Adequacy of terrestrial fauna surveys for the preparation of Environmental Impact Assessments in the mining industry of Western Australia

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Summary The Western Australian Environmental Protection Authority has indicated that terrestrial fauna surveys undertaken for the purpose of preparing Environmental Impact Assessment (EIA) are providing inadequate information for decision-makers to assess development impacts on biodiversity and ecosystems. This study examined the current standard of terrestrial vertebrate fauna surveys undertaken as the basis for preparing an EIA. In the absence of a protocol to assess current standards of terrestrial fauna surveys, 'best practice' was defined and quantified through consultation with an 'expert panel'. Data from fauna surveys contained in 15 recent EIA reports from the Goldfields region of Western Australia were critically examined to determine the extent of compliance with 'best practice'. The majority of surveys performed poorly against the established criteria. A few reports addressed many of the issues comprehensively, however, at least 50% failed to mention or adequately address a high proportion of criteria considered essential, including searches of government databases, detection of rare/endangered fauna and multiseasonal sampling. All reports failed to employ sufficient trapping effort at both the biotope and landscape scales to adequately assess terrestrial vertebrate fauna biodiversity. These results indicate the need to redress minimum standards for terrestrial fauna surveys in order to meet the expectations of the EIA process.

Key words *best practice, Environmental Impact Assessments, terrestrial fauna survey.*

Introduction

Environmental Impact Assessment (EIA) is undertaken to predict the potential impact of mine site disturbance on the environment (Wood & Bailey 1996; Li *et al*. 2000). In addition to assessing potential impacts and contributing to decisions on whether or not the disturbance should proceed, and under what conditions, biological survey data collected for EIA can assist in defining post-development restoration goals by providing baseline biological data, and can make an important contribution to knowledge about biodiversity and ecosystem function (Environmental Protection Authority 2002).

Despite a rapid growth in the EIA process, increasing legal requirements and public expectation for increased environmental protection, significant problems have been identified with the EIA process (Treweek 1996; Wood & Bailey 1996; Eade 2000; Li *et al*. 2000) and there is still considerable scope for improvement (Stirling 1995; Treweek 1996; Wood & Bailey 1996; Hickie & Wade 1998; Wilson 1998; Barker & Wood 1999; Rees 1999; Ortega-Rubio *et al*. 2001; Steineman 2001). Inadequate or inappropriate ecological input into the development of EIA has been criticized as a primary reason for its inability to predict and evaluate ecological impacts of proposed disturbances (Beanards & Duinker 1984; Buckley 1993; Treweek 1999; Wood *et al*. 2000), along with a lack of sufficient data; poor survey methodology, temporal and spatial constraints, economic constraints and inadequate data evaluation leading to unreliable impact prediction (Underwood 1993; Warwick 1993; Wilson 1998; Li *et al*. 2000). However, regardless of the criticism directed at the EIA process, its use continues to increase in importance in government policy in Europe, North America, Asia, the Pacific region and Australia (Hughes 1999).

The Western Australian (WA) Environmental Protection Authority (EPA) claims that sufficient survey effort is rarely applied within an EIA to describe faunal populations prior to, or changes as a consequence of developments (i.e. mining) in WA (Environmental Protection Authority 2002). The purpose of terrestrial fauna surveys in an EIA is to: (i) correctly identify the presence of species within a defined habitat (regional, landscape, biotope), (ii) identify the presence of rare, endangered or range restricted species, (iii) identify fauna and their habitat that are important elements of biodiversity and functional ecosystems for the region, (iv) develop an understanding of the ecological processes within habitats, and (v) develop appropriate rehabilitation programs (Environmental Protection Agency 1995; Environmental Protection Authority 2002). Defining and quantifying the importance of ecosystem processes is complex, difficult, and lacking in scientific certainty (Nilsson & Grelsson 1995; Tilman 1999; Doherty *et al*. 2000; Ehrenfeld 2000). Moreover, the task is made more difficult because little is known about interactions between habitat and

terrestrial fauna diversity (Tilman 1999; Doherty *et al*. 2000; McKenzie *et al*. 2000; Polani *et al*. 2000). However, the ability of researchers and consultants to assess potential environmental impacts is dependent on the quality and coverage of fauna surveys and the subsequent data analyses. Inadequate or poorly designed fauna surveys, and/or an incomplete or inappropriate analysis of data leads to incorrect and inappropriate conclusions (Underwood 1993; Treweek 1996; Ehrenfeld 2000). The outcome of this situation is poor-quality decision-making within the EIA process.

The objective of this study was to assess the quality, usefulness and validity of terrestrial fauna survey data collected for the preparation of EIA in the mining industry of WA.

Methods

Overview

As there are no criteria to judge the adequacy of terrestrial fauna surveys for EIA, we developed criteria by quantifying expert opinion. Our research was undertaken in three stages. In the first stage we identified a comprehensive list of concerns and important issues pertaining to fauna surveys for the preparation of an EIA. The list was prepared from a literature search and information obtained from interviews with an 'expert panel'. In the second stage we used this information to design a questionnaire that was sent to experts (including all 'expert panel' participants) to develop and clarify expert opinion on 'best practice' for terrestrial fauna survey standards for the purpose of preparing an EIA. Results from the questionnaire enabled the compilation of criteria that were then used to evaluate fauna survey data submitted for consideration of the EPA as part of EIAs. In the third stage we used these criteria to evaluate compliance with 'best practice' for fauna surveys described in 15 recent consultant prepared EIA reports. All 15 reports were undertaken within the framework of a Consultative Environmental Review (CER) level assessment and sought approval for disturbances in areas that had not been previously mined or where mining impacts were minimal. These three stages are discussed in more detail below.

For the purposes of this study small terrestrial vertebrate fauna includes all small mammals (less than 200 g), reptiles and amphibians but does not include birds, as they are not typically a component of survey trapping. Bats were not considered, as their capture is highly specialized and rarely included within fauna surveys.

Study area

Data were collected from mine sites within the vicinity of the 'Coolgardie unit' of the Interim Biogeographical Regions of Australia (IBRA), which has been intensively mined (Bingley 1992; Blainey 1993). In comparison to other arid regions of WA, the fauna of the Coolgardie unit is comparatively well known (Dell & How 1984; McKenzie *et al*. 1992). Furthermore, we have considerable unpublished pitfall trap data for areas at either end of the Coolgardie unit, and a number of other small-scale biological surveys have been carried out within the region (M. J. Bamford, S. F. Davies and P. G. Ladd, unpubl. data, 1991; Barrett 1991; Chapman *et al*. 1991; Chapman 1994) which provided a useful reference.

Interviews with experts

Expert opinion was sought from researchers working in WA government agencies (Department of Conservation and Land Management [CALM]; Department of Environmental Protection (DEP) and the EPA), academic institutions, and from environmental consultants working in WA. Inclusion of a person on the 'expert panel' was based on their relevant experience in undertaking field surveys and/or interpreting terrestrial fauna survey data (arbitrarily defined as a minimum 5 years of professional experience). Structured interviews were undertaken with each of the 12 expert panel members and recorded on an audiotape for latter transcription. In addition to personal information (e.g. place of employment, relevant experience) interviewees were asked to identify and discuss the most important issues in terrestrial fauna surveys from a listof potential issues compiled from the literature. Respondents were also asked a series of open-ended questions about their perception of the goals of fauna surveys for application within EIA, adequacy, and strengths and weaknesses of current protocols, key areas of concern, and factors that influenced their opinion. Interviews were transcribed and a summary prepared.

Questionnaire to define 'best practice' criteria

A questionnaire was developed on the outcomes of the literature review and 'expert panel' interviews. The questionnaire was in two parts and sought information on: Part A – desktop surveys, field sampling design, planning, data analysis, interpretation and data validity; and Part B – seasonal trapping and trapping effort. The components of the respective parts of the questionnaire are discussed below.

Part A

Respondents were asked to assign a level of importance to each issue using a four-tiered scale: (i) not important (does not need to be considered); (ii) highly desirable (should be addressed but not essential); (iii) essential (must be addressed) and; (iv) undecided. All issues deemed as essential by a majority of respondents (> 50%) were deemed to be 'best practice' and were used as evaluation criteria when assessing consultants' fauna survey protocols as reported in EIA statements.

Part B

Respondents were asked to indicate the importance of trapping during spring, summer, autumn and winter, and over one annual cycle of all four seasons. Respondents were asked to assign one of the following three alternatives for trapping within a season: (i) mandatory (season must be included), (ii) only in special circumstances, and (iii) generally not necessary. Where a majority of respondents (> 50%) indicated trapping in that season was mandatory we deemed it to be best practice and it was used as evaluation criteria when assessing consultants' fauna survey protocols as reported for the EIA statement.

Field trapping was quantified at: (i) the biotope level (1 km^2 of homogeneous

habitat), and (ii) the landscape level (consisting of 10 homogeneous habitats or biotopes within a 100-km^2 area). Respondents were asked to nominate a level of trapping effort to adequately sample both at the biotope and landscape level (e.g. number of pitfall traps, Elliott traps, wire-cage traps, total trap nights per season per trap type, and total trap nights per trap type for all seasons that should be surveyed). The mean value of trapping effort for each variable was used as the measure of best practice and adopted as the criteria to judge the adequacy of surveys. Total trapping effort was defined as total trap nights for all seasons at the biotope or landscape scale.

Questionnaire respondents

Thirty-eight potential respondents were identified from the Environmental Consultants Register (Environmental Consultants Association 2000) in addition to the already identified 'expert panel' as potential respondents to the questionnaire. Personal contact was made with all potential respondents prior to mailing out of the questionnaire. During this discussion it was ascertained whether that person had relevant experience (defined as per the expert panel) and were available to complete the questionnaire in the required timeframe. Twenty-four respondents were deemed suitable (including members of the expert panel) and agreed to participate. Return rate for the questionnaire was 80% (20/24). Respondents comprised six government employees, 10 consultants and one academic researcher, with three anonymous responses.

Fauna survey reports

Reported terrestrial fauna survey data for CER level EIA reports were obtained from two sources: (i) mining companies in the Coolgardie IBRA, and (ii) publicly available EIA reports accessed through government libraries (CALM, DEP, EPA). The 15 most recent available survey reports (1994–2000) were evaluated using the criteria developed from the aforementioned process. Report compliance to individual criteria was scored on a four-point ordinal scale, as follows: (0) did not mention the issue, (1) mentioned but did not adequately address the issue, (2) addressed the issue to a moderate standard, and (3) comprehensively addressed the issue. To carry out the evaluation as objectively as possible, an evaluation key was used to assess each of the 15 consultant reports. This ensured uniformity in applying the criteria to each report.

Results

Desktop surveys

Searches of both the CALM and Western Australian Museum (WAM) databases, respectively, were carried out by only three of the 15 consultants. Published literature was reviewed during the preparation of all reports, and unpublished literature reviewed for 13 of the 15 reports (Table 1). Discussion on the conservation status of respective fauna groups was comprehensively addressed in 13 reports.

Repeated sampling in each of the four seasons, searches for rare/endangered and priority fauna, and surveys undertaken or supervised by a qualified zoologist were not mentioned or addressed by consultants in 12 of the 15 reports (Table 1). Description of key fauna habitat components was addressed in 10 reports, with five mentioning but not addressing the criterion. Opportunistic fauna observations were noted in 14 of 15 reports.

Data interpretation in the context of regional data sets (13 reports), reference to biodiversity values (12 reports), and reference to fauna identification sources (12 reports) were comprehensively addressed within most consultant reports (Table 1); however, constraints and limitations of fauna surveys were comprehensively addressed in only four reports. Evaluation of community assemblage/structure, and assessment of field data within an ecological context was comprehensively addressed in only three reports. The personnel who carried out the field survey and/or data analyses were mentioned in seven reports.

All reports failed to mention whether species lists conformed to WAM nomenclature and, if there was submission of trap deaths to the WAM (Table 1). Only two consultants submitted specimens to WAM for nomenclature verification where there was some doubt as to the identity of a specimen.

Trapping effort

Seasonal trapping was evaluated for 10 reports, as the other five reports made no reference to the season/s in which data were collected. Three reports indicated consultants undertook trapping in spring and autumn (minimum criteria), with the remaining seven consultants trapping in only one season.

Trapping effort at the biotope and landscape scales was evaluated for seven reports, as the remaining eight did not provide an adequate explanation of trapping methodology or effort. We report the mean level of effort over all sites. Reported total trapping effort (trap-nights for all seasons) was below the established minimum criteria in all reports at the biotope (409 trap nights; Table 2) and landscape (3630 trap nights; Table 2) scales.

Discussion

Although some fauna survey reports comprehensively addressed many of the essential issues, many failed to mention or adequately address a large proportion of issues.

Information used in desktop surveys

The results of our survey concur with the findings of Mattiske *et al*. (1995) who reported that environmental consultants in WA do not routinely search available databases during desktop surveys when preparing EIA reports. These specimen-based databases comprise historical records and are useful verified inventories for both common and threatened species for most areas in WA. It is appreciated that museum collections have some inherent shortcomings, most notably they are historical records that indicate where species were caught in the past, but may no longer exist in particular habitats because the environment has changed, and geographical gaps due to the ad hoc nature of collections (Withers & Edward 1997; Ponder *et al*. 2001). Nonetheless, museum collections are extremely valuable in providing known

Table 1. Evaluation results for desktop surveys, field sampling, field data analyses and interpretation, and data validity

Criteria	Evaluation score*			
	0	1	2	3
Number of reports addressing desktop survey components				
Search of Department of Conservation and Land Management database	12	~	~	3
Search of the Western Australian Museum database	12	~	~	3
A review of published literature relevant to the survey area		~	~	15
A review of unpublished literature/reports	2	~	~	13
Discussion on the conservation status of threatened fauna	1	1	~	13
Number of reports addressing field survey design and planning components				
Fauna sampling to be undertaken for one annual cycle (Spring and Autumn)	12	~	~	3
Description of key fauna habitat components	~	5	2	8
A component of the field survey protocol designed to search for rare/endangered, priority, and threatened fauna categories	12	1	~	2
Notation of opportunistic fauna observations to be described	1	~	~	14
All surveys undertaken or supervised by a qualified zoologist	12	~	~	3
Number of reports addressing field survey data analysis and interpretation components				
A written statement explaining the constraints and limitations of the study	5	2	4	4
Rational of survey methodology	1	1	5	8
Data interpretation in the context of regional data sets	2	~	~	13
Data analysed with reference to local/regional biodiversity values	2	1	~	12
Evaluation of assemblage/community structure for mammals, reptiles and amphibians	5	~	7	3
Reference to sources used for fauna identification			3	12
Assessment of the field data, within an ecological context	3	1	8	3
Identification of personnel that carried out the field survey, and data analysis and interpretation	6	~	2	7
Number of reports addressing data validity components				
Species lists conforming with current Western Australian Museum nomenclature	15	~	~	~
Verification by Western Australian Museum (via voucher specimens): All trap deaths submitted	15	~	~	~
Verification by Western Australian Museum (via voucher specimens): Where there may be some doubt, confusion or potential for incorrect identification	13	~	~	2

*Evaluation scores denoted as: 0, did not mention the issue; 1, mentioned but did not adequately address the issue; 2, addressed the issue to a moderate standard; 3, comprehensively addressed the issue.

and predictive distributional information (Ponder *et al*. 2001). If desktop surveys for EIA are to include the best available information, use of government databases can provide useful data for compiling species lists expected within an area.

Respondents also did not view searches of the National Environment Australia database for gazetted threatened species and ecological communities as essential. Under the Environmental Protection & Biodiversity Conservation Act (1999), the presence of gazetted threatened species and ecological communities is a trigger of the EIA process.

Adequacy of surveys to assess the diversity and status of fauna

Due to the variable climatic conditions for much of the arid environments in Australia, large-scale vertebrate fauna community changes can occur over relatively short periods of time (Buckley 1993; Treweek 1999). The suite of small terrestrial vertebrate fauna trapped can vary appreciably for season-to-season and year-to-year (Read 1992; Treweek 1999; Thompson & Thompson 2002). If the objective of field surveys is to inventory the small terrestrial vertebrate fauna in an area with the purpose of understanding community structure, then trapping must be undertaken when animals are active, and should encompass periods of climatic variation to adequately identify the species richness of arid zone mammals, reptiles and amphibians (Boone & Krohn 2000). Long-term surveys conducted over a range of climatic extremes are required to determine the presence and status of the suite of arid zone reptiles and amphibians (Morton *et al*. 1988; Read 1992, 1994; Morton *et al.* 1993; Cole & Woinarski 2000; Thompson & Thompson 2002). Arid adapted amphibians only surface after heavy rains and are unlikely to be recorded unless surveys are undertaken at the appropriate time (Grigg 2000). If frogs are considered an important component of the biodiversity and ecosystem, then it behoves mining proponents to survey when they are likely to be surface active.

In general, our findings support those of Mattiske *et al*. (1995) who suggest that seasonal effects and the need for multiple stages of data collection are often lacking in fauna surveys undertaken for EIA. In particular, our findings indicated that the majority of fieldwork was undertaken in one season, with only three of the 10 reports surveying in spring and autumn, and with no trapping undertaken in a second year.

Table 2. Comparison of trapping effort with established minimum criteria at the biotope and landscape levels

Trapping effort variables	Reports							Established minimum
	C	D	F	H	J	L	O	
Biotope								
No. sample sites	1	1	1	1	1	1	1	3
No. pit traps	6	5	8	10	10	10	10	10
No. Elliott traps	3	20	6	12	10	10	13	12
No. cage traps	1	0	1	0	1	1	2	4
No. traps nights per season	80	104	119	176	126	210	150	137
No. trap nights all seasons	160	209	119	176	126	210	150	409
Landscape								
No. pit traps	69	55	80	70	70	100	90	166
No. Elliott traps	43	220	60	84	70	100	69	198
No. cage traps	11	0	10	0	7	10	18	56
No. traps nights per season	924	1150	1189	1232	966	1666	1350	1371
No. trap nights all seasons	1848	2300	1189	1232	966	1666	1350	3630

Level of trapping effort required for field surveys

The level of trapping effort undertaken by consultants varied appreciably, with few reports meeting the best practice for any of the criteria. Overall, total trapping effort was well below the best practice at the biotope and landscape levels. Furthermore, based on terrestrial faunal survey pit-trap data for the Coolgardie IBRA region in WA (Thompson *et al*. 2003), the survey effort currently applied to terrestrial faunal surveys by consultants for homogenous and heterogenous habitats was insufficient to catch even 50% of the predicted number of species in the area. Moreover, the best practice criteria as defined by the expert panel was appreciably below what would be required to inventory species at either the biotope or landscape scales in the Coolgardie IBRA region. Low trapping effort may reflect commercial pressure from development proponents requiring consultants to adopt the lowest cost option in data collection strategies. While the WA EPA continues to accept substandard work (Environmental Protection Authority 2000) and does not set minimum field survey requirements (Environmental Protection Authority 2002), mining companies and their consultants will continue to undertake and present the results of inadequate fauna surveys. Information provided to us suggests that environmental consultants actively working with mining companies would welcome published minimum standards, as it would take the guesswork out of what is required.

Adequacy of field surveys to detect threatened fauna

Often the primary purpose of an EIA is to identify rare, endangered or range-restricted species whose habitat might be altered or put at risk if the proposed development was to proceed (Environmental Protection Authority 2002). Detection of threatened or range-restricted species is important as they are often most vulnerable to disturbance and once extinct constitute a measurable loss in biodiversity. For most large-scale pit-trap surveys, in excess of 40% of the species caught are represented by less than 0.5% of total captures (G. Thompson, unpubl. data, 2003) suggesting a high proportion of rare or difficult to catch species in most Australian arid areas. The current level of survey effort is inadequate to detect the presence of most of these species (Morton 1990; Environmental Protection Authority 2002; Thompson & Thompson 2002; Thompson *et al*. 2003), therefore negating the primary purpose of an EIA.

Standard survey protocols as described in most consultants' reports have little success in trapping priority taxa (McArdle 1990; Thompson & Thompson 2002), and most surveys did not employ species-specific strategies to search for threatened fauna. This must be of concern to government environmental authorities as it negates a primary objective of fauna surveys. It is necessary to develop and implement species-specific search strategies to identify the presence or absence of these species, and if the industry is unwilling to commit to this type of investigation then the relevant government agencies must include this in their prescribed protocols.

Summary

Decision-makers (e.g. the EPA in WA) base their assessment on the acceptability of proposed developments on the information provided in EIA documents (Environmental Protection Authority 1993). This study has indicated that for the purpose of preparing an EIA, consultants and mining companies are not adequately surveying terrestrial fauna for the purpose of assessing potential impacts of development on biodiversity and ecosystems, a view expressed by the EPA in Position Statement No. 3 (Environmental. Protection Authority 2002). Fauna surveys have the potential to supply valuable information on the current status of biodiversity and provide valuable insights into ecosystem function; however, inadequate surveys can result in developments proceeding with the significant loss of biodiversity. If adequate data collection and relevant ecological information are collected as part of the fauna survey process, not only can EIA become more useful, but also our knowledge of biodiversity of a region can be enhanced.

Acknowledgements

We thank the 'expert panel' for sharing their experience and expertise; all questionnaire respondents; and the Environmental Protection Authority, Department of Conservation and Land Management and Centre for Ecosystem Management for financially contributing to this research. The Edith Cowan University Ethics Committee approved the research.

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