 2009). A few of these are frugivores, which aid in revegetation by facilitating dispersal and recruitment of rainforest species from other rainforest patches (Bennett *et al*. 2022). The Spectacled Flying-fox could also serve as a seed disperser for rainforest plants (White *et al.* 2004). The presence of Lumholtz's Tree-kangaroo indicates that the revegetated forest at Dungavel Park has established ecological connectivity for arboreal mammals to the mature and uncleared remnant forest patch at the nearby Malanda Falls Conservation Area.

Avenues for future bioblitzes and general reflections

Future planning of events such as the Malanda BioBlitz should, we suggest, include more effective outreach regarding iNaturalist and a heavier emphasis on participant use of the platform in order to benefit the community engaging with nature and contributing high quality georeferenced observations. The platform also serves as a useful place to digitally curate bioblitz observations. The biggest limitation in our use of iNaturalist was encouraging people to come to the iNaturalist booth at check-in and learn how to sign up. Another potential limitation would be that identification of some groups of organisms rely heavily on calls (birds), or are hard to photograph without the use of a microscope or without having a camera out at "the right time" (e.g. moving animals). For such observations, submissions can also be entered into iNaturalist although alternative data curation apps such as Birdata (Birdata 2024) and Butterflies Australia (*www.butterflies.org.au/*) could be promoted. One of the main goals of a bioblitz is to re-enchant people with the natural world so that they are more likely to become natural stewards and care about biodiversity, and there is great potential for iNaturalist and other biodiversity curation apps to help bridge the gap between nature and technology (Francis *et al*. 2017).

Given that the Malanda BioBlitz is the first such public and community-based event in the region, and that the region is one of the most species rich in Australia, there is scope for more such events. Future bioblitzes could be ecologically themed and examine the differences in biodiversity between upland and lowland rainforests, or the biodiversity of specific vegetation communities, or compare biodiversity in contrasting adjacent habitats such as rainforest and savanna (Tng *et al*. 2012). Engagement of traditional landowners in these events could include biocultural mapping that could help preserve their cultural knowledge.

Although bioblitzes have become quite common around some major Australian cities, there have been few in the Wet Tropics, and even fewer where citizen scientist or community engagement has been a prominent feature. Similar events have been called “bush blitzes” (Anon 2017), while others have been reported as “flora and fauna surveys” (Anthony *et al.* 2019), even though the scope of these events, which include sampling of broad groups of organisms, could well qualify them as a bioblitz. We propose that any biodiversity survey of a wide range of plant and animal groups, and which involves a mix of specialists and non-specialists or members of the public, should be termed a bioblitz.

While each bioblitz will have its own characteristics, it is important to provide comprehensive reports of the observations made, and to synthesise and reflect on the data collected, particularly given that observations made can be useful for informing conservation policies. Ideally, such reports should be submitted to peer-reviewed journals and made available to the public. We hope this work will serve as an inspiration and a template for reporting on future bioblitzes.

Acknowledgements

We would like to acknowledge and thank the traditional owners of the Malanda BioBlitz site that we have been working on: the Elders of the Ngadjon-Jii peoples, past, present, and emerging.

Gemma Horner obtained an Animal Ethics Approval from the Queensland Department of Agriculture and Fisheries as well as an Event / Activity Permit from Tablelands Regional Council to hold the event on council land. Several wildlife experts held their own permits through their institutions, including Angus Emmott (Qld Museum) and Alastair Freeman (Department of Environment, Tourism Science and Innovation: DETSI), who surveyed turtles under a DETSI Technical Services scientific purposes permit as a volunteer.

We acknowledge the efforts of the researchers and specialists who contributed the bulk of the data for specific groups, most of whom are co-authors on the article. David Tng, Mia Martin-Fuller, Sydney Sharp, Emma Garman, Stuart Worboys, James Hill, and Rene van Rader contributed botanical data; Allan Gillanders contributed data on stick insects; Peter Valentine contributed observations of butterflies; Mia Derhe, Iris Ballard, Anya Hoepfinger and Vanessa Norris contributed most of the beetle data; Alastair Freeman and Michael Anthony documented reptiles and amphibians; Amanda Freeman, Mark McCaffery, Angela McCaffery, Allan Gillanders and Peter Valentine led bird surveys; and Nigel Tucker contributed Anabat data.

We also thank the various staff and other students of the 2024 Dry semester of the School for Field Studies who participated in the event as co-organisers and demonstrators and who also contributed biological observations. The first three authors, Anne Heiser, Susanna McDowell and Dylan Berr contributed equally to this work. We are also grateful to Don Franklin and a reviewer for their insightful comments on the manuscript.

Supplementary files

A supplementary xlsx file accompanies this paper on its web-page. It contains:

- Table A1: Plant and fungi sightings at Dungavel Park;
- Table A2: Invertebrate sightings at Dunagavel Park; and
- Table A3: Vertebrate sightings at Dungavel Park.

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