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A comparison of an environmental impact assessment (EIA) vertebrate fauna survey with a post-approval fauna salvage program: consequences of not adhering to EIA survey guidelines, a Western Australian example

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Abstract. The Western Australian Environmental Protection Authority (EPA) has issued written guidance on its expectations for terrestrial vertebrate fauna surveys to support environmental impact assessments (EIA). We report on one of the few circumstances where a direct comparison of the results from an EIA vertebrate fauna survey, that did not, in our opinion, appear to conform with the EPA's guidance statement expectations but was seemingly accepted by the EPA, and a comprehensive terrestrial vertebrate fauna salvage program were undertaken at the same site. This has enabled us to comment on the consequences of not undertaking a survey that complies with the EPA's expectations. Excluding incursions by non-local species, bats and avian fauna, ~33% of terrestrial vertebrate fauna species recorded during the fauna salvage program were not reported as being present in the EIA survey. The relative abundance of various species differed appreciably between the fauna salvage program and the EIA survey, and an endangered species present in the project area was not identified as likely to occur. We believe these differences occurred because of a single-season EIA survey, insufficient trapping effort, a failure to survey an important fauna habitat, the presumption that a threatened species would be absent due to a lack of local records and records in the available habitat types. A comprehensive review and rewrite of the outdated Western Australian EPA vertebrate fauna survey guidelines and a requirement for proponents and environmental practitioners to meet (or exceed) the revised guidelines are the recommended outcomes.

Additional keywords: impact assessment, Pilbara, survey guidelines, threatened species, vertebrate

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Introduction

In Western Australia, potential impacts on the environment are assessed by the Environmental Protection Authority (EPA) and other government agencies under the provisions of the *Environmental Protection Act 1986*. To ensure that environmental practitioners provide information that the EPA is seeking in order to undertake an assessment, it published Terrestrial Biological Surveys as an Element of Biodiversity Protection Position Statement No. 3 (EPA 2002). It subsequently published two technical guidance statements: 'Guidance for the assessment of environmental factors terrestrial fauna surveys for environmental impact assessment in Western Australia No. 56' (EPA 2004) and 'Technical guide – terrestrial vertebrate fauna surveys for environmental impact assessment' (EPA and DEC 2010). The first of these two documents was current when the vertebrate fauna assessments for the on-shore Wheatstone project, which is the project being considered here, were undertaken (Bamford Consulting Ecologists 2009; Biota Environmental Sciences 2010*a*, 2010*b*).

Subsequently, the EPA has issued revised overview documents, and Guidance Statement No 56 (EPA 2004) has been rebadged without change as 'Technical guidance – terrestrial fauna surveys' (EPA 2016*a*) and its supporting technical guide (EPA and DEC 2010) was rebadged as 'Technical guidance – sampling methods for terrestrial vertebrate fauna' (EPA 2016*b*).

The EPA's (2002) Position Paper No 3 indicated that biodiversity assessments were required to consider two key aspects – (1) biodiversity value at the genetic, species, and ecosystem levels, and (2) ecological functional value at the ecosystem level – and that biological surveys needed to provide sufficient information to address both these values. Information was provided on what the EPA required at the genetic, species and ecosystem levels; however, most of the commentary related to flora and vegetation and not fauna (see section 3.6 in EPA 2004 for examples). Environmental practitioners typically interpreted Position Statement No. 3 to require them to provide a near-complete inventory of the terrestrial vertebrate fauna and an accurate indication of species relative abundance to enable them to report on ecosystem functional values. Dahlitz and Morrison-Saunders (2015) reported that environmental practitioners in Western Australia had noted a lack of consistency in how to meet

the objectives and challenges in determining the significance of impacts on a factor, with terrestrial fauna being a factor.

The ability to properly consider biodiversity, and therefore impacts on biodiversity, in an environmental impact assessment (EIA) is dependent on good information, not only on flora and fauna, but also on the ecological processes associated with biodiversity (Wegner *et al.* 2005). MacKinnon *et al.* (2018) cited a few papers from the 1970s that discussed field surveys for EIAs, and concluded, subsequent to those papers, that field surveys had not received much attention in the EIA literature.

The EPA's (2004) fauna survey guidance statement is, in the authors' view, generally vague and non-prescriptive, and could be viewed as relatively silent on numerous salient components of fauna surveys (e.g. trapping effort), but it makes comments on the importance of duration and spatial scale in sampling for vertebrate fauna, and the need for multiple surveys in different seasons. More technical detail (e.g. detection strategies, survey duration, repeat surveys, timing, site selection and sampling effort without being prescriptive) and a reiteration of the multiple-season survey requirement is provided in the supporting technical document (EPA and DEC 2010). A section was allocated to the effectiveness of sampling, which concluded that species-accumulation curves were a useful tool in estimating species richness, and it indicated that the value of species inventories was proportional to their completeness and accuracy, and that species inventories were much more informative when accompanied by quantitative data on species abundance.

There are very few opportunities for the veracity of EIA fauna surveys to be assessed against a more comprehensive survey of the terrestrial vertebrate fauna in a potential impact area and to assess the importance of adhering to EPA guidance. In this study, we have assessed the adequacy of the EIA vertebrate fauna survey data for a large, iconic, on-shore development near the coast in the south-west Pilbara of Western Australia (Chevron Australia 2010) against the data collected during the post-approval fauna salvage program during vegetation clearing and the project's early operations. The vertebrate fauna salvage data are publicly available, as it was a licence condition that all data are provided to the State government department that administered the *Wildlife Conservation Act 1950* (now replaced by the *Biodiversity Conservation Act 2016*).

The specific questions examined in this study are:

(1) How representative were the EIA terrestrial vertebrate fauna survey data of the fauna assemblage as known from a comprehensive fauna salvage program?
(2) Were the EPA's guidelines adhered to, and if not, what aspects were not adhered to?
(3) What is the consequence, if any, of the EPA accepting survey data that does not adhere to the expectations of its own guidance on terrestrial fauna surveys?

To meet the EPA's (2004) fauna survey requirements to enable it to understand biodiversity at species and ecosystem levels, and ecological functional value at the ecosystem level for the proposed impact area, we have assumed that a near-complete vertebrate fauna species list is required, a good indication of the relative abundance of each species is provided and all of the conservation-significant fauna are identified with an indication of their relative abundance. The purpose of this paper was not to assess whether the EPA guidance statement itself is appropriate or details adequate content on what and how data should be collected to allow regulators to make an informed decision on an EIA. Nor is our purpose to review or discuss whether a near-complete inventory of the vertebrate fauna is required (or even achievable) for an adequate EIA. However, we do believe that these issues need to be addressed in the revising of the EPA's guidelines.

Methods

Site

The development area (~1000 ha; i.e. project area) was ~15 km south-west of Onslow, on the south-west coast of the Pilbara in Western Australia. The development area was split into two zones: the liquid natural gas (LNG) plant, which is on the coast; and the accommodation camp and supporting infrastructure, which is ~10 km inland. The supporting infrastructure and the LNG plant are now linked to the Onslow Road, which connects Onslow to the North-west Coastal Highway by a bitumen road, but there were numerous unsealed access tracks during the construction phase of the project. The vegetation clearing for the LNG plant and supporting infrastructure included coastal dunes and coastal sand plain with low sand dunes interspersed by clay pans. Three vertebrate fauna assessments were undertaken to provide input into the EIA (Bamford Consulting Ecologists 2009; Biota Environmental Sciences 2010*a*, 2010*b*).

Preassessment surveys

Bamford Consulting Ecologists (2009) undertook a two-season survey of migratory waterbirds in the project area, but as these migratory birds are seldom recorded during a fauna salvage program, no comparison with these data was undertaken. Two reports relate to the terrestrial vertebrate fauna: Biota Environmental Sciences (2010*a*) reported results of its Level 2 terrestrial vertebrate fauna survey for most of the project area ('EIA survey') and Biota Environmental Sciences (2010*b*) is an addendum to the first report and is a desktop assessment of five additional areas adjacent to that surveyed in the first report (i.e. 'EIA desktop assessment'). Data from the first report are the basis of the desktop assessment and no further trapping surveys were undertaken. Bats, birds and short-range endemic invertebrates were recorded and assessed in both reports, but only the terrestrial vertebrate fauna have been compared in this study as other taxa were only opportunistically recorded in the fauna salvage program.

The EIA vertebrate fauna survey was undertaken at 16 sites in April 2009; however, the vegetation clearing program and the supporting fauna salvage program was undertaken in only a portion of the total area surveyed. The proposed gas pipeline from the project area towards the North-west Coastal Highway was excluded from the fauna salvage program, so fauna recorded at EIA survey sites along this pipeline corridor and outside the disturbance area have not been included in this study. Twelve of the 16 trapping sites have been included in this review (WHT01, 02, 03, 04, 05, 07, 08, 10, 11, 12, 14 and AQ001).

Post-assessment fauna salvage

Between November 2011 and July 2018 all terrestrial vertebrate fauna caught during the vegetation clearing program (Thompson

and Thompson 2015*b*), deconstruction of termitaria (Thompson and Thompson 2015*a*) and caught or observed in the vicinity of the project area were recorded. All habitat types where fauna were recorded were like those reported in the EIA survey assessments. During the vegetation clearing program, zoologists salvaging fauna would work in conjunction with machine operators and as fauna were disturbed, moved or fled they were caught by hand and subsequently relocated. During construction of the supporting infrastructure and LNG plant, terrestrial vertebrate fauna seen within the project area were caught and relocated as they were at risk of being injured or killed. Injured and dead fauna (e.g. road kills) in the vicinity of the project area were also recorded. Upon completion of vegetation clearing, and during the construction and early operations of the facility, a vertebrate pest management program was implemented. This program was aimed at removing feral cats from the project area, and these records have been included in this review. Captured live native fauna were relocated to suitable habitat away from the disturbance areas and feral or pest fauna were humanely euthanased.

Limitations

It is acknowledged that the relative abundance of small mammals and reptiles vary within and between seasons and years (see, for example, Dickman *et al.* 2001, Thompson and Thompson 2007; Pavey *et al.* 2020). Bamford and Calver (2015) reported that a survey for terrestrial fauna in the Banksia low woodland and kwongan heath ~150 km north of Perth revealed biases among different survey techniques. On the basis of data from intensively searched 5 m by 5 m plots in two areas, they reported that pit-fall trapping (i.e. 20-L buckets and no drift fences) was extremely biased towards large, surface-active lizards compared with the assemblage determined by total removal, which was dominated by small, fossorial species. In contrast, Craig *et al.* (2009) compared pit-fall trapping (i.e. 850-mL containers, 20-L buckets and 150-mm-diameter PVC pipes, along a fly-wire drift fence) results from six sites in various jarrah-forest habitats with intensively searched 150-m^2 total-removal plots around each pit-fall grid to obtain absolute densities of reptiles. Capture probabilities for the two most common, small, fossorial skinks, *Hemiergis initialis* and *Lerista distinguenda*, were significantly correlated for both survey techniques, and were not correlated with any structural variables, indicating that capture probabilities were consistent across sites. Drift fences are known to increase captures and may significantly increase fossorial species caught (Webb 1999; Jenkins *et al.* 2003; Ellis 2013), which may account for some of the differences in the findings reported in the above studies. The EIA survey used a combination of 20-L buckets and 150-mm-diameter PVC pipes as pit-traps, and funnel traps along flywire drift fences, and aluminium box traps as the trapping techniques, which were supported by habitat searches for Schedule- (under the then *Wildlife Conservation Act 1950*) and Priority-listed fauna (i.e. species that the State Department was monitoring as they have a potential to become threatened), opportunistic observations and secondary signs (e.g. tracks, scats and diggings) to record the vertebrate fauna in the project area. We acknowledge that the relative abundance of vertebrate fauna caught in traps will differ from that recorded during a fauna salvage program.

Results

The EIA survey recorded 50 vertebrate species known to be on-site compared with 75 non-incursion species (81 species in total) recorded during the fauna salvage program (Table 1). Only four of six amphibian species recorded in the fauna salvage program were caught in the EIA survey, and seven of the 16 mammal species present were reported during the EIA surveys. Four of eight dragon lizards and all eight gecko species were recorded during the EIA survey compared with the salvage program. The EIA survey recorded both python species, caught three of the four species of legless lizards, three of the four species of blind snakes, all but two of the skink species, six of the eight front-fanged snake species, and two of the five goanna species recorded in the fauna salvage program. The EIA survey caught 13 *Varanus caudolineatus*, four *Ctenotus inornatus*, one *Ctenotus calurus* and one *Pseudonaja modesta*: none of these species were recorded in the fauna salvage program. Incursions (i.e. *Hemidactylus frenatus*, *Duttaphrynus melanostictus*, *Rattus rattus*, *Litoria caerulea*, *Gehyra nana* and *Litoria gracilenta*) that arrived during construction would not have been included in the EIA survey report.

The EIA survey report indicated that *Dasyurus hallucatus*, which is listed as Endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*), was unlikely to be recorded in the project area. Northern quolls are present in the Onslow township and there were at least two and possibly three northern quolls in the project area. One was caught on multiple occasions (between 1 August 2017 and 7 April 2018) even though it was trapped and moved out of the project area. Another northern quoll, seen on 9 October 2012 and again on 6 June 2013, is highly unlikely to be the male recorded in August 2017, and may have been two individuals as they were not caught.

Discussion

The scope for the EIA fauna survey included identifying and assessing the local and regional conservation-significant fauna and documenting the vertebrate fauna assemblage in the project area (Biota Environmental Sciences 2010*a*). Therefore, species that were listed under the *EPBC Act*, the Western Australian *Wildlife Conservation Act* and on the Department of Parks and Wildlife's (now Department of Biodiversity, Conservation and Attractions, DBCA) Priority species list should have been recorded or assessed if they were in the area.

Not recorded species present in the project area

Twenty-five of the 75 non-incursion species recorded during the fauna salvage program were not recorded during the EIA survey. Of the species recorded in the EIA survey but not recorded during the fauna salvage program, the presence of *C. calurus* in the project area would have been a range extension (Storr *et al.* 1999), so it is possible that this was a misidentified *Ctenotus iapetus* or *Ctenotus maryani*. *Pseudonaja modesta* has a wide geographic distribution in Western Australia (Storr *et al.* 2002) and is normally encountered in low numbers, but it is unusual for a single snake of a species to be caught given the extensive fauna salvage program. It is unlikely that *V. caudolineatus* was in the project area, as it is a small arboreal species of goanna that lives

Table 1. A comparison of non-volant terrestrial vertebrate fauna caught or seen in the project area during the fauna salvage program and the environmental impact assessments (EIA) survey

Family	Species	EIA survey	Fauna salvage
Dasyuridae	*Dasykaluta rosamondae*		101
	Dasyurus hallucatus		7
	Planigale sp.	1	41
	Sminthopsis macroura		24
	Sminthopsis youngsoni		2
Canidae	*Canis familiaris*		28
	Vulpes vulpes		16
Felidae	*Felis catus*	[A]	207
Macropodae	*Osphranter robustus*	3	99
	Osphranter rufus	3	36
Muridae	*Leggadina lakedownensis*		56
	Mus musculus	8	912
	Notomys alexis		102
	Pseudomys desertor	2	22
	Pseudomys hermannsburgensis	4	47
	Rattus rattus[B]		11
Leporidae	*Oryctolagus cuniculus*		1
Tachyglossidae	*Tachyglossus aculeatus*		18
Total no. of mammals		21	1595
No. of mammal species		7	18
Agamidae	*Lophognathus gilberti*		1
	Ctenophorus femoralis		7
	Ctenophorus isolepis	13	88
	Ctenophorus nuchalis	5	301
	Ctenophorus rubens		32
	Diporiphora adductus	8	80
	Gowidon longirostris		20
	Pogona minor	2	89
Total no. of dragon lizards		28	618
No. of dragon lizard species		4	8
Boidae	*Antaresia stimsoni*	5	444
	Aspidites melanocephalus	3	106
Total no. of pythons		8	550
No. of python species		2	2
Carphodactylidae	*Nephrurus levis*	11	143
Diplodactylidae	*Diplodactylus bilybara*	20	1041
	Lucasium stenodactylum	8	20
	Strophurus jeanae	8	67
	Strophurus strophurus	4	113
Gekkonidae	*Gehyra nana*[B]		1
	Gehyra pilbara	1	3218
	Gehyra variegata	1	443
	Hemidactylus frenatus[B]		3
	Heteronotia binoei	9	782
Total no. of geckos		62	5831
No. of gecko species		8	10
Pygopodidae	*Delma butleri*		47
	Delma sp.		127
	Delma tincta	8	1142
	Lialis burtonis	8	61
	Pygopus nigriceps	2	162
Total no. of legless lizards		18	1539
No. of legless lizard species		3	4
Scincidae	*Ctenotus calurus*	1	
	Ctenotus grandis	8	512
	Ctenotus hanloni	9	1569
	Ctenotus iapetus	8	496
	Ctenotus inornatus[C]	4	
	Ctenotus maryani		607
	Ctenotus pantherinus	22	421
	Ctenotus rufescens	6	36
	Ctenotus sp.		69
	Eremiascincus pallidus	17	34
	Lerista bipes	128	1071
	Lerista clara	9	574
	Lerista muelleri		4
	Lerista onsloviana	26	51
	Menetia greyii	10	79
	Tiliqua multifasciata	1	67
Total no. of skinks		249	5613
No. of skink species		13	13
Typhlopidae	*Anilios ammodytes*	3	14
	Anilios grypus	13	20
	Anilios hamatus	1	83
	Anilios pilbarensis		8
	Anilios sp.		31
Elapidae	*Acanthophis pyrrhus*		60
	Demansia psammophis	10	141
	Furina ornata	3	437
	Pseudechis australis	3	184
	Pseudonaja mengdeni	6	228
	Pseudonaja modesta	1	
	Simoselaps anomalus	2	9
	Suta fasciata		3
	Suta punctata	1	179
Total no. of snakes		43	1397
No. of snake species		10	12
Varanidae	*Varanus acanthurus*		3
	Varanus brevicauda	3	562
	Varanus caudolineatus	13	
	Varanus eremius	8	183
	Varanus gouldii		161
	Varanus panoptes		26
Total no. of goannas		24	935
No. of goanna species		3	5
Hylidae	*Cyclorana maini*	8	9407
	Cyclorana occidentalis		1
	Litoria caerulea[B]		51
	Litoria rubella	3	1
	Litoria gracilenta[B]		1
Limnodynastidae	*Neobatrachus aquilonius*	18	521
	Neobatrachus fulvus		192
	Neobatrachus sp.		34
	Notaden nichollsi	1323	166
Bufo	*Duttaphrynus melanostictus*[B]		1
Total no. of amphibians		1352	10 375
No. of amphibian species		4	9
Total no of individuals		1805	28 459
No. of species		54	81

[A]Present.
[B]Incursion.
[C]See Rabosky *et al.* (2014) where this species has subsequently been split to *C. inornatus*, *C. superciliaris* and *C. robustus* and these three species are potentially in the project area.

under bark and in tree hollows or is occasionally found under exfoliating rocks in the Goldfields and Murchison. There is no suitable habitat in the project area for this species and the nearest records are ~100 km away. This species is also unlikely to be misidentified, so it is probably a data entry error. *Ctenotus inornatus* was caught on four occasions and was not recorded during the fauna salvage program. Rabosky *et al.* (2014) indicated that *C. inornatus* is characterised by extreme geographic variation in colour pattern and may be confused with numerous species, so it is possible that it was misidentified as one of the other *Ctenotus* spp. caught in the area. Rabosky *et al.* (2014) indicated that the '*inornatus*' species potentially present in the project area are *C. inornatus*, *C. superciliaris* and *C. robustus*, none of which were recorded in the fauna salvage program.

Some species that retreat to relatively deep burrows (e.g. *Notomys alexis*) would have been lost in their burrows during the vegetation clearing program and other species move out of the area in advance of vegetation clearing, so may not have been recorded (e.g. *Pseudechis australis*). There are other native species that appear to readily move into the built infrastructure and surrounding area (e.g. *Antaresia stimsoni*, *Mus musculus*) that would have been recorded more frequently than those that did not. These behavioural attributes introduce an unavoidable bias into the fauna salvage data, such that the relative abundance of each species reported here would not necessarily be representative of the relative abundance in the undisturbed bushland.

Conservation-significant species

An important aspect of Level 2 terrestrial fauna assessments is to record the presence and relative abundance of conservation-significant species (i.e. listed under the *EPBC Act* or the *Biodiversity Conservation Act*) in and near the project area. Should a species listed under the *EPBC Act* be present and significantly impacted by the project, then a referral to the Commonwealth government is required. Environmental practitioners routinely include the DBCA's listed Priority species in their discussion of potential impacts on threatened species and are encouraged by government to identify their presence in potential impact areas.

A Commonwealth government–listed endangered species (i.e. *D. hallucatus*) was not recorded in the EIA survey. The EIA survey report indicated that *D. hallucatus* was not considered to be in the project area as none of the land systems in which it was known to occur were present (Biota Environmental Sciences 2010*c*). At least two (and possibly three) *D. hallucatus* were in the project area, another was caught in the Onslow township ~15 km north-east of the project area, and local residents reported seeing other individuals around town, so they were in the general area but probably in low densities. Had the presence of northern quolls in the project area been recorded and the project considered a potentially significant negative impact on this species, then it was likely that both the Commonwealth and State governments would have imposed conditions to mitigate potential impacts on this species and may have added additional environmental offsets to the project.

The EIA survey report listed *Pseudomys chapmani*, *Sminthopsis longicaudata*, *Leggadina lakedownensis* and *Dasycercus blythi* as potentially being in the general area. The habitat preference for *P. chapmani* and *S. longicaudata* (Burbidge *et al.* 2008; Start 2008) meant that they were unlikely to be caught during the fauna salvage program but could be recorded further east in other areas assessed during the EIA survey, but *L. lakedownensis* was subsequently caught in the project area.

Importance of termitaria

Although obvious features in the landscape, termitaria were inadequately sampled or considered as fauna habitat during the EIA survey, as there was no indication in the EIA survey reports to indicate that they were searched or targeted spotlighting searches were undertaken of their exterior looking for animals. In all, 158 termitaria were directly impacted during the vegetation-clearing process. Of the 28 457 animals salvaged, 5458 were from termitaria (Thompson and Thompson 2015*a*). Large above-ground termitaria provide an important food resource for small vertebrates (Fleming and Loveridge 2003), protection from fires and flooding, a thermal environment that modifies the external extremes (Vitt *et al.* 2007), and nesting sites for birds and reptiles (King and Green 1999; Brightsmith 2000; Knapp and Owens 2008; Joseph *et al.* 2011). Some species such as *Planigale* sp. and *Gehyra pilbara* were almost exclusively found in large above-ground termitaria, while other species such as *Antaresia stimsoni* and *Furina ornata* were disproportionally abundant in mounds. Given the difference and possible importance of this microhabitat, termitaria should have been surveyed to provide a more complete appreciation of the terrestrial vertebrate biodiversity in the project area.

Not achieving EPA objectives

As the project was formally assessed by the EPA and no additional field surveys or targeted assessments were requested, we concluded that the EPA was satisfied with the adequacy and completeness of the EIA survey. The EIA survey recorded 67% (excluding incursions) of species, reported appreciably different relative abundance for many species (e.g. *Gehyra pilbara*) and did not adequately survey an important fauna habitat (e.g. termitaria). In our opinion, the EPA should have recognised the importance of termitaria and the possible presence of northern quoll, or in the absence of specialist zoological staff to adequately assess projects such as these, then the fauna assessment should have been referred to a peer-review process by experienced field zoologists who may have been able to better identify these gaps in the assessment. If recording 67% of the vertebrate species and reporting incorrect relative abundances for many species is adequate for the EPA to undertake its assessment, then why undertake field surveys at all when that quality of data is readily available from online database searches for many areas in Western Australia. It is our view that the EPA's objectives and expectations, as indicated in its guidance statements, were not achieved by this fauna survey. The extent to which EIA reports, such as the ones discussed here, are reviewed by experienced zoologists is not transparent, and appears to be in need of review by the EPA, and perhaps should be part of the review of its terrestrial vertebrate fauna guidance statements.

Inadequate sampling effort

The EPA (2004) guidance statement required that multiple surveys be undertaken in the appropriate season. The EIA survey was a single-season survey in April. Elsewhere in the Pilbara it has been demonstrated (Thompson *et al.* 2010) that the daily

maximum ambient temperature has a significant effect on the number of animals trapped and the inferred relevant abundance for species. Had two or more surveys been undertaken, with one in the hotter summer months, then it is highly likely that the relative abundance of various species would have been more accurately represented and the species list more comprehensive: this was acknowledged by Biota Environmental Sciences (2010*a*). It is appreciated that poorly executed surveys in hot weather can result in increased trap-deaths, but this impact can be minimised with the implementation of appropriate survey protocols (see Thompson and Thompson 2009; Read *et al.* 2018).

It is acknowledged that different sampling methods (e.g. pit-trapping versus fauna salvage program and destructive sampling of termitaria) will provide differing relative abundances; however, in this situation, inadequate sampling intensity and a lack of survey site replication has been an important contributor to species not being recorded and the relative abundance of some species differing appreciably from the fauna salvage program data. Many vertebrate species have a patchy distribution even at a local scale, with the consequence that if one of their 'patches' is not sampled, then they are not recorded. The EIA survey vegetation mapping recognised multiple vegetation communities in the project area, and, for some of these, the survey effort was insufficient to record most of the species present (Thompson *et al.* 2007) or to accurately represent relative abundance.

An appendix to the EIA survey report listed the reptile and mammal species recorded in other surveys in the general vicinity. There is no comment in the EIA survey report's discussion that uses these data or provides a commentary on how the fauna assemblage in the project area differs from those at these other nearby locations. Based on a comparison with species richness for surveys in the Onslow Salt (Biota Environmental Sciences 2005*a*), Yannerie Salt (Biota Environmental Sciences 2005*b*), Tubridgi Gas Plant and Cane River Conservation Park areas, the authors of the EIA survey report concluded that they had adequately documented the fauna in the project area, as these other surveys were conducted over more than one phase and sampled more habitats than in the project area but caught less species and that these differences reflected the optimal timing of the EIA survey. This conclusion is not supported by the fauna salvage program data, as relative abundance of many species was vastly different to that implied by the EIA survey data, and it makes a significant assumption that the earlier surveys were adequate.

Terrestrial fauna survey 'guidance'

A vertebrate fauna survey is expensive and should therefore add significant value to what is already known about the vertebrate fauna in a project area. The Atlas of Living Australia and DBCA's NatureMap provide online searchable databases that enable environmental practitioners to compile a species list for most areas of Western Australia. A few practitioners also maintain a database of their own records and a very small number maintain a database of fauna records from publicly available reports. So, in areas that have been thoroughly surveyed, a near-complete species inventory can be compiled by reviewing the data collected in adjacent areas. However, seldom are these data adequate to discuss ecosystem functional values, which was a requirement under the EPA Position Statement No. 3. NatureMap and often Atlas of Living Australia provide no or limited information about the source of their data, so it is often not possible to know soils, vegetation types and condition, or the trapping effort or fauna habitats that yielded these data. However, if a species list for a potential impact area is all that is required by the government regulators to assess potential impacts, then in many circumstances online database-generated lists will generally be adequate, saving the proponent the cost of the survey(s). If government regulators require information on the biodiversity value at the species and ecosystem levels, and an assessment of an area's ecological functional value (EPA 2002), then a detailed on-site survey will generally be required.

Fraser *et al.* (2003) assessed 15 EIA fauna surveys for the Goldfields region of Western Australia and indicated that most surveys performed poorly against established criteria, with a high proportion failing to address criteria considered essential, including the search of government databases, detection of rare/endangered fauna and multi-season sampling. All reports failed to employ sufficient trapping effort at both the biotope and landscape scales to adequately assess terrestrial vertebrate fauna biodiversity. Four years later, Thompson (2007) assessed the adequacy of terrestrial fauna surveys undertaken to support publicly released EIAs and indicated that the EPA was not always adhering to its own position and guidance statements. This paper went on to argue that the EPA's guidance needed improvement. The conclusions of these two papers and the data provided here lead us to question, in our judgement, whether environmental practitioners are using the EPA's guidance and it appears, in our opinion, that the EPA is prepared to accept EIA fauna survey data that could be viewed as being unlikely to be helpful in enabling it to understand biodiversity at species and ecosystem levels, and ecological functional value at the ecosystem level for proposed impact areas.

We need new terrestrial fauna guidelines

The current Western Australian EPA (2004, 2016*a*, 2016*b*) guidance statements are out of date, lack a focus on the purpose of assessing vertebrate fauna in an EIA, lack a rationale and guidance for completing in-field assessment(s) and provide no indication of what data are being used by regulators when assessing potential impacts and suitability of proposed management strategies during an EIA process. In our opinion, the guidance statements are in need of significant revision and amendment. This study also highlights that the guidance statements do not appear to be regularly adhered to by environmental practitioners.

Significant advancements and development of new and refined techniques have been made since the guidance statements were published, including the use of camera traps, thermal and night vision equipment, conservation detection dogs and drones. Our knowledge of the terrestrial vertebrate fauna has also appreciably increased for parts of Western Australia that were relatively poorly surveyed (e.g. Goldfields and the Pilbara) compared with when these documents were published. The recently released Terrestrial Vertebrate Fauna Survey Guidelines for Queensland (Eyre *et al.* 2018) is a much more comprehensive guideline of the terrestrial vertebrate fauna survey requirements to support EIAs, including details on generic surveys and specific methods for targeted surveys using a variety of survey techniques. This document outlines the Queensland Department of Environment and Science's minimum requirements, standards, and the appropriate practice for

the survey of terrestrial vertebrate fauna. It provides useful guidelines on important issues such as survey area, survey units, replication and location of survey sites, use of species accumulation curves to determine adequacy of surveys, power of sampling, survey timing, factors that affect survey results and sources of variation, and data management, and is generally a lot more prescriptive than the Western Australian EPA's guidance statements (EPA 2016*a*, 2016*b*). This document would be a useful starting point in redrafting the Western Australian EPA's guidance statements, as would the input of experienced field zoologists that regularly undertake EIA fauna surveys.

The race to the bottom – tendering fauna surveys and assessments

In our opinion, pressure to win competitive work within the parameters of what could be viewed as vague guidance and acceptance of fauna survey data by the EPA that in some instances may not, in our judgement, meet its own guidance minimum standards will likely result in a lowered standard of fauna data collection. In an environment where fauna surveys and assessments undertaken for proponent developments are put to tender and price is a major determinant of who gets the work, vague and non-specific EPA guidance statements result in practitioners looking to do the least amount of field survey work to win the contracts. It is likely, in the authors' view, that the EPA's acceptance of fauna assessments and survey reports that, in our judgement, may not meet its own guidance expectations (EPA 2004, 2016*a*, 2016*b*), without adequate justification, could further exacerbate the problem.

Authors' comment

The data for this study came from one of Western Australia's largest resource developments and one considered iconic (Chevron Australia 2010) in the resource development industry. These are the only data available to us to discuss the points raised about the standard of vertebrate fauna surveys for EIAs in Western Australia. We have read many environmental consultant reports and are of the view that Biota Environmental Sciences' work is of a high standard and competent relative to the work of others. We are confident that had we been able to assess multiple Level 2 fauna survey reports prepared by other consultancies and the follow-up fauna salvage program data, then there would have been many other examples where the findings would have been similar or worse than those reported here.

Conclusion

A single-, rather than multiple-season, survey in different seasons, insufficient trapping effort (i.e. repeated sites in each of the major fauna habitat types), not surveying an important fauna habitat and the presumption that a threatened species was not present due to landform, has resulted in an EIA survey report that contains an incomplete vertebrate species list, biased relative abundance for some recorded species and no record of a species listed as endangered under the *EPBC Act*. This could have resulted in an incomplete or erroneous assessment of potential impacts on biodiversity at species and ecosystem levels, or the ecological functional value of the area at the ecosystem level. Although acceptable to the EPA, the expectations of the EPA's position and guidance statements were not met in undertaking the terrestrial fauna survey. Given that the goal of an EIA is environmental protection and sustainable development (Caldwell 1988; Morrison-Saunders and Arts 2004; MacKinnon *et al.* 2018), an inadequate terrestrial vertebrate fauna survey may impact on the integrity of the process and the outcome.

Reviewing the Western Australian EPA's (2016*a*) rebadged guidance statement and technical guide (EPA 2016*b*) to ensure that they meet the current requirements of the relevant agencies and assessors, and are based on the most recent research, technology and techniques is a priority. Reminding proponents and environmental practitioners of the EPA's expectations should follow the publication of revised guidelines, and supplementary data should be required of proponents and their environmental practitioners by the Western Australian EPA when surveys, assessments and reports submitted to support EIAs are inadequate.

Conflicts of interest

Both authors are Partners and Principal Zoologists with Terrestrial Ecosystems, who was engaged by the developer of the infrastructure for this project to provide fauna management services. Fauna salvage data were collected during this contract.

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References

Bamford, M. J., and Calver, M. C. (2015). A comparison of measures of abundance of reptiles in Kwongan vegetation of the south-west of Australia, determined through systematic searching and pitfall trapping. *Australian Zoologist* **37**, 472–484. doi:10.7882/AZ.2015.017

Bamford Consulting Ecologists (2009). Survey for migratory waterbirds in the Wheatstone LNG Project Area, November 2008 and March 2009. Unpublished report for URS Australia Pty Ltd, Perth.

Biota Environmental Sciences (2005*a*). Onslow Solar Salt Field annual environmental report 2005. Unpublished report for Onslow Salt Pty Ltd, Perth.

Biota Environmental Sciences (2005*b*). Yannarie Salt Project fauna survey. Unpublished report for Straits Salt Pty Ltd, Perth.

Biota Environmental Sciences (2010*a*). Wheatstone Project terrestrial fauna survey. Unpublished report for URS Australia Pty Ltd and Chevron Australia Pty Ltd, Perth.

Biota Environmental Sciences (2010*b*). Wheatstone Project flora and fauna assessment addendum. Unpublished report for URS Australia Pty Ltd and Chevron Australia Pty Ltd, Perth.

Biota Environmental Sciences (2010*c*). Yandicoogina Expansion Northern Quoll position paper. Unpublished report for Rio Tinto Iron Ore, Perth.

Brightsmith, D. J. (2000). Use or arboreal termitaria by nesting birds in the Peruvian Amazon. *The Condor* **102**, 529–538. doi:10.1093/CONDOR/102.3.529

Burbidge, A. A., McKenzie, N. L., Brennan, K. E. C., Woinarski, J. C. Z., Dickman, C. R., Baynes, A., Gordon, G., Menkhorst, P. W., and Robinson, A. C. (2008). Conservation status and biogeography of Australia's terrestrial mammals. *Australian Journal of Zoology* **56**, 411–422. doi:10.1071/ZO08027

Caldwell, L. K. (1988). Environmental impact analysis (EIA): origins, evolution, and future directions. *Impact Assessment* **6**, 75–83. doi:10.1080/07349165.1988.9725648

Chevron Australia (2010) Draft environmental impact statement/environmental review and management program for the Proposed Wheaststone Project: Volume 1 (Chapters 1 to 6). Unpublished report for Chevron Australia Pty Ltd, Perth.

Craig, M. D., Grigg, A. H., Garkaklis, M. J., Hobbs, R. J., Grant, C. D., Fleming, P. A., and Hardy, G. E. StJ. (2009). Does habitat structure influence capture probabilities? A study of reptiles in a eucalypt forest. *Wildlife Research* **36**, 509–515. doi:10.1071/WR09014

Dahlitz, V., and Morrison-Saunders, A. (2015). Assessing the utility of environmental factors and objectives in environmental impact assessment practice: Western Australian insights. *Impact Assessment and Project Appraisal* **33**, 142–147. doi:10.1080/14615517.2014.981057

Dickman, C. R., Haythornthwaite, A. S., McNaught, G. H., Mahon, P. S., Tamayo, B., and Letnic, M. (2001). Population dynamics of three species of dasyurid marsupials in arid central Australia: a 10 year study. *Wildlife Research* **28**, 493–506. doi:10.1071/WR00023

Ellis, M. (2013). Impacts of pit size, drift fence material and fence configuration on capture rates of small reptiles and mammals in the New South Wales rangelands. *Australian Zoologist* **36**, 404–412. doi:10.7882/AZ.2013.005

EPA (2002). Terrestrial biological surveys as an element of biodiversity protection. Position Statement No. 3. Environmental Protection Authority, Perth.

EPA (2004). Guidance for the assessment of environmental factors. Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia No. 56. Environmental Protection Authority, Perth.

EPA (2016*a*). Technical guidance – terrestrial fauna surveys. Environmental Protection Authority, Perth.

EPA (2016*b*). Technical guidance – sampling methods for terrestrial vertebrate fauna. Environmental Protection Authority, Perth.

EPA and DEC (2010). Technical guide – terrestrial vertebrate fauna surveys for environmental impact assessment. Environmental Protection Authority and Department of Environment and Conservation, Perth.

Eyre, T. J., Ferguson, D. J., Hourigan, C. L., Smith, G. C., Mathieson, M. T., Kelly, A. L., Venz, M. F., Hogan, L. D., and Rowland, J. (2018). Terrestrial vertebrate fauna survey assessment guidelines for Queensland. Department of Environment and Science, Queensland Government, Brisbane.

Fleming, P. A., and Loveridge, J. P. (2003). Miombo woodland termite mounds: resource islands for small vertebrates. *Journal of Zoology* **259**, 161–168. doi:10.1017/S0952836902003084

Fraser, J. L., Thompson, G. G., and Moro, D. (2003). Adequacy of terrestrial fauna surveys for the preparation of environmental impact assessments in the mining industry of Western Australia. *Ecological Management & Restoration* **4**, 187–192. doi:10.1046/J.1442-8903.2003.00155.X

Jenkins, C. L., McGarigal, K., and Gamble, L. R. (2003). Comparative effectiveness of two trapping techniques for surveying the abundance and diversity of reptiles and amphibians along drift fence arrays. *Herpetological Review* **34**, 39–42.

Joseph, G. S., Cumming, G. S., Cumming, D. H. M., Mahlangu, Z., Altwegg, R., and Seymour, C. L. (2011). Large termitaria act as refugia for tall trees, deadwood and cavity-using birds in a miombo woodland. *Landscape Ecology* **26**, 439–448. doi:10.1007/S10980-011-9572-8

King, D., and Green, B. (1999) 'Goanna: The Biology of Varanid Lizards.' (UNSW Press: Sydney.)

Knapp, C. R., and Owens, A. K. (2008). Nesting behavior and the use of termitaria by the Andros iguana (*Cyclura cychlura cychlura*). *Journal of Herpetology* **42**, 46–53. doi:10.1670/07-098.1

MacKinnon, A. J., Duinker, P. N., and Walker, T. R. (2018). Conceiving a role for science in EIA. In 'The Application of Science in Environmental Impact Assessment'. (Eds A. J. MacKinnon, P. N. Duinker, and T. R. Walker.) pp. 11–16. (Routledge: New York.)

Morrison-Saunders, A., and Arts, J. (2004). Introduction to EIA follow-up. In 'Assessing Impact Handbook of EIA and SEA Follow-up'. (Eds A. Morrison-Saunders, and J. Arts.) pp. 1–17. (Earthscan: London.)

Pavey, C. R., Nano, C. E. M., and Waltert, M. (2020). Population dynamics of dasyurid marsupials in dryland Australia: variation across habitat and time. *Austral Ecology* **45**, 283–290. doi:10.1111/AEC.12854

Rabosky, D. L., Hutchinson, M. N., Donnellan, S. C., Talaba, A. L., and Lovette, I. J. (2014). Phylogenetic disassembly of species boundaries in a widespread group of Australian skinks (Scincidae: *Ctenotus*). *Molecular Phylogenetics and Evolution* **77**, 71–82. doi:10.1016/J.YMPEV.2014.03.026

Read, J. L., Pedler, R. D., and Kearney, M. R. (2018). Too much hot air? Informing ethical trapping in hot, dry environments. *Wildlife Research* **45**, 16–30. doi:10.1071/WR17069

Start, A. N. (2008). Western pebble-mouse. In 'Mammals of Australia'. (Eds S. Van Dyck, and R. Strahan.) pp. 621–622. (Reed New Holland: Sydney.)

Storr, G. M., Smith, L. A., and Johnstone, R. E. (1999) 'Lizards of Western Australia. I: Skinks.' (Western Australian Museum: Perth.)

Storr, G. M., Smith, L. A., and Johnstone, R. E. (2002) 'Snakes of Western Australia.' (Western Australian Museum: Perth.)

Thompson, G. G. (2007). Terrestrial vertebrate fauna surveys for the preparation of environmental impact assessments; how can we do it better? A Western Australian example. *Environmental Impact Assessment Review* **27**, 41–61. doi:10.1016/J.EIAR.2006.08.001

Thompson, S. A., and Thompson, G. G. (2007). Temporal variations in ground-dwelling invertebrate biomass in the Goldfields of Western Australia. *Records of the Western Australian Museum* **23**, 235–240. doi:10.18195/ISSN.0312-3162.23(3).2007.235-240

Thompson, G. G., and Thompson, S. A. (2009). Comparative temperature in funnel and pit traps. *Australian Journal of Zoology* **57**, 311–316. doi:10.1071/ZO09052

Thompson, G. G., and Thompson, S. A. (2015*a*). Termitaria are an important refuge for reptiles in the Pilbara of Western Australia. *Pacific Conservation Biology* **21**, 226–233. doi:10.1071/PC14921

Thompson, S. A., and Thompson, G. G. (2015*b*). Fauna-rescue programs can successfully relocate vertebrate fauna prior to and during vegetation-clearing programs. *Pacific Conservation Biology* **21**, 220–225. doi:10.1071/PC14922

Thompson, G. G., Thompson, S. A., Withers, P. C., and Fraser, J. (2007). Determining adequate trapping effort and species richness using species accumulation curves for environmental impact assessments. *Austral Ecology* **32**, 570–580. doi:10.1111/J.1442-9993.2007.01729.X

Thompson, G. G., Thompson, S. A., and Finlayson, G. R. (2010). Spatial and temporal variations in the trapped terrestrial vertebrate fauna of the Hamersley Range, Western Australia. *Journal of the Royal Society of Western Australia* **93**, 51–64.

Vitt, L. J., Shepard, D. B., Caldwell, J. P., Vieira, G. H. C., Franca, F. G. R., and Colli, G. R. (2007). Living with your food: geckos in termitaria of Cantao. *Journal of Zoology* **272**, 321–328. doi:10.1111/J.1469-7998.2006.00273.X

Webb, G. A. (1999). Effectiveness of pitfall/drift-fence systems for sampling small ground-dwelling lizards and frogs in southeastern Australian forests. *Australian Zoologist* **31**, 118–126. doi:10.7882/AZ.1999.012

Wegner, A., Moore, S. A., and Bailey, J. (2005). Consideration of biodiversity in environmental impact assessment in Western Australia: practitioner perceptions. *Environmental Impact Assessment Review* **25**, 143–162. doi:10.1016/J.EIAR.2004.03.003