Croajingolong National Park Victoria

7–15 November and 28 November–7 December 2016

Bush Blitz Species Discovery Program

Australian Government
Department of the Environment and Energy

bhpbilliton
Sustainable Communities

EARTHWATCH INSTITUTE

Australian Biological Resources Study

What is Bush Blitz?

Bush Blitz is a multi-million dollar partnership between the Australian Government, BHP Billiton Sustainable Communities and Earthwatch Australia to document plants and animals in selected properties across Australia.

This innovative partnership harnesses the expertise of many of Australia's top scientists from museums, herbaria, universities, and other institutions and organisations across the country.

Abbreviations

ABRS
Australian Biological Resources Study

Advisory List
Advisory List of Rare or Threatened Plants in Victoria - 2014 OR *Advisory List of Threatened Vertebrate Fauna - 2013*

ALA
Atlas of Living Australia

ANIC
Australian National Insect Collection

CSIRO
Commonwealth Scientific and Industrial Research Organisation

DELWP
Department of Environment, Land, Water and Planning (Victoria)

EPBC Act
Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)

FFG Act
Flora and Fauna Guarantee Act 1988 (Victoria)

MV
Museums Victoria

UM
University of Melbourne

UNSW
University of New South Wales

RBGV
Royal Botanic Gardens Victoria

Summary

Bush Blitz expeditions were conducted in Croajingolong National Park during November and December 2016. This park, managed by Parks Victoria, stretches along the far south-east coast of Victoria. Due to the large size of the park, one expedition focused on the section of the park west of Mallacoota and another focused on the area east of Mallacoota. This Bush Blitz had a large marine component and included surveys of Gabo Island and Cape Howe Marine National Park, also managed by Parks Victoria, and nearby coastal areas.

The far south-east of Victoria is particularly important in terms of unique environments because the eastern and southern biotas meet there. Despite the importance of this region, very little biodiversity work had been undertaken in the park, particularly the eastern part, prior to the Bush Blitz. For example, the Bush Blitz included the first known moth surveys in the eastern part of the park.

Approximately 1776 species were recorded during the two Bush Blitz expeditions and this report summarises the findings. At least 702 species had not been recorded previously in the areas studied and 25 of those may be completely new to science (one echinoderm, 13 true bugs, five snails, one flowering plant, one fern and four marine algae). Ten threatened animal species were recorded and 72 state-listed plant species, including 18 that are listed as Threatened.

Some highlights of the survey included:

- a significant increase in species records from the region for all groups targeted
- the collection of frog and reptile tissue samples and voucher specimens
- the collection of many new records for the park that provide valuable information about species distribution, including 286 species of moth
- the discovery of a sea cucumber *Pseudocnus sentus*—a new record for Australia
- the location of a number of conservation-listed species of plants and animals.

This report identifies noteworthy sites and species found during the Bush Blitzes and provides advice for managing these values. Some further survey work is recommended. For example, to assess whether the reserve system is adequately protecting threatened reptiles and frogs, and to monitor the size and condition of seagrass cover in estuaries. During the expedition, one vertebrate and 32 exotic or pest invertebrate species were recorded. Sambar Deer (*Cervus unicolor*) are active within the park and pose a threat to vegetation communities, particularly where state-listed plant species are being damaged. A species of particular concern in the marine environment is the Long-spine Sea Urchin (*Centrostephanus rodgersii*), and further surveys are recommended to determine if action is required to control population size. In addition, 21 exotic plants were recorded. Recommendations are made for the management of these species, including information that will assist in prioritising weed control. Listed plants that are vulnerable to roadside disturbance, weeds and management actions are also highlighted.

Contents

Introduction

This is a report for the Bush Blitz program, which aims to improve our knowledge of Australia's biodiversity. Bush Blitz is an initiative of the Australian Government, through the Australian Biological Resources Study (ABRS), in partnership with BHP Billiton Sustainable Communities and Earthwatch Australia. Bush Blitz aims to:

- promote, publicise and demonstrate the importance of taxonomy through species discovery
- undertake a national species discovery program
- support the science of taxonomy in Australia through training of students and early career researchers, and by providing grants for species description and resolution of taxonomically problematic, nationally important groups
- promote partnerships between scientific institutions, government, industry and non-government organisations
- inform reserve managers and other stakeholders of the results of Bush Blitz projects.

The Croajingolong National Park Bush Blitzes

Due to the large size of Croajingolong National Park, two Bush Blitzes were conducted. Some taxonomic groups were targeted on both expeditions—reptiles, amphibians, moths, freshwater invertebrates, true bugs and plants—while others were only targeted on one Bush Blitz.

The first expedition (7–15 November) focused on the section of the park west of Mallacoota. However, this Bush Blitz also included the marine and coastal environments of the region and targeted additional groups—fish, echinoderms and marine algae. The main base camp was at the Mallacoota Foreshore Holiday Park in the township of Mallacoota and two smaller temporary base camps were located at Gabo Island and Wingan Inlet. Eight BHP Billiton employees participated in the Bush Blitz as field assistants to the scientists. This was a professional development opportunity for the employees and scientists appreciated their help, both in the field and the lab. A community day was held in Mallacoota, aimed at raising public awareness of taxonomy and biodiversity.

The second expedition (28 November–7 December) focused on the section of the park east of Mallacoota. Additional target groups for this Bush Blitz were mammals and molluscs, and terrestrial invertebrates were also collected. The main base camp for the expedition was at Marshmead—the Year 9 campus of Melbourne-based Methodist Ladies College (MLC). The campus is situated on a 114 ha farm, bordered by Croajingolong National Park and Mallacoota Inlet. Eight MLC students (Year 10 and 11) and two MLC staff spent a day with scientists.

Bush Blitz provided the logistical coordination and overall leadership for the expeditions. Museums Victoria (MV) was the host institution for this Bush Blitz, providing the core group of personnel, and accessioning the specimens into their collection. Experts from the following organisations also conducted field and laboratory work:

- Entomological Society of Victoria
- University of Melbourne (UM)
- University of New South Wales (UNSW)

- Royal Botanic Gardens Victoria (RBGV).

Acknowledgements

The ABRS acknowledges the Traditional Owners of country throughout Australia and their continuing connection to land, sea and community. We pay our respects to them and their cultures and to their elders both past and present.

The Bush Blitz team comprised Kate Gillespie, Jo Harding, Bella Miras, Damian Wrigley and Megan Donaldson. They would like to thank the Traditional Owners of the land on which the expeditions took place. In particular, special thanks are given to the Traditional Owners that were available to provide a welcome to country and represented the Traditional Owner groups—Bidawal, Nindi-Ngudjam Ngarigu Monero and Gunaikurnai.

Thanks also to staff from Parks Victoria and the Department of Environment, Land, Water and Planning (Victoria) (DELWP) for providing advice and assistance both before and during the expeditions. In addition to providing ground support to the teams, Parks Victoria provided two vessels and skippers to assist with marine surveys, two dive co-ordinators to manage diving and snorkelling activities, and two air observers and two flight followers to assist with helicopter operations.

Bush Blitz was privileged to be able to use the facilities at Marshmead during the second Bush Blitz and would like to thank MLC and the staff at Marshmead for their support. In particular, thanks to Dan Short (Director Outdoor Education), Steve Davies (Director Marshmead), Marion Martin (Deputy Director Marshmead) and Stuart Llewellyn (Deputy Director Marshmead).

The team would also like to thank the caterers, the helicopter crew and all the participants who so willingly assisted each other with fieldwork. BHP Billiton staff were coordinated by Bruce Paton and Andrea Haas from Earthwatch Australia.

Reserve overview[1]

Reserve name: Croajingolong National Park

Area: 885 km^2

Description

Croajingolong National Park is located in Far East Gippsland, Victoria, and extends as a wide tract of land almost 100 km long from Sydenham Inlet in the west to the NSW border in the east. This large park was created in 1979 and is managed by Parks Victoria. The park includes coastal river systems, tidal inlets, estuaries, coastal sand dunes, rocky cliffs, lakes and ranges, with extensive remote and wilderness environments. It is bordered by State forest to the north, Cape Conran Coastal Park to the west and Bass Strait to the south, including the Point Hicks and Cape Howe Marine National Parks. Most of the park is flat and less than 300 m above sea level.

Cape Howe Marine National Park (40.5 km^2) and the surrounding marine area support a mixture of cool water southern marine species and warmer water species more common in the north. Habitats found along this part of the coastal waters include kelp forest, granite and sandstone reefs, sand beach and soft sediment. The marine life in this region is diverse due to the ability of species of both warm and cool areas to reside here.

Gabo Island is a small (1.54 km^2) granitic island located approximately 14 km from Mallacoota at the eastern tip of Victoria, approximately 500 m off the wilderness coast of Croajingolong National Park. The island has a temperate maritime climate. The centre of Gabo Island has high dune ridges covered by low forest while the periphery has low scrub and grassland. The island supports several plant species that are considered rare and large numbers of sea birds, including possibly the largest breeding colony of Little Penguins (*Eudyptula minor*) in the world.

Conservation values

Some of the significant natural values of the park are:

- A wide variety of highly significant coastal landforms including tidal inlets, estuaries and lagoons, dune-blocked lake and swamp systems, freshwater interdune lakes, extensive sand dunes and sand sheets, and prominent rocky cliffs.
- Significant and well-developed sites of Warm Temperate Rainforest in the lower reaches of a number of rivers—of note are Wau Wauka Creek, Harrisons Creek and Dowell Creek.
- Coastal Heathland, a community considered to be extremely species-rich, and covering up to 10% of the park.

[1] Croajingolong National Park Management Plan, National Parks Service, Department of Natural Resources and Environment (Victoria), June 1996

- Records for the park of one third of Victoria's, and one quarter of Australia's, bird species.
- Some of the richest amphibian habitats in Victoria.
- Highly significant coastal streams and catchments which are relatively undisturbed, with an absence of introduced fish species and good populations of native fish species.
- Localities among the highest wilderness quality in the State, outside the Mallee, and two of the three coastal wilderness areas in Victoria.

Together with Nadgee Nature Reserve in NSW, Croajingolong National Park forms Croajingolong Biosphere Reserve, designated under UNESCO's Man and the Biosphere Program.

Methods

Taxonomic groups studied and personnel

A number of taxonomic groups were selected as targets for study. Table 1 lists the groups surveyed and the specialists who undertook the fieldwork.

Table 1 Taxonomic groups surveyed and personnel

Group	Common name	Expert	Affiliation
Mammalia	Mammals	Phoebe Burns	MV
	Bats	Tony Mitchell	DELWP
Amphibia and Reptilia	Frogs and reptiles	Jane Melville	MV
		Joanna Sumner	
		Nick Clemann	MV/DELWP
		Geoff Heard	UM
Pisces	Fishes	Dianne Bray	MV
		Martin Gomon	
Echinodermata	Echinoderms	Guadalupe Bribiesca Contreras	MV/UM
		Kate Naughton	
Lepidoptera	Moths	Peter Marriott	Entomological Society of Victoria
		Marilyn Hewish	
Terrestrial invertebrates		Peter Lillywhite	MV
		Simon Hinkley	
Freshwater invertebrates		Richard Marchant	MV
Heteroptera	True bugs	Ryan Shofner	UNSW
		Marina Cheng	
Crustacea	Amphipods / Copepods	Genefor Walker-Smith	MV
	Decapods	Gary Poore	
Mollusca	Snails	Adnan Moussalli	MV
Vascular and non-vascular plants		Andre Messina	RBGV
		Val Stajsic	
		Daniel Ohlsen	
		Neville Walsh	

Group	Common name	Expert	Affiliation
Vascular and non-vascular plants (cont.)		Nimal Karunajeewa	RBGV
Marine algae		Heroen Verbruggen	UM
		Pilar Diaz Tapia	
		Kyatt Dixon	

The Bush Blitz team would also like to acknowledge the contributions of the following:

- All Parks Victoria and DELWP staff who assisted with planning the operation, participated in fieldwork and/or provided logistical support.
- MV staff Julian Finn, Maik Fiedel, Tamara Morgan and Andrew O'Grady (fieldwork), David Paul and Rod Start (wildlife photography), Rob Zugaro (videography), Tracey-Ann Hooley (administrative and logistical support), and Patrick Honan and his team from the Live Animal Support unit.
- Renee Catullo (University of Western Sydney) who assisted with frog identification.
- Ken Harris (moth collection and identification), David Mules (moth collection) and Dean Hewish (moth collection) from the Entomological Society of Australia.
- E. D. (Ted) Edwards (ANIC) and Axel Kallies (UM) who assisted with insect identification and provided information on previous surveys.
- Gerry Cassis, Serena Lam and Cynthia Chan (all UNSW) who undertook the identification, data management and reporting of Heteroptera specimens.
- the SCUBA divers who collected algae and sponges from which many of the crustaceans were extracted.
- John Stanisic (Queensland Museum) and Kevin Bonham who assisted in identifying and designating the charopid snails.
- Catriona McPhee (Melbourne Museum) for assistance with equipment and reagents for moth surveys.
- Doug Hilton and Egbert Friedrich who provided information on previous moth surveys.
- M. Malipatil (AgroBio, La Trobe University) and Sabine Perron (Biosecurity and Agrisystems Protection) for information on native moths of economic significance as pests.
- Ken Walker (Melbourne Museum) and Marianne Horak (ANIC) for their assistance with insect identification.
- Jeremy Bruhl (University of New England), who provided information on the taxonomy of the undescribed *Banksia* species.
- Pina Milne and the National Herbarium of Victoria, for provision of field supplies to the marine algae team.

Site selection

All terrestrial scientists surveyed two standard survey sites selected by Bush Blitz by using modelling prepared by CSIRO. Each standard survey site was centred on a point (permanently marked), but the actual area surveyed varied between taxa. Standard methodologies were used to sample these sites.

The use of standard survey sites provides a unique opportunity to examine broad-spectrum biodiversity. Among other benefits, this will enable Bush Blitz's partners at CSIRO to test assumptions that underpin many conservation decisions (e.g. assumptions about relationships between the diversity of different

taxa). It will also allow comparisons between sites, and establish a basis for future monitoring by reserve managers.

Apart from standard survey sites, site selection and collection methods were left to the discretion of the individual scientist. Site selection largely depended on access, suitability for trapping and time restrictions. A cultural heritage assessment was undertaken to ensure collection sites that involved disturbance would not impact upon Aboriginal Cultural Heritage values.

Further considerations included:

- Mammal sites were selected based on Ecological Vegetation Classes likely to support Smoky Mice (*Pseudomys fumeus*) or Broad-toothed Rats (*Mastacomys fuscus*). Bat sites were selected with two objectives—to sample for a general species list and to target rainforest sites specifically for the Golden-tipped Bat (*Phoniscus papuensis*).
- Reptile and frog sites were selected to provide a cross-sample of the range of habitats occurring in the park and on Gabo Island. Effort was focused on coastal heath, inaccessible tall wet forests and woodlands, as consultation prior to the survey indicated that these habitats were least well known.
- Fish collecting sites were chosen primarily on the basis of accessibility from land, with the overall aim of maximising coverage for the overall survey area and full range of habitats capable of being sampled with collecting methods permitted.
- Echinoderm site selection depended on accessibility, weather conditions, depth and type of substrate. The sites surveyed were: off Cape Howe Marine National Park, Gabo Island and Tullaburga Island.
- Moth sites were chosen to sample a variety of habitats and for accessibility to four-wheel drive vehicles and, for remote areas, a helicopter.
- Freshwater invertebrates were sampled at sites in streams within or near the Marshmead property, at the south-western end of Lake Barracoota, at Lake Wau Wauka and at the creek on Howe Flat.
- Heteroptera sites were selected based on vegetation characteristics such as heterogeneity and the presence of flowers, in order to maximise collection efforts.
- Crustacean collecting sites were chosen primarily on the basis of accessibility from land. Sites with algae or sponges were also selected so crustaceans from these habitats could be collected.
- Mollusc sites were chosen on the basis of accessibility and the degree of disturbance. Priority was given to warm temperate rainforest/riparian habitat as these tend to provide long-term refuge and act as sources for the surrounding open sclerophyll forest.
- Flora sites were chosen across the park and in a wide variety of vegetation types—rainforest, forest, woodland, heathland, wetland, coastal rocks, dunes, scrub, and disturbed roadsides—to maximise the diversity that could be encountered in the time available. Some sites were chosen to survey known occurrences of threatened taxa. Other sites were visited because there were known occurrences of plant species that have not been photographed for the Bush Blitz-funded online Victorian Flora, VicFlora. Some sites were visited because of reports of potential new species for Victoria or because they were remote areas that had been less intensively collected previously and were expected to be the most likely places to find new Victorian records or range extensions. Many collections were made en route to planned destinations, usually the sighting of a significant taxon worthy of collection from the car or while walking prompted stopping and the designation of a collection site. As a result collections were often dispersed along roads or walking tracks rather than clustered in discrete sites.
- Marine algae sites were selected initially to cover the variety of habitats where different taxa of the target groups were expected to be found. An initial selection was made based on satellite imagery and habitat maps. The aim was to cover the following habitats: (1) shallow-water sheltered sites

inside Mallacoota Inlet; (2) intertidal rocky habitats with different levels of sand cover along the mainland coast; (3) subtidal sites around Gabo Island, around Tullaburga Island and in Cape Howe Marine National Park. Due to weather conditions, some sites could not be visited and were replaced by more accessible sites. Nonetheless, collection occurred at least once in each habitat type.

Site locations were recorded using global positioning systems.

Survey techniques

A standard suite of survey techniques was used:

- **Mammals** were surveyed using remote cameras and live trapping. Cameras were deployed at 12 sites. At each site, two bait stations were established 50–100 m apart. Each bait station consisted of a metal cage (modified cutlery drainer) slotted onto a plastic garden stake. Within each cutlery drainer, there were six tea strainers filled with peanut butter, oats, golden syrup and vanilla essence as olfactory lures. Bait stations were placed so that the bottom of each cutlery drainer was approximately 20 cm from the ground. One PixController DigitalEye white flash camera (PixController Inc.: Pittsburgh, PA; set to maximum sensitivity, 1 m focus, one image per trigger—to conserve limited battery power and SD card space) was placed approximately 20 cm above the ground and 1 m from each bait station. Cameras were left in place for 4–6 nights. Live trapping was conducted at three sites (including the two standard survey sites) using 20 LFA Sherman live traps (76 x 89 x 229 mm; H. B. Sherman Traps, Inc.: Tallahasse, FL) per site. Traps were baited with peanut butter, oats, golden syrup, and vanilla essence, furnished with polyfil for warmth, and set in a meander with 10 m between traps. Traps were left open for four nights. Captured small mammals were identified to species.

  Bats were surveyed using standard harptraps (Austbat-Faunatech Bairnsdale Vic). Harptraps were deployed at 15 sites for a period of three nights per site. At five sites the harptraps were deployed on forest tracks where vegetation funnelled bat activity towards the trap. At the remaining 10 sites, traps were placed specifically for Golden-tipped Bats in unconventional settings, either in gaps within rainforest vegetation or across creek lines in dense vegetation. All bats caught were measured and identified to species then released at the point of capture. Tissue samples were collected from a sample of the bats caught. Nocturnal observations were made for additional species.
- **Reptiles** were captured using three different techniques—pitfall trap lines, hand capture and noosing with dental floss. Lizards, snakes and turtles were actively searched for at sites and hand-caught. Dragon lizards and some skinks were captured using a dental floss slip-noose on the end of an extendable fishing pole. Drift fences with pitfall and yabby traps were used in the coastal heathland, which is difficult to survey using the other methods. This trap line was set up with the assistance and permission of local management authorities, with one drift fence approximately 5 m in length, 30 cm high and approximately four buckets and eight yabby traps along the length. Animals caught via these methods were measured, photographed in-hand, weighed, sexed, a tissue sample collected and a blood smear collected from tissue sampling site (to test later for blood parasites). Tissue sampling was a tail tip or, in larger species, a scale clip. Animals were then released at point of capture within 10 minutes. Once an animal was caught, all other activity ceased and the field team focused on processing the single animal, which minimised handling time of the animal. A number of reptiles were retained as voucher specimens to be lodged at Melbourne Museum.

- **Frogs** were surveyed at night using a one-hour active search. Specimens were captured by hand, measured, photographed in-hand, weighed and sexed. A skin swab was taken (to later test for chytrid fungus) and a tissue sample was collected before they were released at the point of capture. Some frogs were retained as voucher specimens to be lodged at Melbourne Museum.
- **Fishes** were sampled using a 3 m seine (1 cm stretch mesh), small baited funnel traps and long handled dip nets. The 3 m seine was operated by two handlers and pulled for the full length of sea grass patches in depths of less than 1 m and then beached on the nearest shore where the catch was examined, sorted and excess numbers of specimens per species returned to the water. In areas where sea grass was too sparse to form discrete beds, the seine was pulled for no more than 20 m before beaching it. Bait traps were deployed in mostly sandy areas as species occurring in unvegetated habitats were considered likely to inhabit burrows and escape the seine. In estuarine areas only, extreme tides prevented collecting. Along the open coast, waves and surge prevented the use of the seine and bait traps. Dip nets were employed in an attempt to sample coastal tide pools. The presence of juvenile individuals in grass beds was thought to reflect a late winter/early spring reproductive periodicity of the relevant species. Visual and photographic records were recorded by divers at Gabo Island.
- **Echinoderms** were hand collected by SCUBA divers, either by lifting rocks or taking seaweed holdfasts or sponges to process in the laboratory.
- **Moths** were surveyed using a light trap (a 250W mercury vapour light shining on a vertical white sheet). The trap was generally set up at dusk, checked through the night and early morning and shut down at sunrise. However, circumstances such as rain and strong wind sometimes led to the early shutdown of the light trap. Moth specimens were occasionally captured opportunistically during the day. Each species was photographed. Where possible, significant specimens were collected and lodged as voucher specimens in the Melbourne Museum collection.
- **Freshwater invertebrates** in streams, shallow water and littoral habitats were captured using a 30 cm wide hand net (200 µm mesh). The net was swept over a distance of 5–10 m, disturbing bottom sediments, woody debris and any macrophytes present. The net contents were emptied into white trays and live specimens were removed with pipettes and forceps for a period of 30–45 minutes. The aim was to collect specimens of all species or taxa present rather than to remove all individuals caught. Specimens were preserved in 70% ethanol.

  At sites within or near the Marshmead property, streams were sampled at two locations to determine whether the benthic fauna varied from the upstream to the downstream site. Such longitudinal variation is common for stream benthic communities.

  Samples were taken in deeper water in Lake Barracoota using an air-lift sampler operated by a diver. An air-lift sampler retrieves benthic sediment and organic material using a stream of compressed air to create suction. The benthic material flows into a mesh (180 µm) bag, trapping specimens. Samples were elutriated on shore to remove organic material, which was then preserved in 70% ethanol.
- **Terrestrial invertebrates** were collected using a beating sheet, by direct searching, log sampling and light trapping.
- **Heteroptera** specimens were collected primarily by beating or sweeping vegetation, focusing on flowers, fruits and seeds. Specimens were also obtained by general collecting. At standard survey sites (SSS), consistent with previous heteropteran Bush Blitz surveys, beating or sweeping of vegetation took place for one hour.
- **Crustacean** collection methods included gathering algae and sponges by hand and washing crustaceans from these substrates by dunking them in a bucket of freshwater; by turning over rocks in rock pools and gathering specimens by hand (rocks were rolled back to their original position afterwards); by using a yabby or bait pump to collect specimens from sand; and by using a small

hand net. In line with MV's animal ethics permit, all decapods were killed humanely in a solution of clove oil. This is a recognised narcotising agent for decapod crustaceans. Algal and sponge samples were generally collected by SCUBA divers. In these instances, divers would place a handful of algae (for example) into a clear plastic bag, the bag then secured with a rubber band. Every effort was made to place only a single species of algae in each bag, to discover if the amphipods and copepods were displaying any habitat preferences (the results of any habitat preferences will be discussed in a report due for submission in 2018). These bags of algae were then returned to the field-lab where they were washed in a bucket of freshwater. This bucket of water, which contained the disassociated crustaceans, was then poured through a 300 µm mesh sieve. Collected crustaceans were then washed into Petri dishes, extracted individually from the samples using forceps, and identified. Identified specimens were fixed in 70% or 95% ethanol. As mentioned previously, decapods were killed humanely in a clove oil solution before being rinsed in freshwater and transferred to ethanol. In situations where time was limited, specimens were fixed in ethanol before being identified.

- **Molluscs** were collected primarily by active searching, targeting micro-habitats such as logs, rock crevices and leaf litter. Once chosen, a site was rapidly surveyed for approximately 15 minutes, with the primary focus being the collection of post-mortem shells. If diversity and/or abundance was sufficiently high, a systematic survey was then undertaken, with search effort extended to one to two person hours. Both live specimens and post-mortem shells were collected by hand. Live specimens were drowned by placing them in a container filled with tap water and sealed so that no air remained. They were left in the container for 12–24 hours before being preserved in 70% ethanol. The same collection methods were used for the SSS, but effort was restricted to one person hour.
- **Flora** collections were made of individuals bearing fertile structures (buds, flowers, fruits, sporangia, apothecia). Specimens were photographed *in-situ* to record important features and habitat and to contribute to the online Victorian flora, VicFlora. Gatherings were made either of one or more entire individuals (small herbaceous plants) or portions of stems bearing representative foliage, flowers etc. Where possible, sufficient material was collected to prepare duplicate specimens to be sent to other herbaria. Lichens and bryophytes were collected by removing a portion of substrate including the specimen. Plant specimens were dried in presses. In order to preserve the structure of flowers, specimens of some groups (Orchidaceae, Commelinaceae) were preserved in alcohol (70% ethanol with 5% glycerol). When plants of particular interest for phylogenetic study were collected, portions of vegetative material were placed in silica gel to dry this tissue rapidly, increasing the chance of DNA being preserved successfully. At the SSS a full floristic inventory was recorded within a 20 m x 20 m quadrat.
- **Marine algae** surveys in intertidal habitats were carried out on foot, in shallow subtidal habitats by snorkelling, and in subtidal habitats by SCUBA divers. All collections were made by hand and processed for future molecular and anatomical work. Voucher specimens were pressed.

Identification

The specimens taken were identified using available literature and the holdings of museums and herbaria. Fauna specimens were deposited in the Melbourne Museum collection. Vascular plants and lichen were deposited in the National Herbarium of Victoria at the RBGV. All specimen data are available through the Atlas of Living Australia.

Results

Locational data for all flora and fauna records are available to reserve managers. At least 702 species were new records for the study areas (some results are yet to be finalised), including 25 putative new species which await formal identification. Ten threatened animal species were observed and 18 threatened plants. Thirty-three exotic or pest animal species and 21 weed species were also recorded. There were incidental records for one bird (from a mammal camera) and two butterfly species (from moth light traps).

An additional 291 specimens of terrestrial invertebrates were collected that are not listed in Table 2. These specimens were sorted to order, registered, databased and deposited with the Melbourne Museum where they are available to researchers for future taxonomic work.

Table 2 provides a summary of the flora and fauna records for the study area.

Table 2 Summary of flora and fauna records

Group	Common name	Total species recorded	Species newly recorded for study area	Putative new species	Threatened species*	Exotic and pest species**
Mammalia	Mammals	23	0	0	6	1
Aves	Birds	1	0	0	0	0
Reptilia	Reptiles	14	0	0	2	0
Amphibia	Frogs and toads	11	0	0	2	0
Pisces	Fish	86	0	0	0	0
Echinodermata	Echinoderms	27	5	1	0	2
Lepidoptera	Butterflies	2	0	0	0	0
Lepidoptera	Moths	658	285	0	0	22
Trichoptera	Caddisflies	21	20	0	0	0
Diptera	True flies	38	34	0	0	0
Coleoptera	Beetles	13	12	0	0	0
Megaloptera	Alderflies, dobsonflies	1	1	0	0	0
Heteroptera	True bugs	115	115	13	0	3
Plecoptera	Stoneflies	3	3	0	0	0
Ephemeroptera	Mayflies	11	10	0	0	0
Odonata	Dragonflies, damselflies	8	5	0	0	0
Arachnida	Spiders and mites	1	1	0	0	0

Group	Common name	Total species recorded	Species newly recorded for study area	Putative new species	Threatened species*	Exotic and pest species**
Crustacea	Crustaceans	82	59	0	0	1
Annelida	Annelid worms	7	7	0	0	0
Gastropoda	Snails and slugs	19	17	5	0	4
Tricladida	Flatworms	1	1	0	0	0
Hydrozoa	Hydrozoa	1	1	0	0	0
Magnoliophyta	Flowering plants	351	7	1	15	19
Pinophyta	Conifers	1	0	0	0	0
Tracheophyta	Ferns and fern allies	45	1	1	3	0
Bryophytes	Liverworts and mosses	13	0	0	0	0
Fungi	Fungi	8	2	0	0	0
Lichens	Lichens	13	7	0	0	0
Marine algae	Marine algae	202	109	4	0	2
Total		1776	702	25	28	54

* Species listed as threatened under the Commonwealth EPBC Act or an equivalent listing under the FFG Act or Advisory Lists.
** Includes native species that at times are pests or are exotic to this region.

Species lists

Lists of all species recorded during the Bush Blitz are provided in Appendix A. Species lists were compiled using data from participating institutions. Lists of species previously known to occur in the study areas were provided for some taxonomic groups but not others so this should not be considered a complete species list for the park.

Some specimens have been identified only to family or genus level. This is partly because identification of specimens is very time-consuming, with detailed microscopic examination needed in many cases. Also, some groups are 'orphans': currently no experts are working on them, or are available to work on them, and the taxonomic literature is out of date; species-level identification is not possible for these groups. Unidentified Bush Blitz specimens are held in institutional collections where they are available for future study. Collections hold many such specimens, among them species not yet described (i.e. unnamed species) as well as described species that have not been identified. For example, ANIC holds tens of thousands of unidentified specimens. Specimens often wait decades before the resources become available for their study. A key component of Bush Blitz is the funding of studies of specimens collected on Bush Blitz surveys.

Nomenclature and taxonomic concepts used in this report are consistent with the Australian Faunal Directory, Australian Plant Name Index and Australian Plant Census, AusMoss, and the Catalogue of Australian Liverworts and Hornworts.

Discussion

Putative new species

Here we use the term ‘putative new species’ to mean an unnamed species that, as far as can be ascertained, was collected for the first time during this Bush Blitz. It is confirmed as a new species once it is named and its description is published. Specimens collected during the Bush Blitz also include unidentified taxa that are already known from museum and herbarium collections—these are not counted as putative new species.

Fauna

Invertebrates

Echinoderms

It is possible that specimens of a brittle star, *Amphioplus* sp. 1 "cf. *ochroleuca*", were collected for the first time on this Bush Blitz. Undescribed species that have been collected previously in adjacent areas, but not described due to a lack of material, can now be described using material collected on this trip.

Heteroptera

Thirteen of the collected heteropteran species are putative new species—12 belonging to the family Miridae and one to Pentatomidae.

Crustacea

There could be several new species of copepods and amphipods within the samples collected from Gabo Island and the Mallacoota region. Due to the small size (10 mm to 0.3 mm) of the peracarid crustaceans (amphipods, isopods and tanaids) and the copepods, and the number of undescribed species in the Australian fauna, it takes time to investigate whether the specimens collected are truly new species or just new records for the area. Work on these specimens is ongoing.

Snails and slugs

Five putative new species, including four charopids, were found during this survey. The Charopidae is the most diverse family of land snails in eastern Australia with well over 500 species currently described, and an equal number that are known but yet to be described. This is an important group that should be afforded high priority in terms of support for further taxonomic work. Ultimately the Australian charopid radiation will represent one of the best model systems for a historic biogeographic study of eastern Australian biota.

Table 3 Putative new invertebrate species

Family	Species
Echinoderms	
Amphiuridae	*Amphioplus* sp. 1 "cf. *ochroleuca*"

Family	Species
True bugs	
Miridae	*Acaciacapsus* sp_BBCROb16_Msp040
Miridae	*Austromiris* sp_BBCROa16_Msp.035
Miridae	*Austromiris* sp_BBCROa16_Msp.036
Miridae	*Austromiris* sp_BBCROb16_Msp030
Miridae	Gn_Orthotylini_MALL001 sp_BBCROa16_Msp.023
Miridae	Gn_Orthotylini_MALL003 sp_BBCROa16_Msp.025
Miridae	Gn_Orthotylini_MALL004 sp_BBCROa16_Msp.044
Miridae	Gn_Orthotylini_MALL007 sp_BBCROa16_Msp.047
Miridae	Gn_Orthotylini_MARS001a sp_BBCROb16_Msp042
Miridae	Gn_Orthotylini_MARS002a sp_BBCROb16_Msp043
Miridae	Gn_Orthotylini_MARS003a sp_BBCROb16_Msp038
Miridae	*Naranjakotta* sp_BBCROb16_Msp031
Pentatomidae	*Avicenna* sp_BBCROb16_Msp020
Snails	
Charopidae	Charopidae/gen. nov. sp. nov.
Charopidae	*Luturopa* sp. nov.
Charopidae	*Meredithena* aff. *dandenongensis*
Charopidae	*Scelidoropa* sp. nov.
Cystopeltidae	*Cystopelta* aff. *purpurea*

Flora

Flowering plants

A potentially new species of *Viola* was found on Dowell Creek. It is similar to *Viola hederacea*, but differs in having smaller, predominantly white flowers and broadly ovate (rather than reniform) and pointed leaves. Living material was collected to be grown at the Royal Botanic Gardens Melbourne. Seeds will be harvested to grow on in order to test whether it is of hybrid origin.

A putatively new species of *Banksia* requires further study to determine whether it represents a new species worthy of formal description. According to Prof. Jeremy Bruhl, the *Banksia* plants may represent an undescribed taxon. However, it is possible that they are merely a hybrid between *B. marginata*, which they are very similar to, and *B. spinulosa*. A small population of three plants was found near Shipwreck Creek. This species closely resembles *B. marginata* in its habit and its leaf morphology, but

the style remains clearly hooked below the apex as in *B. spinulosa* (*B. marginata* has a style that straightens).

A collection of what was suspected of being a new species of *Viola* was made near Dowell Creek. In the field it appeared similar to *Viola hederacea*, but differed by its smaller, predominantly white flowers and broadly ovate (rather than reniform) and pointed leaves. Living material and seeds were collected to be grown at the Royal Botanic Gardens Melbourne. After growing on under benign, well-illuminated conditions, both the live material grown on, and plants produced from the collected seeds produced uniform plants typical of *V. hederacea* subsp. *hederacea*. It is possible that the small, white flowers were a cleistogamous condition induced by the low light levels, however the difference in flower size and colour from the wild and cultivated plants was quite extraordinary.

A *Senecio* species was collected on Gabo Island which cannot be keyed reliably to any of the currently described Australian species of *Senecio* using the most recently published keys. *Senecio* readily hybridises, occasionally making identification confusing. Consequently, it is uncertain whether this collection represents a putative new species or a hybrid. Determining the status of this collection requires inspection from an expert of *Senecio* in Australia who authored some recent treatments (I. Thompson) and who will be contacted for an opinion.

Ferns

A putative new species of *Blechnum* was collected. A population of this fern was collected at Rame Head and was observed near where the Sandpatch Walking Track emerges onto the beach that extends between Sandpatch Point and the Benedore River mouth. It most closely resembles *Blechnum wattsii*; however, it is unusual for this species to occur near the ocean, its lighter less coriaceous fronds have wavy margins and its scales are lighter. These plants resemble the undescribed *Blechnum* sp. 'King Island'. The pressed collection and silica-dried leaf material may be used in future molecular studies to compare these plants to the similar *Blechnum* sp. 'King Island' from King Island and to determine whether it is distinct from *B. wattsii* and therefore warrants description as a new species. It is possible that it is merely an unusual environmental form of *B. wattsii*.

Marine algae

At least four putative new species of algae were found during the Bush Blitz. Cryptic diversity (species that are practically indistinguishable based on morphology) is very common in marine algae. A conservative approach has been taken and only morphologically distinct entities from groups the participants have studied intensively are listed as putative new species. Anatomical and molecular information will be needed to confirm this list.

An entity of *Aphanocladia* sp. was collected at Shipwreck Creek which differs morphologically from previously described species in the genus. The entity of *Dipterosiphonia* sp. has a habit more similar to *Polysiphonia* than to *Dipterosiphonia*. Several small but reproductive specimens were found of an entity in the genus *Lophurella* that does not correspond morphologically to known species of this genus. A *Codium* species with short branches spreading sidewards from a mat-forming base was found on Gabo Island Lighthouse Reserve. This growth form is not known among south or east coast species and thus the *Codium* probably is a new species. The tactical taxonomy grant awarded to Verbruggen and Diaz will focus on characterising this species.

It is likely that, in addition to the species listed here, further new species will be discovered in the cryptic species complexes. The tactical taxonomy grant will also focus on that aspect, particularly the *Diplocladia patersonis* and *Dasyclonium incisum* complexes.

Table 4 Putative new flora species

Family	Species
Flowering plants	
Proteaceae	*Banksia* sp. 'Shipwreck Creek'
Ferns	
Blechnaceae	*Blechnum* sp. nov. 'King Island'
Marine algae	
Codiaceae	*Codium* sp.
Rhodomelaceae	*Aphanocladia* sp.
Rhodomelaceae	*Dipterosiphonia* sp.
Rhodomelaceae	*Lophurella* sp.

Threatened species

Australia is home to an estimated 580,000–680,000 species, most of which have not been described. Approximately 92% of Australian plants, 87% of mammals, 93% of reptiles and 45% of birds are endemic. Changes to the landscape resulting from human activity have put many of these unique species at risk. Over the last 200 years, many species have gone extinct; many others are considered to be threatened, i.e. at risk of extinction.[2]

Fauna

Vertebrates

Mammals

Potoroos (*Potorous* sp.) were detected on camera at two sites, however the images captured did not allow discernment between the two species—Long-nosed Potoroo (*Potorous tridactylus tridactylus*) and Long-footed Potoroo (*Potorous longipes*). Both species are listed under the Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth) (EPBC Act) and the *Flora and Fauna Guarantee Act 1988* (Victoria) (FFG Act). They are both highly susceptible to predation by foxes and are expected to benefit from the broadscale fox-baiting program, *Southern Ark*.

Eastern Pygmy Possum (*Cercartetus nanus*) is not listed under the EPBC Act or the FFG Act. However, it is listed as Near Threatened on the *Advisory List of Threatened Vertebrate Fauna in Victoria - 2013* (Advisory List). Adult *C. nanus* weigh 15–38 g and are patchily distributed from the south-east corner of Queensland to the south-eastern tip of South Australia, on Flinders and King Islands, and throughout

[2] Chapman, A. D. 2009, Numbers of Living Species in Australia and the World, 2nd edn. Australian Biological Resources Study, Canberra.

Tasmania. Factors contributing to the decline and threatened status of *C. nanus* include predation by foxes and cats, competition with feral honeybees and increasing fire frequency. The detection of *C. nanus* on camera at two sites was not unexpected.

Table 5 includes three sea mammal species that were observed and photographed by the dive boat crews at Gabo Island.

Reptiles

Eastern She-oak Skink (*Cyclodomorphus michaeli*) is listed as Threatened under the FFG Act and Near Threatened on the Advisory List. One individual was captured on coastal sand dunes at a site at the extreme eastern extent of the park.

Lace Monitor (*Varanus varius*) is listed as Endangered on the Advisory List. This is a large wide-ranging monitor lizard that occurs in eastern Victoria and up the east coast of Australia. Three individuals were captured at Lake Barracoota and Marshmead Boatramp and a tail tip was taken as a tissue sample. The Lake Barracoota site was eucalypt forest. A further three individuals were seen in vine thicket and eucalypt woodland at the Wingan Inlet campground. One individual was captured by hand and a tail tip taken as a tissue sample.

Frogs

Green and Golden Bell Frog (*Litoria aurea*) is listed as Vulnerable on the Advisory List and under the EPBC Act. Multiple individuals were seen, part of what appeared to be a large population, at a man-made dam near the airport. Two individuals were collected.

Martin's Toadlet (*Uperoleia martini*) is listed as Critically Endangered on the Advisory List. Numerous individuals were heard calling, indicating a large population, at a paperbark swamp at the East Wigan Road site. Four individuals were collected. The identification was later checked with Dr Renee Catullo, at the University of Western Sydney, who is an expert on this group. This species is virtually indistinguishable from *U. tyleri*, based on morphology. Dr Catullo confirmed that, based on genetics, these frogs would be *U. martini*, as she has found no evidence of *U. tyleri* occurring in Victoria.

Fishes

Seven species listed under the EPBC Act potentially occur within the limits of the survey area: Grey Nurse Shark (eastern population) (*Carcharias taurus)* is Critically Endangered, White Shark (*Carcharodon carcharias*), Black Rockcod (*Epinephalus daemelii*), Australian Grayling (*Prototroctes maraena*) and Whale Shark (*Rhicodon typus*) are Vulnerable, and School Shark (*Galeorhinus galeus*) and Blue Warehou (*Seriolella brama*) are Conservation Dependent.

Similarly, five species on the Advisory List potentially occur in the survey area: Australian Greyling (*Prototroctes maraena*), White Shark (*Carcharodon carcharias*), Flatback Mangrove Goby (*Mugilogobius platynotus*), and Southern Pygmy Perch (*Nannoperca australis*) are Vulnerable, and Grey Nurse Shark (*Carcharias taurus*) is Data Deficient.

None of the listed species were captured or observed during the survey, although a single specimen of undescribed species of *Nannoperca* previously thought to be conspecific with the Southern Pygmy Perch *Nannoperca australis* (Vulnerable) was collected upstream of the Mallacoota Estuary.

Table 5 Threatened vertebrate species

Family	Species	Common name	Status	Comments
Mammals				
Balaenopteriae	*Megaptera novaeangliae*	Humpback Whale	Vulnerable (EPBC Act) Threatened (FFG Act) Vulnerable (Advisory List)	
Miniopteridae	*Miniopterus schreibersii oceanensis*	Eastern Bent-wing Bat	Threatened (FFG Act) Vulnerable (Advisory List)	
Otariidae	*Arctocephalus pusillus doriferus*	Australian Fur-seal	Threatened (FFG Act)	
Otariidae	*Arctocephalus forsteri*	New Zealand Fur Seal	Vulnerable (Advisory List)	
Potoroidae	*Potorous* sp.			
	P. longipes	Long-footed Potoroo	Endangered (EPBC Act) Threatened (FFG Act) Vulnerable (Advisory List)	Detected on camera at two sites but could not be identified to species
	P. tridactylus tridactylus	Long-nosed Potoroo (SE mainland)	Vulnerable (EPBC Act) Threatened (FFG Act) Near Threatened (Advisory List)	
Pteropodidae	*Pteropus poliocephalus*	Grey-headed Flying-fox	Vulnerable (EPBC Act) Threatened (FFG Act) Vulnerable (Advisory List)	
Reptiles				
Scincidae	*Cyclodomorphus michaeli*	Eastern She-oak Skink	Threatened (FFG Act) Near Threatened (Advisory List)	1 individual caught in coastal sand dunes at the extreme eastern extent of the park
Varanidae	*Varanus varius*	Lace Monitor	Endangered (Advisory List)	6 individuals sighted; Lake Barracoota, Marshmead Boat Ramp and Wingan Inlet campground

Family	Species	Common name	Status	Comments
Frogs and toads				
Hylidae	*Litoria aurea*	Green and Golden Bell Frog	Vulnerable (EPBC Act and Advisory List)	Numerous individuals were sighted and were heard calling at the Airport Pond site.
Myobatrachidae	*Uperoleia martini*	Martin's Toadlet	Critically Endangered (Advisory List)	Numerous individuals were sighted and were heard calling at the East Wigan Road site.

Invertebrates

Moths

No moths listed under the EPBC Act or the FFG Act were found. Several species are rare or limited in distribution in Australia or Victoria and are worthy of protection but few moth species are listed under such legislation. For many species, there is little information on status and distribution, factors on which such listing could be based.

Several species recorded are rare at the national level, with 15 or fewer records known in the Melbourne Museum collection and the ANIC, e.g. *Proboloptera embolias*, *Hypodoxa horridata*, *Callopistria rivularis*, *Coenotoca subaspersa*. At the state level, the Bush Blitz species discovered in Victoria for the first time have low numbers and a limited distribution. The species unique to warm temperate rainforest have a restricted distribution in Victoria as this habitat is limited and patchy, extending westwards only to Mitchell River National Park. In all these cases, the Croajingolong populations are likely to be important in ensuring the survival of these species statewide and nationally.

Snails and slugs

No species found during this survey are listed under either national or state legislation. Nevertheless, a very large proportion of indigenous terrestrial molluscs have highly restricted distributions, in particular among charopids. Hence, additional taxonomic work in conjunction with appraisals of conservation status for most groups should be considered a high priority.

Flora

None of the flora recorded during the two Bush Blitzes are listed as threatened under the EPBC Act. However, many are state-listed in Victoria.

The 18 plant species included in Table 6 are listed as Vulnerable in the *Advisory List of Rare or Threatened Plants in Victoria - 2014* (Advisory List), and three of these are also listed as Threatened in the FFG Act. An additional 49 plant species are listed as Rare and five are listed as Poorly Known in the Advisory List. All 72 listed plant species are noted in Appendix A. Three additional species included in the Advisory List were observed outside the surveyed areas—*Adiantum formosum* (Vulnerable), *Dendrophthoe vitellina* (Rare) and *Notothixos subaureus* (Rare).

The population size of one Vulnerable tree species and two Vulnerable fern species were assessed. *Polyscias murrayi* was found to have a population of 10 mature individuals on one of the upper tributaries of Harrison Creek, extending for approximately 500 m along the creekline. These collections have been added to the State Botanical Collection at the National Herbarium of Victoria (with numerous duplicates to be forwarded to other herbaria) and records are now visible on Australia's Virtual Herbarium. *Gleichenia rupestris* and *Asplenium obtusatum* subsp. *northlandicum*, were found to have large thriving populations within the park. *Asplenium obtusatum* subsp. *northlandicum* was found east of the Rame Head trig point, near where the vegetation meets the rocks along the sea. This species was previously recorded from Rame Head in 2015 by Daniel Ohlsen as a single population of ten plants. This population was as far south on that point that Daniel Ohlsen had previously walked. Rame Head was more thoroughly surveyed on this Bush Blitz and this species was found to extend south of that previously known population, sporadically, for at least 500 m.

Table 6 Threatened flora species

Family	Species	Status	Comments
Araliaceae	*Astrotricha* sp. Wallagaraugh	Vulnerable (Advisory List)	Scattered in area extending along ridge top along Cape Horn
Araliaceae	*Astrotricha* sp. Wingan Inlet	Vulnerable (Advisory List)	Rare; small populations of less than 10 plants
Araliaceae	*Polyscias murrayi*	Vulnerable (Advisory List)	Ten plants seen, all at one site
Adoxaceae	*Sambucus australasica*	Vulnerable (Advisory List); Threatened (FFG Act)	Occasional plants at Marshmead
Cunoniaceae	*Eucryphia moorei*	Vulnerable (Advisory List)	Found at four sites; 20 plants at one site, rare at another and locally common at two sites
Fabaceae	*Mirbelia rubiifolia*	Vulnerable (Advisory List)	Over 100 plants at site, but localised over approx. 50 m of track length
Goodeniaceae	*Scaevola calendulacea*	Vulnerable (Advisory List)	Very rare at one site; uncommon at another
Moraceae	*Ficus coronata*	Vulnerable (Advisory List); Threatened (FFG Act)	Uncommon but a large population occurs along 'Marshmead' rainforest walk
Poaceae	*Plinthanthesis paradoxa*	Vulnerable (Advisory List)	Found at six sites; ranging from rare to locally common
Proteaceae	*Conospermum taxifolium*	Vulnerable (Advisory List)	24 plants seen at three scattered sites in damp heathland; generally uncommon, sterile specimens only
Rhamnaceae	*Cryptandra ericoides*	Vulnerable (Advisory List)	Uncommon to rare at site; only the second collection of the species for Victoria.

Family	Species	Status	Comments
Rhamnaceae	*Spyridium cinereum*	Vulnerable (Advisory List)	Occasional over a 200 m stretch of heath
Rutaceae	*Zieria littoralis*	Vulnerable (Advisory List)	Common at a site on northern end of Gabo Island
Santalaceae	*Santalum obtusifolium*	Vulnerable (Advisory List)	Locally common at one site west of jetty accessing Brokewell's Hut—population extends 250 m along inlet southwest of jetty; two plants found on Gabo Island
Stylidiaceae	*Stylidium laricifolium*	Vulnerable (Advisory List)	Abundant at site
Ferns			
Aspleniaceae	*Asplenium obtusatum* subsp. *northlandicum*	Vulnerable (Advisory List)	East of the Rame Head Trig Point; additional three plants seen on Gabo Island but known from other parts
Cyatheaceae	*Cyathea leichhardtiana*	Vulnerable (Advisory List); Threatened (FFG Act)	Common and two sites; only one plant seen at third site
Gleicheniaceae	*Gleichenia rupestris*	Vulnerable (Advisory List)	Several large colonies at both the Rame Head and Sandpatch Wilderness sites. Colony collected from at Rame Head 15 x 4 m. Colonies collected from at Sandpatch Point 10 x 2 m and 50 x 20 m.

Exotic and pest species

Conservation reserves help to protect Australia's rare and threatened ecosystems and provide refuge for species at risk. Invasive species can have a major impact on already vulnerable species and ecosystems, as well as economic, environmental and social impacts. The inclusion of exotic and pest species records as part of this report is designed to provide land managers with baseline information to assist with further pest management programs.

Fauna

Vertebrates

Sambar Deer (*Cervus unicolor*) are active within the area and pose a threat to vegetation communities with tree mortality through antler rubbing, grazing pressures, soil compaction, and habitat destruction through the creation of wallows. There was substantial evidence of Sambar Deer activity, particularly around Howe Flat.

Table 7 Exotic and pest vertebrate species

Family	Species	Common name	Comments
Mammal			
Cervidae	*Cervus unicolor*	Sambar Deer	Extensive Sambar Deer wallows observed

Invertebrates

Echinoderms

The warm-water Long-spine Sea Urchin (*Centrostephanus rodgersii*) has expanded its latitudinal distribution to colder water from NSW to Victoria. Its presence has been documented in Mallacoota and, during the expedition, extensive urchin barrens were observed. These areas showed the lowest biodiversity of all the surveyed sites, possibly reflecting the known negative impact that the species has on ecosystems when its abundance increases.

The introduced New Zealand Seven-arm Sea Star (*Astrostole scabra*) was observed in low numbers. Its impact has not been documented for this site, but it is known to prey on reef invertebrates such as abalone; therefore constant monitoring for increase in abundance should be considered.

Moths

The main moth families in Victoria, Noctuidae, Pyralidae and Crambidae, have some members that cause agricultural damage as larvae. Most that cause economic losses are native species that feed on crop, pasture or plantation species, generally on species related to their native host plants. There are currently no official lists of native moths that are pests at the federal or state levels. The species in Table 8 are moths and caterpillars of economic significance. These species generally frequent open country. Several were found in the cleared area around the Marshmead campus and at the Rainforest Walk which abuts this cleared area. Others may have moved into the park from surrounding cleared and fragmented areas. Noctuids are strong fliers and some species are highly mobile, e.g. migratory Bogong Moths (*Agrotis infusa*). The adults may visit or invade nearby forests for nectar or in migration events. The other species listed inhabit woodlands and forests.

True bugs

Three pest heteropteran species were collected in the park. The Rutherglen Bug (*Nysius vinitor*) was collected at many localities. This small Australian native sap-sucking insect is a pest of many crops, e.g. sunflower, sorghum, canola and safflower. It breeds on a wide range of native and exotic plants, building up to large numbers in inland Australia when winter and spring rains allow the growth of vegetation. In spring, as the host plants start to dry off, large numbers of bugs move into cropping areas, dispersing on the winds of storm fronts. It can build up to large numbers, seriously damaging fruit and vegetable crops.

Crustacea

The only exotic crustacean species collected was the European Shore Crab (*Carcinus maenas*). This species was introduced to Victoria in the 1800s and was observed throughout the Mallacoota Estuary in densities similar to those found in other regions in Victoria.

Snails and slugs

Four introduced species were observed, namely the common garden snail, *Cornu aspersum,* and three slug species, *Limax maximus*, *Limacus flavus* and *Lehmannia nyctelia*. None of these species are listed as pest species. All four were abundant within the vicinity of the Marshmead campus. None were found at the survey sites, indicating relatively recent introduction into the area. It is likely that these species will eventually migrate into the surrounding native bushland and compete with indigenous species.

Table 8 lists the exotic and pest native invertebrate species that were collected or observed in the study area.

Table 8 Pest invertebrate species

Family	Species	Common name	Comments
Echinoderms			
Asteriidae	*Astrostole scabra*	Seven-arm Sea Star	Fewer than five specimens observed; Cape Howe Marine National Park
Diadematidae	*Centrostephanus rodgersii*	Long-spine Sea Urchin	Very abundant (urchin barrens); Cape Howe Marine National Park
Moths			
Crambidae	*Achyra affinitalis*		Uncommon; minor pest
Crambidae	*Culladia cuneiferellus*		Uncommon; minor pest
Crambidae	*Hellula hydralis*		Uncommon; minor pest
Crambidae	*Hellula undalis*		Uncommon; minor pest
Geometridae	*Capusa senilis*		Uncommon; minor pest
Geometridae	*Chloroclystis approximata*		Moderately common; minor pest
Geometridae	*Chloroclystis testulata*		Common/moderately common; minor pest
Geometridae	*Ectropis excursaria*		Uncommon; minor pest
Geometridae	*Pholodes sinistraria*		Uncommon; minor pest
Geometridae	*Phrissogonus laticostata*		Moderately common/common; minor pest
Noctuidae	*Agrotis infusa*	Bogong Moth	Common; of major economic importance
Noctuidae	*Agrotis ipsilon*		Uncommon; minor pest

Family	Species	Common name	Comments
Noctuidae	*Agrotis munda*		Moderately common; minor pest
Noctuidae	*Agrotis porphyricollis*		Uncommon; minor pest
Noctuidae	*Chrysodeixis argentifera*		Moderately common/uncommon; minor pest
Noctuidae	*Diarsia intermixta*		Uncommon; minor pest
Noctuidae	*Helicoverpa punctigera*		Common/uncommon; of major economic importance
Noctuidae	*Mythimna convecta*		Moderately common/uncommon; of major economic importance
Noctuidae	*Persectania ewingii*		Moderately common/uncommon; of major economic importance
Plutellidae	*Plutella xylostella*		Uncommon; of major economic importance
Pyralidae	*Etiella behrii*		Uncommon; minor pest
Tortricidae	*Crocidosema plebejana*		Uncommon; minor pest
True bugs			
Lygaeidae	*Nysius vinitor*	Rutherglen Bug	57 specimens
Miridae	*Sidnia kinbergi*	Crop Mirid	1 individual
Pentatomidae	*Plautia affinis*	Green Stink Bug	8 specimens
Crustacean			
Carcinidae	*Carcinus maenas*	European Shore Crab	
Snails and slugs			
Helicidae	*Cornu aspersum*		
Limacidae	*Lehmannia nyctelia*	Striped Field Slug	
Limacidae	*Limacus flavus*	Yellow Cellar Slug	
Limacidae	*Limax maximus*	Leopard Slug	

Flora

Flowering plants

The 19 introduced flowering plants in Table 9 were recorded within the eastern section of the park, on the Marshmead property or on Gabo Island.

Hydrocotyle bonariensis is a weed of coastal or near-coastal areas and colonises dunes. On Gabo Island this species appears to be localised to Santa Barbara Bay and consequently could be completely eradicated from the island if acted upon promptly. It has spread dramatically in the Cape Howe area since a visit by one of the participants in around 1980. Its spread should be monitored and consideration given to eradication in areas of dominance (e.g. near Cape Howe), but its extensive occurrence along the eastern Australian coast suggests that it will be an ongoing management issue.

Arctotheca populifolia is a rare weed of coastlines in Victoria where it is known only from Nelson in the far south-west and from Croajingolong National Park. Immediate eradication should be a priority given that its localised occurrence in Victoria would make complete eradication possible.

Cotula coronopifolia is a long-established weed throughout the southern half of Australia, with collection dating back to the 1850s. Control where the species is locally dominant should be considered, but total eradication is unlikely to be successful.

Gladiolus gueinzii is widespread along the New South Wales coast and recently (since 2002) has extended further into Victoria though previously known there only from around the entrance of Mallacoota Inlet. It is spread by buoyant corms. Immediate eradication in Victoria is a priority given that it is still rare in Victoria but has potential to become widespread along the Victorian coast. Its occurrence along the eastern Australian coast suggests that it will be an ongoing management issue.

No weed species were recorded within the western section of the park. However, six additional weeds were recorded around Mallacoota—*Freesia laxa* subsp. *laxa*, *Homalanthus populifolius*, *Oxalis incarnata*, *Verbena rigida* var. *rigida, Pseudoscleropodium purum* (moss) and *Puccinia oxalidis* (rust fungus). Some of these had not been recorded previously in far-eastern Victoria, yet are common around Mallacoota and known to invade native vegetation.

Marine algae

Two introduced marine algae species were recorded within Croajingolong National Park.

One problem with *Codium fragile* subsp. *fragile* is that there are also two native subspecies of *C. fragile* in Australia, which are difficult to distinguish from the invasive subspecies based on external morphology but are genetically distinct. While we are nearly certain that the collections represent the invasive subspecies, it will be important to identify the collections accurately to confirm or reject our suspicion. *Codium fragile* subsp. *fragile* is a native from Japan and Korea and has been accidentally introduced to Europe, New Zealand, the east coast of Canada/USA and Chile. In Australia it is known mainly from embayments in NSW, Victoria, SA and Tasmania, and recently has been found in WA.

The awarded tactical taxonomy grant will address this *Codium* subspecies issue and generate the molecular and microscopic data needed to identify these samples at the subspecies level. It is also possible that there are invasive *Grateloupia* species among the collections, but similarly there are several native look-alikes in that group, so anatomical or molecular confirmation is required before reporting their presence formally.

Melanothamnus japonicus (previously *Neosiphonia japonica*) is native to South Eastern Asia (type locality in Japan), and was recorded as introduced in Europe, Atlantic and Pacific North America, New Zealand. In Australia it is known from Tasmania and WA.

Table 9 lists the exotic weed species that were collected or observed in the study area.

Table 9 Non-gazetted weeds

Family	Species	Comments
Flowering plants		
Araliaceae	*Hydrocotyle bonariensis*	Dramatic spread in Cape Howe area; new record for Gabo Island; common at site; management required
Asteraceae	*Arctotheca populifolia*	Observed near NSW-Victoria coastal border; locally common; consider as a critical priority for control and eradication, if feasible
Asteraceae	*Cotula coronopifolia*	Observed near small creek near old Lakeview Hotel site; consider control where locally dominant
Asteraceae	*Gamochaeta calviceps*	Marshmead; a common and widespread weed throughout Victoria; control unlikely to succeed
Asteraceae	*Gamochaeta purpurea*	Marshmead; a common and widespread weed throughout Victoria; control unlikely to succeed
Asteraceae	*Leontodon saxatilis*	Observed near NSW-Victoria border; common; a common and widespread weed throughout Victoria, not considered in need of control, nor would control be likely to succeed
Asteraceae	*Vellereophyton dealbatum*	Observed near NSW-Victoria border; scattered plants; a common and widespread weed throughout Victoria
Commelinaceae	*Tradescantia* sp.	Gabo Island (and around Mallacoota); new weed for Victoria; invades native vegetation, especially riparian sites; on Gabo Island only known from one site—eradication required and would take minimal effort given current size of population
Fabaceae	*Dipogon lignosus*	Marshmead; three plants seen near library; widespread, invasive species; consider as a critical priority for control and eradication, if feasible
Iridaceae	*Gladiolus gueinzii*	Observed near NSW-Victoria coastal border; rare, only three plants at one site; has potential to become an ongoing management issue
Iridaceae	*Sisyrinchium iridifolium*	Croajingolong National Park (CNP) and Gabo Island; a widespread weed throughout southern Victoria

Family	Species	Comments
Iridaceae	*Sisyrinchium rosulatum*	CNP; locally common; the third collection of this species in Victoria, the other two are from nearby sites (Reedy Creek northeast of Cann River and Coopracambra National Park); appears to thrive in full sunlight amidst grass-dominated vegetation; successful revegetation of this previously pastured area should result in its eradication in time
Juncaceae	*Juncus articulatus*	Observed near Cape Howe; occasional in wetter sites; a common and widespread weed of wet sites throughout Victoria; currently not seen as 'transformational' of associated vegetation; eradication attempts are unlikely to succeed
Juncaceae	*Juncus bufonius*	CNP; widespread throughout Victoria; uncertain whether this species is naturalised or native
Lamiaceae	*Stachys arvensis*	Marshmead; a few plants observed in front of herb garden; not considered in need of control, but control likely to succeed
Passifloraceae	*Passiflora edulis*	Marshmead; one plant observed; consider as a critical priority for control and eradication, if feasible; its growth habit and propensity to be spread by frugivorous birds and mammals render it likely to become troublesome in nearby rainforest patches
Poaceae	*Ammophila arenaria*	Observed near Cape Howe; common on backs of low primary dune; introduced along Australian coasts as a dune stabiliser, now widespread along coast often displacing native *Spinifex sericeus* and *Poa billardierei* that perform the same role
Poaceae	*Anthoxanthum odoratum*	Marshmead; common; a widespread grass throughout Victoria, often deliberately cultivated as a pasture species, but invasive in grassy native vegetation
Solanaceae	*Physalis peruviana*	Gabo Island; sporadically appearing mostly as a weed of coastal or near coastal areas
Marine algae		
Codiaceae	*Codium fragile* ? subsp. *fragile*	Identity to be confirmed; common; Pebbly Beach and Mallacoota Inlet
Rhodomelaceae	*Melanothamnus japonicus*	Rare; Pebbly Beach

Range extensions

Fauna

Invertebrates

Echinoderms

The most striking discovery was the sea cucumber *Pseudocnus sentus*, as this species was originally described from Stewart Island, south of New Zealand, and it was recovered during an expedition to the Kermadec Islands. The species was previously reported only for New Zealand, however little work has been done with small sea cucumbers and its range could be wider.

Moths

Detailed Victorian distribution data has been collated for several moth families covered in the *Moths of Victoria* series Parts 1–7. For members of these families, new records for Victoria and range extensions within the state can be detected. Other species found during the surveys may later prove to be interesting as the *Moths of Victoria* project is ongoing. Distributions in other parts of Australia have been determined from museum and private collections, and records published online in the ALA and the BOLDSYSTEMS Public Data Portal, but they may not be complete.

The majority of range extensions were new records for Victoria and indicated an extension in known range from populations in NSW. The largest extension was for *Symphonistis monospila*—almost 1000 km from the nearest known record. This species appears to be rare with only a few known records scattered across the continent. Other significant range extensions were for *Anydraula glycerialis* (430 km), *Amblychia subrubida* (330 km), *Maxates multitincta* (320 km), *Sauris lichenias* (440 km), *Callopistria rivularis* (610 km) and *Opodiphthera loranthi* (470 km). *Proboloptera embolias* was found at three sites and is probably established in the reserve. *Lambula transcripta* is listed as the first record confirmed for the state. Two previous specimens, probably *L. transcripta*, came from near Cann River in January 2015. However they were worn and the identification was uncertain. They were initially placed under *Lambula* sp. (2).

Four species newly recorded in the park probably represent established populations. *Amblychia subrubida*, *Callopistria rivularis* and *Acosmeryx anceus* were found at three sites and *Opodiphthera loranthi* at five. (*Boarmia*) *driophila*, *Lambula transcripta* and *Proboloptera embolias* were found for the first time in Victoria during the Mallacoota-based survey and were confirmed on the Marshmead survey. They are probably also established in the area. *Syneora fractata* is thus far known only from Victoria. However, the extension in distribution to the Marshmead area close to the NSW border indicates that it almost certainly ranges into that state.

For some species the infills in range linked populations in NSW to apparently isolated populations in Victoria. Some of these were predicted previously, e.g. *Neoteristis paraphanes*, *Oenochroma turneri* and *Opodiphthera loranthi*. *Oenochroma turneri* was recorded during both Bush Blitzes so is probably established in the reserve.

Hypobapta barnardi is particularly interesting. The specimens from Buckland Road and SSS2 are indistinguishable in general appearance from earlier specimens taken in Victoria, but these were restricted to the dry inland in the north-west of the state. The Bush Blitz specimens are coastal and in the far east. This suggests that this species has well-separated, disjunct populations in Victoria. There are other coastal records in NSW and Queensland, and the Marshmead records may indicate an

extension in range to the south from these populations. A sample of Australian coastal and inland specimens was shown to represent one species by DNA analysis (BOLDSYSTEMS Public Data Portal). It is possible that in parts of NSW and Queensland the populations are linked. Another geometrid, *Corula geometroides*, also has a disjunct distribution in western inland Victoria and East Gippsland.

True bugs

There were no known previous Heteroptera records for the park so the distribution records for all taxa recorded represent range extensions. These are not considered significant at present due to lack of existing baseline data.

Crustaceans

Due to the lack of surveys in the Mallacoota area, little can be said about range extensions of crustaceans. While some species that had only been recorded previously from NSW were found (e.g. *Porcellidium pulchrum*), their occurrence may only reflect that the area has not been well surveyed in the past, particularly for smaller crustaceans such as copepods and amphipods.

Flora

Flowering plants, ferns, mosses, fungi, lichens

The largest range extensions discovered were for fungi and lichen. Two lichens from Croajingolong National Park—*Verrucaria inquilina* and an unidentified *Coenogonium* species—and a rust fungus from Gabo Island, *Uromyces microtidis* (on a *Microtis* orchid), were new Victorian records.

Some of the species listed below are known from a limited number of sites in Victoria (i.e. *Gladiolus gueinzii*, *Santalum obtusifolium*) and so some of the extensions apparent from collections of these species are not nearly as large as some of the other taxa, but they are still significant and listed here.

Significant range extensions were found for the moss species that were new to the park and the populations of the fern *Gleichenia rupestris*, collected near Sandpatch Point. In Victoria *Gleichenia rupestris* was previously known only from Rame Head.

Marine algae

Due to the very limited published information available about algae in the region, many of the records represent range extensions and infill distribution records. Table 10 only includes the most obvious examples. A more comprehensive analysis of range extensions will be possible once the data have been fed into Australia's Virtual Herbarium.

Table 10 Range extensions

Family	Species	Nearest previous record / Comments
Echinoderms		
Cucumariidae	*Pseudocnus sentus*	First record for Australia
Moths		
Crambidae	*Anydraula glycerialis*	430 km (Blackheath, NSW); first record for Victoria
Crambidae	*Archernis callixantha*	130 km (Bermagui, NSW); first record for Victoria

Family	Species	Nearest previous record / Comments
Erebidae	*Brunia replana*	130 km (Bermagui, NSW); first record for Victoria
Erebidae	*Lambula transcripta*	130 km (Bermagui, NSW); first confirmed record for Victoria
Erebidae	*Ophiusa tirhaca*	470 km (Bateau Bay, NSW); first record for Victoria
Geometridae	*Amblychia subrubida*	330 km (Tongarra, NSW); first record for Victoria; probably established in the park
Geometridae	*Apodasmia rufonigraria*	Infill in range; Providence Ponds FFR, Vic. (220 km) to Kosciuszko, NSW (180 km)
Geometridae	*(Boarmia) driophila*	80 km (Bournda, NSW); first record for Victoria
Geometridae	*Chaetolopha oxyntis*	Infill in range; Beaconsfield, Vic. (390 km) to Stanwell Park, NSW (380 km)
Geometridae	*Chrysolarentia ptochopis*	Infill in range; Sale, Vic (240 km) to Moruya, NSW (170 km)
Geometridae	*Dichromodes molybdaria*	Infill in range; Mitchell River National Park (210 km) to Moruya, NSW (170 km)
Geometridae	*Eucyclodes metaspila*	Infill in range; Tynong North, Vic (360 km) to Bawley Point, NSW (220 km)
Geometridae	*Horisme mortuata*	Infill in range; Beaconsfield, Vic (390 km) to Sydney, NSW (420 km)
Geometridae	*Hypobapta barnardi*	Range extension or infill in range (see above); Rainbow, Vic (710 km) to Smiths Lake, NSW (610 km)
Geometridae	*Maxates multitincta*	320 km (Barren Grounds Nature Reserve, NSW); first record for Victoria
Geometridae	*Neoteristis paraphanes*	Infill in range; Moe, Vic (310 km) to Barrington SF, NSW (640 km)
Geometridae	*Oenochroma turneri*	Infill in range; Wilsons Prom., Vic (330 km) to Wingham, NSW (680 km)
Geometridae	*Onycodes rubra*	130 km (Bermagui, NSW); first record for Victoria
Geometridae	*Paradromulia ambigua*	130 km (Bermagui, NSW); first record for Victoria
Geometridae	*Proboloptera embolias*	370 km (Mt Keira, NSW); first record for Victoria; probably established in the park
Geometridae	*Sauris lichenias*	440 km (Ebenezer, NSW); first record for Victoria
Geometridae	*Syneora fractata*	240 km (Sale, Vic)
Noctuidae	*Callopistria rivularis*	610 km (Smiths Lake, NSW); first record for Victoria; probably established in the park

Family	Species	Nearest previous record / Comments
Nolidae	*Nola biguttalis*	Infill in range; Moe, Vic (310 km) to Wilton, NSW (370 km)
Plutellidae	*Tritymba dianipha*	340 km (Mittagong, NSW); first record for Victoria
Pterophoridae	*Trichoptilus inclitus*	330 km (Barrengarry Mtn, NSW); first record for Victoria
Pyralidae	*Symphonistis monospila*	990 km (Silverton, NSW), 1250 km (Imbil, Qld); first record for Victoria; apparently rare but widespread in Australia
Saturniidae	*Opodiphthera loranthi*	470 km (Narara, NSW); first record for Victoria; probably established in the park
Sphingidae	*Acosmeryx anceus*	80 km (Bournda, NSW); first record for Victoria; probably established in the park
Tineidae	*Erechthias acontistes*	250 km (Canberra, ACT); first record for Victoria
Flowering plants		
Asteraceae	*Senecio pinnatifolius* var. *maritimus*	Found on Gabo Island; only previously reported from western Victoria; a number of eastern coastal NSW specimens in AVH but reliability of determinations is uncertain
Cyperaceae	*Baumea arthrophylla*	85 km (west side of Sydenham Inlet); most Victorian records are from the south-west
Droseraceae	*Drosera pygmaea*	Found on Gabo Island; nearest previous record Kanni Flora Reserve, near Buchan; rare at site; damp site among *Campylopus australis*, trampled by cattle
Iridaceae	*Gladiolus gueinzii*	20 km (near the opening of Mallacoota Inlet)
Orchidaceae	*Calochilus therophilus*	140 km (near Wulgulmerang); Poorly Known on Advisory List
Orchidaceae	*Thelymitra media*	20 km (beside Stony Peak Road, west of Genoa)
Plantaginaceae	*Veronica grosseserrata*	95 km (Mt Bonang); Poorly Known on Advisory List; possibly overlooked due to similarity with *V. notabilis*
Santalaceae	*Santalum obtusifolium*	Found on Gabo Island; 12 km from nearest previous record at Brokewell's Hut on Mallacoota Inlet; Vulnerable; known from limited sites in Victoria
Violaceae	*Viola eminens*	50 km (Nungatta Mountain, NSW)

Family	Species	Nearest previous record / Comments
Ferns		
Gleicheniaceae	*Gleichenia rupestris*	11 km; now known from two localities in Victoria (Rame Head and near Sandpatch Point); Vulnerable in Advisory List
Mosses		
Brachytheciaceae	*Rhynchostegium tenuifolium*	50 km (Cann River); widespread species but first record for the park
Hypopterygiaceae	*Hypopterygium rotulatum*	30 km (Mt Drummer); widespread species but not previously collected in the park
Fungi		
Hymenochaetaceae	*Fomitiporia robusta*	100 km (Marlo); common species typically on Myrtaceae
Incertae sedis (Basidiomycota)	*Aecidium eburneum*	200 km (Providence Ponds near Stratford); common rust species but not often collected; on *Platylobium parviflorum*
Porinaceae	*Porina* sp.	90 km (Cape Conran and Errinundra Plateau); rarely collected in Victoria
Pucciniaceae	*Puccinia gnaphaliicola*	Common rust species but rarely collected; on *Gamochaeta purpurea*
Pucciniaceae	*Uromyces microtidis*	Rust fungus on *Microtis* orchid; Gabo Island; first record for Victoria, nearest records SA and NSW; rare at site
Lichens		
Arthoniaceae	*Arthonia banksiae*	Found on Gabo Island; nearest previous record Shipwreck Creek; a poorly known but common species, seldom collected; likely to occur wherever there is a significant stand of *Banksia integrifolia*
Arthoniaceae	*Arthonia cyanea*	260 km (Tarra-Bulga National Park); foliicolous lichen
Coenogoniaceae	*Coenogonium* sp.	First record for Victoria; foliicolous lichen; three other *Coenogonium* species occur in Victoria which are all not foliicolous
Gomphillaceae	*Gyalectidium microcarpum*	40 km (Alfred National Park)
Graphidaceae	*Graphis* sp.	Found on Gabo Island; common species
Pilocarpaceae	*Badimiella pteridophila*	Errinundra National Park
Pilocarpaceae	*Tapellaria phyllophila*	95 km (Errinundra National Park)

Family	Species	Nearest previous record / Comments
Verrucariaceae	*Verrucaria inquilina*	330 km (Moreton National Park, NSW); first record for Victoria
Marine algae		
Rhodomelaceae	*Aphanocladia stichidiosa*	Tullaburga and north of Gabo harbour; abundant in subtidal habitats; nearest previous record NSW
Rhodomelaceae	*Perrinia ericoides*	Found at Shipwreck Creek, Bastion Point; nearest previous record Walkerville, Vic.

Other points of interest

Fauna

Vertebrates

Mammals

Croajingolong National Park is host to a diverse mammal fauna. However, the area of the park east of Mallacoota has not been extensively surveyed for small mammal species. Most terrestrial mammal species present in the area are known from fewer than five records, many of which are decades old (ALA).

The proximity to the park of historical records of threatened rodent species—Smoky Mouse (*Pseudomys fumeus*) and Broad-toothed Rat (*Mastacomys fuscus*)—and the presence of habitat types that appear at least superficially suitable for the two species, suggest that additional surveying effort may uncover previously unknown populations of the species. Listed under the EPBC Act as Endangered, *P. fumeus* has undergone substantial declines and range contractions in the past 40 years and has not been detected in East Gippsland since 1991. Similarly, *M. fuscus* has undergone substantial declines in recent decades, particularly at low elevation sites. Native rodent populations typically cycle through periods of high and low abundance. If the few previous surveys in the area occurred during low periods, it is unlikely that the species would have been detected. This survey aimed to determine the presence or absence of *P. fumeus* and *M. fuscus* at sites east of Mallacoota, and provide a snapshot of the broader mammal community present in the area.

Camera surveys were conducted at 12 sites and returned images of nine mammal species and one bird. Live trapping was conducted at three sites. At SSS1 there were 25 captures of Bush Rats (*Rattus fuscipes*) in 80 trap nights over four nights. Live trapping at SSS2 returned one capture of a Black Rock Skink (*Egernia saxatilis*) in 60 trap nights over three nights. The third live trapping site returned one Swamp Rat (*Rattus lutreolus*) capture in 80 trap nights over four nights. The target species, Smoky Mice (*P. fumeus*) and Broad-toothed Rats (*M. fuscus*), were not detected during the surveys. Incidental observations confirmed the presence of: Common Brushtail Possum (*Trichosurus vulpecula*), Common Ringtail Possum (*Pseudocheirus peregrinus*), Sambar Deer (*Cervus unicolor*) and Long-nosed Bandicoot (*Peremeles nasuta*) in the immediate area surrounding Marshmead.

The Bush Blitz provided a unique opportunity to survey sites that had not been surveyed previously for small mammals, creating valuable records in remote areas. Although the target species, *P. fumeus* and

M. fuscus, were not detected, the absences recorded for these species are valuable for species distribution modelling purposes to target future survey efforts.

Bats

Bat trapping was conducted at 15 sites with a total 62 bats representing seven species being caught. At SSS1 a cluster of four traps caught only a single specimen of the Large Forest Bat (*Vespadelus darlingtoni*). The site selected for SSS2 contained no suitable position for a harptrap and was not sampled. An additional bat species, the Grey-headed Flying-fox (*Pteropus poliocephalus*), was observed during nocturnal searches.

The Golden-tipped Bat (*Phoniscus papuensis*) has not yet been recorded in Victoria, however a recent survey sampled an individual just north of the state border in NSW close to the study area. Ten of the harptrap sites were selected to specifically target Golden-tipped Bats but the species was not caught.

Reptiles and amphibians

Croajingolong National Park has high reptile and amphibian diversity for Victoria and a high number of conservation-listed species. However, the park is large and the eastern sections are virtually unsurveyed due to limited access. Some of these sections may support reptiles and frogs that have not yet been recorded in Victoria, or species that have not been recorded in Victoria for decades. A search of MV's database revealed only 83 reptile and amphibian specimens from the Mallacoota and Croajingolong area, the vast majority of these specimens collected prior to 1970. There were few tissue samples from this region.

In Victoria, 15 frog species are listed on the Advisory List of Threatened Vertebrate Fauna in Victoria - 2013 (Advisory List). Gippsland is particularly notable in terms of the number of Victoria's listed frogs that occur in the region (nine species), with a pervasive lack of data on their distribution, abundance and basic biology. This survey aimed to provide important information on the presence of these species and collect skin swabs that will allow assessment of the occurrence of disease (chytrid fungus).

Extensive surveys focused first on the south-western extent of the park and surrounds (7–15 November) and then on the eastern extent of the park, from east of the Mallacoota Inlet up to the NSW border, plus Gabo Island (1–10 December). The aim of these surveys was to: document reptile and amphibian species present in the region and the ecological associations of these species; collect tissue samples, blood smears (blood parasite screening) and skin swabs (for frogs) of animals caught in the field; collect voucher specimens to provide a baseline record of species in the under-sampled region of Victoria; and to assess the presence of conservation-listed taxa in the region.

In the south-western part of the park, coastal heathlands and woodlands were of particular interest, as they had been subject to the least survey work previously. Using active searches and a pit fall trap line, nine species of frogs and 12 species of reptiles were captured. Of these species, one lizard and two frogs were conservation listed—Lace Monitor (*Varanus varius*), Green & Golden Bell Frog (*Litoria aurea*) and Martin's Toadlet (*Uperoleia martini*). Only one of these, the Lace Monitor, was found within the boundary of the park. Of note was the high diversity of tree frogs—at one site (Genoa Falls) five species of tree frog were recorded in a single night—indicating the importance of this region for frog diversity in Victoria.

In the eastern extent of the park, coastal heathlands and tall wet forests were the focus, as their inaccessibility had meant that very little survey work has been undertaken previously. Using active searches and pit fall trap lines, eight species of frogs and 12 species of reptiles were captured. Of these

species, two lizards were conservation listed: Lace Monitor and Eastern She-oak Skink (*Cyclodomorphus michaeli*). Both of these species were found within the boundary of the park. Although the aim was to survey wet forest gullies, their inaccessibility hampered efforts and this remains to be done in the future. These survey results highlight the lack of data currently available on frog and reptile species in this part of the park. Further survey work is needed in the far eastern coastal and wet gully habitats to comprehensively assess species diversity, distributions and habitat requirements.

In the first comprehensive herpetological survey of Gabo Island, two lizard species and one frog species, were recorded, all of which were common species.

Although there were no new records for the park or Gabo Island, there were very few previous records of many species and the surveys provided a significant increase in data records for the reptiles and amphibians of the region. Tissue samples and specimens of frog and reptile species collected on this trip will contribute to continuing efforts to identify unique genetic diversity within species and help clarify taxonomic diversity in species complexes. The samples and voucher specimens provide a baseline for current biodiversity in this region and will provide an invaluable resource to researchers both now and in the future.

The survey located a number of conservation-listed species, two of which (*Litoria aurea* and *Uperoleia martini*) were only found outside the boundary of the park, highlighting the need for further survey work in the region to assess whether the reserve system is adequately protecting these species. There is a particular need for further survey work on the frog genus *Uperoleia*, determination of the species present in Victoria, and a full review of the status of *Uperoleia* species in Victoria. Work on the identification of *Uperoleia martini,* and consultation with Dr Catullo at the University of Western Sydney, indicate that it is possible that *U. tyleri* does not occur in Victoria. Thus, further surveys and sampling are required to determine whether this is so, as *U. tyleri* is currently listed as Data Deficient under the Advisory List. If this species does not occur in Victoria a re-assessment of the status of *Uperoleia* species in Victoria would be warranted.

Surveys of the coastal heaths within the park yielded common and abundant reptile species, such as *Lampropholis delicata* and *Amphibolurus muricatus*. However, on the Betka River Heath Walk site, which is coastal heathlands outside the reserve, *Pygopus lepidopodus* was recorded—there were only three records of this species in the region previously. Further work is required to determine if and where populations occur within the park and whether these species are adequately protected in this region under the current reserve system.

Fishes

Croajingolong National Park is situated at the eastern extreme of the Victorian coastline, within what has long been regarded as a biogeographical overlap zone involving the cool tropical/warm temperate lower coast of eastern Australia and the cool temperate southern coast of Australia. The southern flowing Eastern Australian Current turns to the east soon after reaching the eastern edge of Bass Strait, with waters carrying planktonic eggs and larvae from populations to the north entering Bass Strait only when driven by wind and tides. As a consequence, the eastern edge of Bass Strait is a passive boundary for species distributed along Australia's east coast, just as the western edge of Bass Strait is to species occurring to the west of it. The identifiable limits of the ranges of species occurring in eastern Bass Strait fluctuate with the serendipitous replenishment of stocks by the vagaries of climatic conditions. The presence and absence of species in the study area reflect these fluctuations, especially for species living at or near the extremes of their environmental tolerances and thus their range. The sudden appearance of species not previously reported in the area can imply a change in environmental conditions, especially if supported by more than a one-off occurrence. Although the study area has been sampled previously,

this has not been done on a regular temporal basis and therefore trend lines for these perturbations are certainly not established. Consequently, a means for testing indicators of change, like global warming, that might involve concepts such as 'animals on the move', require further distributional documentation. Surveys like this Bush Blitz are not just about discovering new species but are also an important opportunity for recording presence and absence.

Within the marine environment, no faunal groups are better known and documented than fishes. This was acknowledged by the most recent revisitation of marine bioregionalisation, which used the distribution of fish, rather than the perceived physical surrogates of oceanography, climatology and physical geography, to model the natural distributions of living organisms. The more that is known about the distribution of each and every fish species, the more accurately the dynamic limitations of these bioregions can be gauged.

Sampling for fishes was limited to estuarine areas of several coastal catchments between Mallacoota and Bemm River, primarily as a result of permit conditions. Several attempts to collect at open coastal localities were unsuccessful due to unfavourable conditions. The fish component of sea grass communities at all localities was found to comprise small, typical seagrass species and juveniles of others that reach a considerably larger maximum size, thus supporting the 'nursery ground' characterisation of such habitats.

The study area had not been sampled extensively in the past and no comprehensive list of the fish species recorded there is known to exist. As no attempts have been made to verify identifications of museum specimens collected in the area, Appendix A only includes the 86 species recorded during the Bush Blitz. Twenty-one species were identified among the 305 specimens captured. Others were observed taken by recreational fishers or those directly involved in the Bush Blitz. The remainder were sight records, recorded at Mallacoota or by divers visiting Gabo Island and its adjacent waters.

Specimens were initially identified to family, many to species, because the two surveyors were personally familiar with the taxa. Those that were unidentifiable were either small individuals at a juvenile stage that differs morphologically from the adult stage or of small species belonging to diverse groups with species sharing similar morphology and colouration. Attempts to refine the identifications were made at the end of the field work. The species list is partly based on visual records that are not verifiable by vouchers. Some reports were reliable only to the family level and may involve more than one species, particularly as a significant number of juveniles were involved, including some members of quite speciose families, like the leatherjackets (Monacanthidae).

The highest number of species recorded for a fish family was eight—these belonged to the Labridae and the Gobiidae (gobies), the latter the most diverse family in coastal marine waters of the world. The next most diverse family recorded was the conservation-listed Syngnathidae (pipefishes and seahorses), represented by five species.

The number of taxa recorded probably represents only 20–25%, if not fewer, of species expected to occur in coastal waters of the area. This is not surprising, due to the short duration of the survey and methodological constraints. The timing of the survey is unlikely to have greatly affected detection of current species diversity. No species occurring within the area are likely to have especially small ranges and species additions or losses would most likely be due to range extensions or contractions, as the area is in the vicinity of range limits for a significant number of species present around the south-east corner of Australia. All species confidently identified as differing from others collected have reasonably broad distributions and are considered to have been taken in their recognised range.

The major habitats along the Croajingolong coast that are experiencing the effects of human activities are those at the freshwater/marine interface within the estuaries, where turbidity resulting from upstream activities and the contraction of seagrass habitat is visible. Because of the physical complexity of seagrass, these habitats provide homes for the largest number of fishes and marine invertebrates in estuaries and their deterioration impacts the overall health of the system. In fact, the destruction of seagrass habitat is more likely to impact adversely fish species diversity than targeted capture of fishes. Anecdotal reports of environmental alteration in the estuary at Mallacoota and other drainages surveyed attributed to anthropogenic effects appeared to be manifested, at least in Mallacoota, in the reduced size of seagrass patches relative to those observed during a visit in 1989. The size and condition of seagrass coverage surveyed should be monitored in all estuaries.

Despite the observed decline in seagrass cover, the presence of juvenile Blue Groper (*Achoerodus viridis*) in two catchments, supported by general observations, indicates that populations of the species are increasing in southeastern Australia. This bodes well for the recovery of populations and demonstrates the importance of sea grass communities as fish nursery grounds. Numerically the Hairy Pipefish (*Urocampus carinirostris*) appeared to be the dominant species in healthy seagrass communities and can be regarded as an indicator species, despite its nationally protected status as a member of the family Syngnathidae.

Invertebrates

Echinoderms

The Croajingolong West conservation estate region is important biogeographically as the Bassian Isthmus has repeatedly submerged and emerged with glaciation cycles. New genetic lineages have developed, resulting from isolation of populations of marine organisms and changes in temperature regimes. Preliminary work suggests that the region is crucial to understanding the repeated formation and proliferation of cryptic lineages in echinoderms, specifically among ophiuroids. While the region has been surveyed extensively for echinoderms, and specimens are deposited in scientific collections, most of the data collected has not been made available in reports.

Among the 394 specimens collected, 18 previously described species, from the five echinoderm classes, were identified. Two exotic species were observed but not collected. Among the undescribed taxa were possible cryptic species which require further study. *Clarkcoma canaliculata* and *Ophionereis schayeri* represent a complex of cryptic species for which at least four and six species respectively have been revealed with molecular data.

It is important to assess the impact of invasive species and determine if any action is required to control population size. In particular, regular surveys are recommended to assess the impact of the tropical sea urchin *Centrostephanus rodgersii*—urchin barrens were observed in both Croajingolong National Park and Cape Howe Marine National Park and this species is known to decrease diversity. A few species need to be studied in more detail, as these could represent complexes of species. Among these are several species from the genus *Ophiothrix*. There is also genetic evidence suggesting possible cryptic speciation in *Ophionereis*, *Clarkcoma*, and *Cenolia*. Further detailed morphological studies, and molecular studies if not already available, are necessary in order to accurately determine the diversity of echinoderms in the area.

Moths

In the study of the insect order Lepidoptera (moths and butterflies) in Australia, butterflies have received more attention. In many ways, the study of moths is still in the pioneering stages. In Australia, current knowledge is largely based on notable collections in museums and the Australian National Insect

Collection (ANIC). The number of moth species occurring in Australia is not known but it is very large. Australia has approximately 10,400 named moth species, but about twice as many species are already deposited in Australian insect collections. However, more widespread collecting and photographic recording are becoming the norm and frequently new records for Victoria and range extensions are found. Statewide, the information is being collated in the *Moths of Victoria* book series that provides a baseline for further work. There are no complete field guides covering other parts of Australia, but distribution information can be collated from collections, reference books and reputable websites.

Moth surveys have been conducted in and around the park on several occasions over the last 12 years, however no species lists were made. Prior to the Bush Blitzes, an exhaustive search was made through these records to compile a comprehensive moth list for the park. Sources of information included a small number of records in MV's EMu database, ANIC specimens listed in the BOLDSYSTEMS Public Data Portal and records from private collectors and photographers.

The results from these earlier surveys suggest that Croajingolong National Park west of Mallacoota Inlet supports a rich and diverse moth community. The total moth species count for the park before the Bush Blitzes was 453, of which 375 were able to be named to species level. No previous records existed for the eastern section of the park but several favourable factors suggested that it would also be rich in moths—it has a similar variety of habitats, and much of the area is remote, difficult to access, undisturbed and little affected by weeds, introduced plants, clearing or fragmentation.

The Bush Blitz surveys aimed to further document the moths of the park and far-eastern Victoria in general, to detect undiscovered populations and range extensions into the area, and to explore the link between East Gippsland and coastal NSW.

During the first survey, on the western side of Mallacoota Inlet, 370 species (including 271 named taxa) from 38 families were recorded from eight sites. The most productive site was Genoa Peak (161 species), probably because the weather was calm and dry, ideal conditions for moths to fly, and because the light trap was run all night. The Cicada Trail heathland and Betka Track were also productive, with 86 and 85 species respectively, even though the light traps were closed early. SSS1 and SSS2, produced 58 and 47 species, but poor weather and early closure of the light traps probably restricted the counts. The high numbers of species recorded probably reflected the variety of habitats sampled.

During the second survey, on the eastern side of Mallacoota Inlet, 452 moth taxa (including 348 named taxa) from 32 families was found on nine nights. All 452 species were new for the eastern section of the park as no previous moth surveys are known in that area. The most productive site was SSS1 (160 species), even though the light trap was not run all night. The mixed habitat of eucalypt forest and rainforest and the running of two light traps in different positions may have contributed to the high count. Buckland Road (107 species), the coastal scrub opposite Gabo Island (103) and SSS2 (101 and 96 species in two surveys) were also productive. Although the site at Lake Barracoota had a similar habitat to the coastal site opposite Gabo Island, only 45 species were found there. Persistent rain all night was not heavy enough to force closure of the light trap but it may have deterred moths from flying. The Lake Barracoota site was also more open and less sheltered than the other coastal site. A possible explanation for an even higher number of species recorded during this survey is that more sites were sampled and the weather was consistently more favourable so the traps were, on average, run for longer each night.

Of particular scientific and conservation interest were several species associated with warm temperate rainforest, e.g. *Orthocraspis leptoplasta*, *Craniophora fasciata* and *Amblychia subrubida*. These species were not recorded at other sites, suggesting that rainforest supports some species restricted to, or at

least more common in, that habitat. This habitat is limited in Victoria and East Gippsland is its western limit in southern Australia. Heathland sites had species that are typical of other heathlands in Victoria, e.g. *Thudaca mimodora*, *Corynophora lativittalis*, *Adeixis inostentata*, *Phrixocomes ophiucha* and several species of *Dichromodes*. The rare species, *Hypodoxa horridata*, was found only at heathland sites and for the rare *Proboloptera embolias*, four of the five records were in areas of heathland.

The two surveys added 286 new records, giving a total of 908 species for the park, including 661 named taxa. Many of the newly recorded named species are known to occur in other parts of Gippsland. These surveys, though of limited duration, confirmed the richness and diversity of moth populations in the park. The high species count may reflect the range of habitats available for moths and the protection offered by the reservation of a large, continuous area including Croajingolong National Park, Victoria, and Nadgee Nature Reserve, NSW.

Around a quarter of the species from each survey could not be named to species level. Many moth species that have not been formally named are nevertheless familiar to collectors and photographers. In the ANIC and Melbourne Museum collection, they are lodged under the appropriate family, subfamily, tribe or genus, generally with an identifying species number (unique to each institution). Other species have not been fully identified. Most of these are small and clarification of their specific identity probably requires detailed study, perhaps involving genitalia dissection and DNA analysis. For some generic groups, a thorough revision of the Australian members is needed before specimens can be placed.

Surveys close to the Victoria/NSW border would be expected to detect species that range only a short distance into Victoria from their main range in NSW. Such species may be visitors, established in similar habitats to those used in NSW or recent arrivals. Some moth species have moved south in recent years, possibly in response to a warming trend in climate. It is therefore not surprising that surveys carried out before the Bush Blitz registered several first records for Victoria and other rarely recorded species. Most are moths regularly found in Queensland and/or NSW. A few examples are the Geometridae species, *Aporoctena scierodes*, (*Aspilates*) *pallidiscaria*, *Syneora silicaria*, an undescribed species of *Chorodna*, *Hemichloreis exoterica* and *Cernia amyclaria*. At Genoa Peak, *Porela vitulina* (Lasiocampidae) was recorded in Victoria for the first time in more than a century.

Significant findings during these Bush Blitzes included species that are rare or of limited distribution, and major range extensions and infills in distribution for 30 species. As predicted, these surveys close to the border detected new Victorian species, their range extending southwards from similar habitats in coastal NSW. The largest range extension was more than 900 km and some others were 300–600 km. Newly recorded species occurring at multiple sites are considered to have established populations in the park, and thus in Victoria: *Proboloptera embolias*, *Amblychia subrubida*, *Callopistria rivularis*, *Acosmeryx anceus*, *Opodiphthera loranthi*, (*Boarmia*) *driophila* and *Lambula transcripta*. The others may be established, occasional visitors or recent arrivals responding to a warming climate. It is possible that the Croajingolong moths are isolated, and if so there may have been genetic drift and even species differentiation. Comparative DNA studies of Croajingolong and NSW specimens could be illuminating. However, there may be other explanations for the lack of records in southern coastal NSW. This area has not been visited frequently by lepidopterists who collect for the ANIC. In addition, some species may be rare, they may have short flight times or they may not be readily attracted to lights.

The value of this region for moths has been confirmed by these surveys. Most moths have limited flight times and surveys at other times of year will detect different suites of species. Future monitoring could identify which other range extensions and species newly recorded for the reserve are in established populations and may detect a general southwards shift in range from coastal NSW to Gippsland, associated with a warming trend in climate. Ideally monitoring should continue in other seasons and at

other sites. Lists from the Standard Survey Sites provide a baseline for future monitoring at those locations. Day-flying species and larvae were not specifically sampled. The moths restricted to warm temperate rainforest have been singled out as being of state and possibly national importance and could be targeted for monitoring in November in future.

Continued protection of this large, connected area as a designated National Park and Nature Reserve is important for the survival of moth populations large enough to be viable in the long term. Fire regimes, weed and pest control, maintenance and extensions of access tracks into remote areas, construction and tourist development should be managed as far as possible to protect patches of warm temperate rainforest, and the park as a whole.

Freshwater invertebrates

Freshwater macroinvertebrates were sampled during both Bush Blitzes. Macroinvertebrates are considered to be those invertebrates >0.5 mm in length and visible to the naked eye.

The main aim of the first survey was to sample benthic macroinvertebrates in Lake Barracoota and Lake Wau Wauka sand dune lakes in the park. Freshwater benthic invertebrates of rivers and streams have been sampled throughout Victoria. However, much less attention has been given to the benthos of lakes and other still waters.

The benthos of Lake Barracoota has been examined only once previously, during the summer of 1969 and the winter of 1970 at a series of depths (1.5 m to 8 m)—28 freshwater taxa were recorded, dominated by species of chironomid larvae. Three other taxa, that have since been described, had clear marine affinities—two isopod crustaceans (in families Anthuridae and Sphaeromatidae) and a segmented worm (the polychaete *Boccardia* sp.). It was concluded that Lake Barracoota had once been an arm of the estuarine Mallacoota Inlet (the lake is now about 3 km from the inlet), but had been isolated by recent sedimentation in Howe Flat, a trough connecting the lake and inlet. Presumably the marine species are relicts, which have adapted to freshwater. It was expected that the list of freshwater taxa would be much expanded by the Bush Blitz because taxonomic and systematic work in recent decades has greatly increased knowledge of this group of biota. It was also hoped to confirm that the three species with marine affinities remain in the lake.

A total of 27 taxa were recorded in Lake Barracoota, one fewer than the number previously recorded. If allowances are made for differences in nomenclature since the previous study, 14 taxa were recorded previously and 13 are new records for the lake. The benthos of Lake Barracoota was again dominated by chironomid larvae (6 species), particularly *Procladius* sp.—none of the other taxa were very numerous. Three genera (*Paralimnophyes* sp., *Polypedilum* sp., *Cricotopus* sp.) are new records, undoubtedly resulting from a greatly increased ability to discriminate and identify chironomid larvae. However, several species (*Tasmanocoenis tillyardi*, *Notalina spira*, *Triplectides magnus*), which would have been recognised (if only by family), were not recorded previously so these perhaps are genuine examples of species that have colonised Lake Barracoota in the last four decades. Also, two species of segmented worms and the ostracods were not recorded previously, perhaps a result of the previous study using a coarser sieve (400 µm) to process the benthic samples. Two of the three previously recorded taxa with marine affinities (the anthurid isopod and the polychaete *Boccardia*) were not recorded. Both of these taxa occurred in restricted parts of the lake that were not sampled during the Bush Blitz. The third taxon (Sphaeromatidae: *Cymodetta gambosa*) was widespread in both surveys.

All of the species recorded belong to well-known families of freshwater invertebrates. The only exception is the sphaeromatid isopod. This is a marine family frequently found in shallow nearshore habitats. In Lake Barracoota it was common in the shallow littoral habitat and was also caught at depths

of 3.2 and 3.5 m. Some taxa could not be named because the specimens were either too immature to determine species identity or the species within the genus are not well known.

Additional samples were taken from the creek that flows across Howe Flat to determine whether invertebrates (particularly those with marine affinities) were migrating between the lake and inlet. The benthos in the creek was not particularly diverse and was largely a subset of that found in Lake Barracoota. The presence of *C. gambosa* suggests that at least one of the taxa with marine affinities is able to move between the lake and the inlet, so the lake may not be completely isolated from the estuarine Mallacoota Inlet. The creek on Howe Flat had a few taxa unlikely to be found in Lake Barracoota—larvae of *Simulium* sp. are characteristic of running water, while scirtid beetle larvae occur in swamps such as those alongside the creek.

Lake Wau Wauka is a small lake, several kilometres to the north east of Lake Barracoota and its benthos had not been sampled previously. The benthic fauna appeared to be reasonably distinct from that in Lake Barracoota. However, sampling was confined to a very small area of the lake and it is unwise to make comparisons with such limited data. Lake Wau Wauka contained several genera of chironomid larvae and trichopteran larvae that were not seen in Lake Barracoota. Generally the diversity was lower in Lake Wau Wauka compared with Lake Barracoota, but sampling effort was much less at this site.

During the second Bush Blitz, the benthic invertebrates at seven stream sites within or near the Marshmead property were sampled. No sampling of stream benthic invertebrates had previously occurred in the eastern part of Croajingolong National Park. The Victorian Environment Protection Authority (Vic EPA) has surveyed many streams in East Gippsland, but their nearest sampling sites are along the Betka River, which flows just to the west of Mallacoota. It was expected that the benthic fauna would be similar to that found in the Betka River and other low altitude streams in the East Gippsland drainage basin.

The streams sampled were all short and mostly flowed into Mallacoota Inlet. All seven sites were in dense forest and a few in patches of rainforest. Some species were characteristic of heavily shaded streams, e.g. *Triplectides altenogus*. However, the majority of macroinvertebrate taxa recorded were typical of undisturbed streams in eastern Victoria and south-eastern Australia generally. None are rare or have restricted distributions.

The composition of the benthic fauna differed little between sites at Marshmead. Old Harrison's Creek was less diverse than the others, but its benthos was a subset of that at the other sites, rather than having a distinct composition. This creek was narrower than the others (1–3 m versus 4–5 m), had less discharge and was heavily overgrown by riparian vegetation such as tree ferns. The stream bed was silty with small patches of sand and gravel, overlain with leaves, twigs and other organic debris. The other sites had stream beds composed of coarser material such as gravel and cobbles (and even bedrock at Royds Creek). Rocky river beds will almost always have a richer fauna than sandy or silty ones because rocks provide a greater range of habitats, refuges and food sources for stream invertebrates than fine sediment. No significant changes in composition occurred between the upper and lower sites.

Diversity at four sites on the Betka River (and two others nearby) sampled by VicEPA ranged from 14 to 32 families for single samples, similar to that at Marshmead. There were no obvious compositional differences (at the family level) between the Betka River sites and the sites at Marshmead. However, a number of taxa showed different frequencies of occurrence, probably because the VicEPA data were based on samples taken from several seasons over 2–4 years. Such increased sampling effort will result in more species being detected and greater accuracy in estimating frequencies of occurrence. Previous

experience indicates that to obtain 80% of the macroinvertebrate species at a stream site in Victoria requires three sets of samples taken at different seasons over several years.

Heteroptera

The Heteroptera of Australia comprise approximately 2500 species. Recent surveys during Bush Blitz Phase 1 revealed 1391 species of Heteroptera, of which 391 are recognised as being new to science. In a report to the ABRS on Bush Blitz Phase 1, Prof. Cassis and Prof. Laffan indicated that the species taxonomic accumulation curve was not levelling, and predicted that the total heteropteran fauna of Australia would amount to approximately 6,500 species. The Gippsland region is not considered to be an area with a high diversity of Heteroptera.

These were the first surveys of Croajingolong National Park by the Cassis Laboratory. They focused on the collection of plant-associated heteropterans using methods previously employed in Bush Blitz Phases 1 and 2. Heteroptera were surveyed at 40 localities by beating/sweeping of vegetation and general collecting. A PhD candidate participated in the fieldwork and continued his entomological training.

Including five species collected by the freshwater invertebrate team, 115 Heteroptera species were recorded. Of these, only 17 taxa could be identified to species—the remainder require further taxonomic work in order to be determined to described species or established as new species. Thirteen species are recognised as putatively new to science, belonging to the family Miridae (12 species) and Pentatomidae (1 species). Eighteen families of Heteroptera were represented in the collection, with the greatest species richness occurring in the Miridae (55 species). Four species were recorded on both Bush Blitzes, including two pest species.

Crustacea

The arthropod sub-phylum, Crustacea, is diverse. It contains well-known groups such as the Decapoda (e.g. crabs, shrimps and lobsters) and species rich, but poorly known, groups such as the Amphipoda (amphipods) and the Copepoda (copepods).

Prior to the Bush Blitz, the OZCAM data in ALA recorded the presence of 112 crustaceans in the Mallacoota/Gabo Island region. This low number was not due to a lack of diversity but the result of the limited number of surveys conducted in the past. Due to the lack of previous sampling effort it was expected many species would be recorded in the area for the first time.

This Bush Blitz has considerably increased our knowledge of the crustacean fauna in the area. In the intertidal and shallow subtidal marine waters around Gabo Island, and in the estuarine and marine waters in the Mallacoota region, 77 crustacean species were identified. This included 57 species not previously recorded in the area, bringing the total number of crustacean species for the Mallacoota region to 169. The 92 species recorded in the region prior to the Bush Blitz but not found during the Bush Blitz can be explained, in part, by the limited number of habitats and depths that were sampled. All crustaceans collected came from a depth of less than 10 m and were collected from algae, seagrass, sponges, rock pools or intertidal sand. No sediments (other than intertidal sand) were sampled. No deep water was sampled.

In the field, specimens were identified to the lowest possible taxonomic level. For decapod crustaceans this generally meant to the level of species, but amphipods, isopods and copepods were rarely identified beyond the level of genus and sometimes could only be placed in a family. This was largely due to the small size of these crustaceans and the need to dissect appendages, mount them on slides and observe

them under a compound microscope. Due to the limitations of time it was not possible to undertake this work during the survey. There is no single guide book to the smaller Australian crustaceans (i.e. amphipods, isopods and copepods) and identifying these taxa to the level of species can be difficult, and frequently requires reference to the primary taxonomic literature.

At least 15 different species of harpacticoid copepods were collected during this survey. Very few harpacticoid copepod species have been described from Australia and although they are diverse and abundant, prior to this Bush Blitz, there were no formal records of copepods in the Mallacoota region. This is partly due to their tiny size (less than 0.5 mm) but mainly because there is a lack of harpacticoid taxonomists in Australia. Dr Genefor Walker-Smith is one of only two employed in Australia—a situation that has not changed in the past twenty years. Within the 57 species that were recorded for the first time in the region, it is anticipated there will be several new species of amphipods. The identity of several of the unidentified amphipods and harpacticoid copepods collected will be revealed in an upcoming report, funded by ABRS, and due for submission in early 2018.

The freshwater invertebrate team collected an additional five crustacean species, including two new records for the region.

Snails and slugs

The malacofauna (molluscs) of far-eastern Victoria is highly under-surveyed, and no previous systematic survey is known to have occurred at Croajingolong National Park. This region represents a transition zone between two relatively distinct faunas, one that is dominated by coastal southern NSW taxa and the second centred on the south-eastern highlands of Victoria. For these two reasons there was a high expectation that either new species would be discovered, or notable range extensions would be recorded. Of particular interest were taxa associated with the warm-temperate rainforest remnants within this region. Given the high level of fragmentation of this forest type, associated fauna would equally be restricted and potentially highly endemic and/or exhibit a high degree of population structuring, i.e. represent evolutionary significant units.

Prior to the Bush Blitz, there existed records for only four species east of Mallacoota—one rhytidid, two charopids and the semislug *Helicarion niger*. The rhytidid, *Austrorhytida capillacea,* is common in south-eastern NSW, and was collected during this survey. The two charopids, *Mulathena fordei* and *Pernagera officeri*, however, are most likely misidentified. Both these species tend to be restricted to south-central Victoria. *P. officeri* has now been assigned to the genus *Scelidoropa*, and a new undescribed congeneric was recorded in the current survey. As for *M. fordei*, this species tends to be found in wet sclerophyll forest/cool temperate rainforest in the central highlands, hence if a congeneric species exists east of Mallacoota, it would probably be associated with warm temperate rainforest.

A total of 19 species of terrestrial molluscs were found during the Bush Blitz—four are introduced and 16 represent new records for Croajingolong National Park. Warm temperate rainforest in the vicinity of the Marshmead campus had the highest diversity, and ongoing monitoring of potential impact from introduced, invasive species is encouraged.

Overall, the indigenous malacofauna at the surveyed sites was relatively depauperate, both in terms of diversity and, most noticeably, abundance. While in part this may be due to recent disturbances, such as forestry and agriculture, it is not clear why the region remains so low in diversity given appreciable habitat recovery. One possibility is that the region had experienced large scale bushfires in the past (>100 years ago), and recovery is still on-going for such low dispersal taxa. Support for this is the observed lack of diversity and abundance of low dispersal invertebrates in general.

The rainforest circuit trail and nearby open forest yielded the highest diversity of all the sites surveyed. Accordingly, this catchment should be given high priority in terms of mitigating against introduced species. Unfortunately, this was the closest site to the Marshmead campus, on which introduced species are well established and in high abundance. A more thorough survey of the campus is needed to ascertain whether species of the genus *Oxychilus* are also present. *Oxychilus alliarius*, in particular, is highly predatory, and has been shown to be associated with the decline of indigenous snail populations in places where it has been introduced.

Flora

Flowering plants, ferns, bryophytes, fungi, lichens

Croajingolong National Park has a high diversity of plant species relative to other reserves in Victoria, with 945 native vascular plant species and 138 introduced vascular plant species recorded prior to the Bush Blitzes. Among the Victorian reserves, only the Alpine National Park and Grampians National Park have a higher recorded number of vascular plant species.

The area of East Gippsland containing Croajingolong National Park has been the focus of numerous botanical surveys and collecting expeditions, beginning with Victoria's first Government Botanist, Ferdinand Mueller, who collected in the area in 1860. The ALA holds over 29,000 observational records of plants and fungi and records of more than 4000 herbarium specimens collected within the park.

Croajingolong National Park east of Mallacoota Inlet harbours 13 vascular plant species that are otherwise unknown from elsewhere in Victoria. These species also occur in NSW. As such, this area of Victoria has been a hotspot for the detection of new Victorian records. However, based on an extensive history of botanical collection in the area it was considered unlikely that any vascular plants or bryophytes not previously recorded for Victoria would be encountered during this survey. Discovery of new Victorian records of lichens was thought to be more likely, particularly on Gabo Island. It was expected that range extensions might be recorded for some plants, particularly exotic species.

During the eight-day survey of the park west of Mallacoota Inlet, 233 collections were made. A further 453 collections were made during the nine-day survey of the park east of Mallacoota Inlet, at Gabo Island, and the Marshmead property. These collections included 398 vascular plant species, 8 fungi, 13 bryophytes and at least 13 species of lichen. They improve the collections at the state herbarium and enhance our understanding of the distribution and habitat of the collected species. Photographs of 223 vascular plant species (489 images) are a valuable contribution towards the online Victorian flora, VicFlora.

Results were consistent with expectations based on botanical exploration of the area. In the surveys to the west of Mallacoota Inlet and Alfred National Park no vascular plant species were newly recorded. This was not surprising given that those areas are reasonably accessible and have had a long history of botanical collection. In contrast, four new fungi taxa (including two lichen taxa and one rust) and two new moss species were recorded for Croajingolong National Park and two new lichen taxa were recorded for Alfred National Park. The contrast between the numbers of new fungi taxa compared to new plant species recorded in the survey areas was to be expected given that fungi are not collected as often as plants and are much less well known in Victoria. In the survey east of Mallacoota Inlet, 13 taxa were newly recorded in the park—six lichen, one rust fungus and six vascular plant species. Eight taxa were newly recorded for Gabo Island, comprising two lichen, one rust fungus and five vascular plant taxa.

One species, *Astrotricha* sp. Wingan Inlet (J.A.Jeanes 2268) Vic. Herbarium, that has not been formally described was collected during the Bush Blitz. This species has been recognised for over 15 years but its formal description awaits a revision currently being undertaken by M. Henwood (The University of Sydney) and R. Makinson (Australian National Herbarium Canberra). Molecular data from plants previously referred to as *Asplenium obtusatum* subsp. *northlandicum* in New Zealand have shown that they are best recognised as *A. decurrens*. A collection made of *A. obtusatum* subsp. *northlandicum* during the survey has been incorporated into a taxonomic study of *Asplenium obtusatum* using molecular data conducted by D. Ohlsen to establish whether Victorian plants currently assigned to *Asplenium obtusatum* subsp. *northlandicum* are conspecific with New Zealand plants which would necessitate a name change. A manuscript for this study has been prepared and will be submitted for publication in the scientific journal *Muelleria*, published by the Royal Botanic Gardens Victoria.

Damage inflicted by deer was observed on some of the state-listed plant species (e.g. *Ficus coronata* on the Ken Morrison Rainforest Walk and *Santalum obtusifolium* around Brokewell's Hut) and one large Sambar Deer was observed grazing on the Marshmead property. Consideration should be given to managing the impacts of deer. Subsaline herbfields in freshwater seeps within extensive dunefields near Cape Howe were clearly targeted by deer. Extensive tracks across the dunes and highly selective grazing of some of the species within the community were evidence of surprisingly high populations in a habitat, until relatively recently, regarded as unsuitable for Sambar.

No recruitment was observed amongst *Polyscias murrayi*. Instead, the entire population appeared to comprise all mature trees of a similar age. The persistence of this species in Victoria requires successful recruitment of the populations on the tributaries of Harrison Creek as this is the only known location of the species in Victoria. Future monitoring of this species is required to determine if recruitment occurs. If recruitment is not recorded, monitoring trees for fruiting material followed by collection and germination of seed with the assistance of the Millenium Seedbank project at the Royal Botanic Gardens Victoria may be necessary to ensure the long-term survival of this species in Victoria.

The rainforest patch on the east side of the Howe Range visited (centred at about 37°29'29''S 149°52'23''E) was dominated by the state-listed vulnerable tree species, *Eucryphia moorei* and is possibly the largest single stand of this species in Victoria, extending along the main creek from at least 37°29'23''S 149°52'22''E to 37°29'36''S 149°52'29''E and up the tributaries that flow into the main creek along that stretch. As such, this warm temperate rainforest patch represents a highly significant site. *Eucryphia moorei* is otherwise only known in Victoria from the Harrison Creek catchment and David Creek. At these sites the *E. moorei* rainforests are confined to short sections along the creeks after which the steep slopes change to sclerophyllous vegetation. *Eucryphia moorei* is much less common in these rainforest sites than other tree species such as *Syzygium smithii* and *Tristaniopsis laurina*. The Advisory List endangered and FFG Act-listed orchid, *Sarcochilus falcatus*, has also been recorded in this patch of rainforest but was not seen during the Bush Blitz. It is not known to occur naturally in other parts of Victoria. Targeted searches for this species are warranted to ensure its ongoing survival in the state.

Some introduced plant species encountered were of localised occurrence but have the potential to spread from sites observed throughout the area. Such species included *Arctotheca populifolia*, *Gladiolus gueinzii*, *Hydrocotyle bonariensis*, and *Passiflora edulis*. These species should be targeted for eradication given that they are currently restricted in their occurrence making complete eradication feasible.

On Gabo Island weeds, such as Blackberry (*Rubus fruticosus* agg.) and Kikuyu (*Cenchrus clandestinus*), and trampling and browsing by cattle pose threats to some significant vegetation such as the moss beds that are habitat for uncommon species such as *Orthoceras strictum* and *Drosera pygmaea*. Browsing

pressure by cattle may also pose a threat to the vulnerable *Santalum obtusifolium* newly recorded on the island. The cattle also aid the dispersal of weeds.

Listed plants that are vulnerable to roadside disturbance include *Astrotricha* sp. Wingan Inlet, *Brachyscome salkiniae*, *Coopernookia barbata*, *Lobelia purpurascens*. *Lindsaea microphylla*, a small lacy light green to yellowish fern that grows in the ground often amongst rocks is a rare plant that is vulnerable to weeds and roadside disturbance. Any attempts to control weeds at this site (- 37.6409167, 149.7013611) must be supervised in order to protect the *Lindsaea*. The rare *Oxalis rubens* is vulnerable to being targeted in weed control, due to resemblance to the exotic *Oxalis* species.

Marine algae

Macroalgae (seaweeds) are a diverse group of macroscopic, multicellular, marine algae. They are defined based on their photosynthetic activity and are taxonomically heterogeneous, belonging in three different phyla: Rhodophyta, Chlorophyta and Phaeophyceae (Ochrophyta). Australia, its south coast in particular, is known as a biodiversity hotspot for macroalgae. Macroalgae are important primary producers in coastal ecosystems and along with phytoplankton they form the basis of the marine food web. The meadows they form also play a major role as habitat constructors and as nurseries for species of interest for commercial fisheries (e.g. kelp and crayweed beds).

Besides the larger macroalgae that form meadows, there are many smaller species forming algal turfs. Turfs are usually defined as assemblages of densely packed, small macroalgae associated with trapped sediment and associated microbiota. Despite their significant contribution to primary productivity and nutrient cycling, turf algae have largely been overlooked taxonomically. As a consequence of the small size of turf-forming species, along with the high species diversity and taxonomic complexity of the family Rhodomelaceae in particular, numerous species have been overlooked previously. Furthermore, cryptic diversity, i.e. species that are practically indistinguishable based on morphology, is very common in this group.

Information about the marine algae of the region is scarce. There are few records in Australia's Virtual Herbarium, mostly of ecologically dominant species. It is possible that further information may reside in non-digitised collections in herbaria, but these were not available. Two technical reports by Parks Victoria summarise the ecologically dominant species of marine algae in the Point Hicks and Cape Howe marine parks and provide a species list.

The Bush Blitz led to an extensive collection of macroalgae and turf algae that were pressed as herbarium vouchers but also preserved for future anatomical and DNA work. The survey included the mainland coast of Croajingolong National Park and Mallacoota, and Tullaburga Island and Gabo Island, and resulted in collection of around 700 samples of marine algae. Due to the lack of published information of marine algae in the region, a large number of species can be considered new for the reserve. Only taxa that were not previously recorded from the wider area, predominantly from Cape Howe and Point Hicks have been considered new records.

Algae were identified to the taxonomic level achievable in the field laboratory. In many cases this was the genus level. If it was possible to identify to the species level based on external characters in a timely manner, this was done. Occasionally specimens could only be identified to a higher taxonomic level. No identifications have been made beyond those achievable using external morphological observations in the field laboratory. It is well known that due to their simple and plastic morphology, algae have few reliable morphological traits for delimitation and identification of taxa based on external morphology. For that reason, the identifications given here should be regarded tentative. Due to the problems with morphological identification and the fact that cryptic diversity is prevalent, molecular data have become

the primary tool for algal species discovery and in some cases it is also the only reliable identification method. A Bush Blitz tactical taxonomy grant has been awarded to Verbruggen and Diaz to generate molecular data for a selection of the marine algae collected.

The following two sites stood out in having a remarkably diverse algal flora, at least in part due to physical features of the habitat:

- Shipwreck Creek Beach. At this site there is a gradient from sheltered rocks near the beach to much more expose rocks further west. Especially the rocks and rock pools near the beach (which were often covered in a layer of sand) had a highly diverse algal flora with many species only recorded there.
- East Landing, Gabo Island Lighthouse Reserve. Underwater gully with near vertical walls covered in macroalgae and species-rich algal turfs. Remarkable algal biodiversity, with many delicate species one typically only encounters at greater depth.

Glossary

Cryptic species (cryptospecies): species that are physically similar but genetically different and reproductively isolated from each other.

Endemic: native to or limited to a certain region.

Exotic species: a species occurring outside its normal range.

Host plant: a species of plant that is used by larvae of insects as food and a place to develop.

Macroalgae: algae that are clearly visible to the naked eye.

Pest species: a species that has the potential to have a negative environmental, social or economic impact.

Putative new species: an unnamed species that, as far as can be ascertained, was collected for the first time during the Bush Blitz.

Range extension: increase in the known distribution or area of occurrence of a species.

Species complex: a group of closely related species that are so similar in appearance that the boundaries between them are often unclear.

Species range: the geographical area within which a particular species can be found.

Taxon (plural taxa): a member of any particular taxonomic group (e.g. a species, genus, family).

Taxonomy: the categorisation and naming of species. The science of identifying and naming species, as well as grouping them based on their relatedness.

Threatened: fauna or flora that are listed under Section 178 of the EPBC Act (or equivalent State legislation) in any one of the following categories—extinct, extinct in the wild, critically endangered, endangered, vulnerable, conservation dependent.

Type locality: the location where the primary type specimen(s) (holotype or syntype series) was found.

Type specimen(s) (holotype, syntypes): the specimen (or set of specimens) on which the description and name of a new species is based.

Undescribed taxon: a taxon (usually a species) that has not yet been formally described and named.

Vascular plants: A lineage of plants that possess well-developed veins (vascular tissue) in their stems, roots and leaves. Vascular plants include the majority of familiar land plants: flowering plants, ferns, conifers, cycads and fern allies, but not mosses, liverworts or algae.

Vouchers (voucher specimens): any specimen, usually a dead animal or preserved plant sample, that serves as a basis of study and is retained as a reference.

All publications are available online at:
www.bushblitz.org.au

PUBLISHER ABRS, Canberra
EDITOR ABRS
LAYOUT Biotext
DESIGN TEMPLATE Biotext

Contributors

Bush Blitz is coordinated by the Australian Biological Resources Study (ABRS), which is part of the Australian Government Department of the Environment and Energy. The program is a partnership between the Australian Government, BHP Billiton Sustainable Communities and Earthwatch Australia.

Research agencies involved in this Bush Blitz were Museums Victoria, the Entomological Society of Victoria, the University of Melbourne, the University of New South Wales and the Royal Botanic Gardens Victoria.

Photo credits

Photographs are reproduced in this publication with permission. Effort has been made to credit the photographers correctly; however, please contact BushBlitz@environment.gov.au if a photo is incorrectly credited.

FRONT COVER David Paul © Copyright, Museums Victoria

BACK COVER Blue Mountains Tree Frog (*Litoria citropa*), David Paul © Copyright, Museums Victoria

Croajingolong National Park

Victoria

7–15 November and 28 November–7 December 2016

Australian Government
Department of the Environment and Energy

bhpbilliton
Sustainable Communities

EARTHWATCH INSTITUTE

Australian Biological Resources Study