SPECIES IMPACT STATEMENT

AERIAL BAITING WITH 1080 POISON FOR WILD DOG CONTROL IN NEW SOUTH WALES NATIONAL PARKS AND WILDLIFE SERVICE RESERVES

DECEMBER 1999

Prepared for:
NSW National Parks and Wildlife Service
PO Box 1967
Hurstville, NSW 2220
Australia.

Prepared by:
Dr John McIlroy
Wildlife Consultant
38 Hempleman Drive, Akaroa
New Zealand.
Telephone: 0011 64 3 304-7210 Facsimile: 0011 64 3 304-8430

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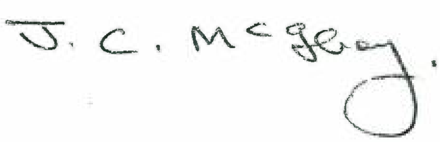
AERIAL BAITING WITH 1080 FOR WILD DOG CONTROL IN NEW SOUTH WALES NATIONAL PARKS AND WILDLIFE SERVICE RESERVES

This is to certify that this Species Impact Statement set out herein has been prepared in accordance with the requirements of Section 109 and Section 110 of the *Threatened Species Conservation Act 1995* and the requirements of the Director-General of the National Parks and Wildlife Service of New South Wales.

Signed:



Dr John McIlroy
Wildlife Consultant
38 Hempleman Drive, Akaroa
New Zealand.

December 1999

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EXECUTIVE SUMMARY

1. There are five National Parks in eastern New South Wales where the NPWS either wish to continue carrying out limited aerial baiting programs for wild dog control or want aerial baiting to be assessed as to its suitability as a last resort control method. The main reasons presented for these programs are their cost-effectiveness, given the difficult access for trapping or mound baiting in some areas, and the pressures imposed on NPWS by adjacent landholders for the Service to reduce the movements of wild dogs from the Parks and their attacks on domestic livestock.

2. Varying numbers of vulnerable and endangered animal species listed under the *Threatened Species Conservation Act 1995* occur, or may occur in each Park. Apart from the brush-tailed phascogale, *Phascogale tapoatafa*, and eastern quoll, *Dasyurus viverrinus*, whose current status in the Parks or susceptibility to 1080 poison are largely unknown, the only threatened species that may be significantly affected by the aerial baiting programs is the spotted-tailed quoll, *D. maculatus.*

3. Evidence obtained from each NPWS District indicates that spotted-tailed quolls are still reasonably common in the four northern Parks, including in traditionally aerial baited areas. However, the species seems to be struggling for survival in the Byadbo Wilderness Area (Kosciuszko National Park), to the south. This may be because the habitat is only of marginal quality, because competitive or predatory foxes are numerous in the area or simply because there has been insufficient survey work on the species in the area and rest of the Park.

4. Based on current evidence, the limited aerial baiting programs against wild dogs, with suggested modifications, are unlikely to significantly affect spotted-tailed quoll populations in the four northern Parks. This may not be so in Byadbo Wilderness Area and alternative control programs are suggested. These alternatives, particularly the timing of baiting, should also be considered for the four northern Parks.

5. In all cases priority research should be directed towards determining the current status of spotted-tailed quolls in each Park. That is, to measure whether their numbers are declining, remaining stationary or increasing. If their numbers are declining, the extent of population mortality due to the wild dog baiting programs needs to be measured.

6. Other research should be directed towards ascertaining whether the baiting programs are being carried out in the most appropriate areas within the Parks in terms of effectiveness in reducing wild dog impact on livestock in adjacent areas and the risk of poisoning faced by spotted-tailed quolls. Ultimately, rather than continuing to bait year after year in 'traditional' areas because of pressure imposed by adjacent landholders, the NPWS should instigate some 'adaptive management' trials. The objective of these would be to determine whether new strategies,

particularly increasing control efforts just outside Park boundaries, can provide equally or more efficient reduction in wild dog attacks on livestock and reduce the risk of poisoning faced by native wildlife, including dingoes, inside the Parks.

ACKNOWLEDGMENTS

Many people, particularly NSW NPWS staff contributed information for the preparation of this SIS.
I am particularly grateful to Stuart Boyd-Law (Glen Innes), Janice Cawthorn (Jindabyne), Andrew Claridge (Queanbeyan), Janien Floyd (Glen Innes), Joanna Knight (Coffs Harbour) and Ken Pines (Armidale) for their promptness and professionalism.
I also acknowledge the assistance provided by Anni Blaxland-Faud (Coffs Harbour), Megan Bowden (Jindabyne), Keith Cherry (Coffs Harbour), Andy Collins (Armidale), Aaron Ledden (Port Macquarie), Bob Leggatt (Armidale), Andrew Marshall (Port Macquarie), Michael Murphy (Coffs Harbour), Pam O'Brien (Jindabyne), David Page (Coffs Harbour), Shane Robinson (Port Macquarie), David. Scotts (Coffs Harbour), Jamie Shaw (Glen Innes), Andrew Steed (Coffs Harbour) and Elise Stocker (Head Office, Sydney).

Andy Murray (DNRE, Victoria) and Roger Pech (CSIRO, Canberra) also provided useful information. Geoff Wright (Landcare, New Zealand) kindly passed on the results of the 1080 analysis from the s-t quoll that died in Tallaganda State Forest. Michael Murphy and Andrew Steed (Northern Zone) and Andrew Claridge (Southern Zone) provided the necessary liaison and assistance required. Andrew Leys (Head Office, Sydney) supplied the direction and support necessary for the preparation of this report.

Finally, I thank Peta Mitchell for her assistance in preparing this report.

1. INTRODUCTION

1.1 Background

In most parts of New South Wales (NSW) wild dogs (feral dogs, *Canis lupus familiaris;* dingoes, *Canis lupus dingo;* and hybrids of the two) are declared noxious animals because of their attacks on domestic livestock, particularly sheep. Dingoes, however, were not previously declared noxious animals if they remained on National Parks and Wildlife Service (NPWS) lands. This was because they were considered part of the native fauna of NSW. Instead they were listed as "unprotected" under Schedule 11 of the *National Parks and Wildlife Act 1974.*

Such a duality of status sometimes led to conflict between landholders living adjacent to or near NPWS Reserves and the NPWS. The landholders often wanted greater control of wild dogs within the boundaries of NPWS Reserves to lessen or prevent their economic losses from dog attacks on their livestock. At the same time, the NPWS was aware of its public responsibility to conserve existing populations of dingoes because they are now regarded as native species in NSW. This also includes prevention or reduction of hybridisation between dingoes and wild dogs.

The NSW Parliament recently passed a number of changes to the Rural Lands Protection Act 1989 and a revised Act (the Rural Lands Protection Act 1998) will be proclaimed shortly. Wild dogs will be defined in functional terms and there will no longer be any reference to dingoes under the new Act. Pest Animal Orders for Wild Dogs will require all owners or managers of agricultural land to control wild dogs, including dingoes. The new Act also binds the Crown. This will require the NSW NPWS to control wild dogs to the extent necessary to minimise their impact on adjoining lands. For this reason it is proposed that there be a second and distinct Wild Dog Control Order which will apply to conservation areas of importance to dingoes. This will involve the five National Parks included in this report. It is proposed that management plans be developed for these areas to meet the joint objectives of ensuring the conservation of dingoes and minimising the impact of wild dogs/dingoes on neighbouring livestock enterprises.

Current control or management of wild dogs in NSW is largely based on trapping, shooting or poisoning individual dogs that have moved out, or are likely to move out of NPWS Reserves or other State land and attack livestock on adjacent freehold or leasehold grazing land. In some specific areas dog-proof fencing is also used as a preventative method.

Aerial baiting with 1080 poison is permitted for control of wild dogs in eastern NSW through an Off-Label Permit (PER2339) issued by the National Registration Authority under the Agricultural and Veterinary Chemical Code Act 1994. The programs are restricted to the northern and southern tablelands areas where the rugged terrain makes ground baiting much more difficult to carry out. Each regional baiting program, undertaken in May/June each year, is a cooperative process involving Rural Land Protection Boards, wild dog control associations and government agencies such as State Forests of NSW, Department of Land and Water Conservation and the

NPWS. NSW Agriculture coordinates the programs and prepares a submission for the approval of the NSW Minister for Agriculture. NPWS can only participate with the approval of the Director-General NPWS. This is the only approval required for aerial baiting on NPWS estate.

NPWS reserves on the northern and southern tablelands are important habitat for a range of native fauna. Because of increasing concerns about the potential impacts of aerial baiting of wild dogs on non-target species, the NPWS wish to phase out this method of control on its reserves wherever possible. At the same time it is aware that aerial baiting may be the only practical or cost-effective method for controlling wild dogs in a few critical areas within its reserves. Such areas, which are extremely difficult to access from the ground, are regarded historically as important habitat/corridors for wild dogs that attack domestic livestock on neighbouring properties.

The NSW NPWS, as the lead agency for conservation of biodiversity and cultural heritage in NSW, has a duty to ensure its own activities comply with the law and are environmentally sound. This is particularly relevant to considering environmental impacts under Part V of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). A part of this process involves preparing a Species Impact Statement (SIS) where a proposed activity (such as aerial baiting) may have a significant effect on a threatened species, population or ecological community in NSW.

1.2 Project Objectives

The objective of this consultancy report is to provide a SIS for aerial baiting with 1080 poison for wild dog control in specified areas of five national parks in NSW. These parks are Kosciuszko NP, Oxley Wild Rivers NP, Washpool NP, Werrikimbe NP and Willi Willi NP.

Based on the evidence reviewed in the SIS, the report will make specific recommendations on whether it is acceptable to proceed, or not to proceed, with aerial baiting in each of the specified areas of the reserves, and will include the reasoning on which such recommendations are based [such grounds may include, but are not restricted to, unacceptable risk to non-target species (to be clearly identified), a more target-specific and effective control technique could be reasonably implemented, etc]. The report will also identify where information is inadequate, and make recommendations on what research is necessary to fill knowledge gaps on the impact of aerial baiting of 1080 on non-target species.

1.3 Requirements of the Director-General

Matters to be Addressed

The Director-General's requirements for the preparation of this SIS are as follows:

"The SIS must meet all the matters specified in Sections 109 and 110 of the TSC Act with the exception of those matters limited" (see later). "In addition to these sections (refer Appendix 1 0, I require the matters described below to be addressed. Previous survey and assessments may be used to assist in addressing these requirements. All references used throughout the SIS must be cited and listed in a bibliography.

1. Description

The SIS must include the information requested below:

The proposal and surrounding areas

1.1 The type of activity proposed must be detailed. This is to include details of the following for each locality where aerial distribution of baits (hereinafter referred to as aerial baiting) is proposed (each subject site): (i) the frequency and timing of aerial baiting, (ii) the spatial extent of aerial baiting, (iii) the location of aerial baiting in relation to topographic position in the landscape, (iv) the type of baits to be used, (v) bait toxicity (1080 dosage rate), (vi) the number of baits to be deployed and (vii) the method of bait deployment. In addition, methods for measuring the effectiveness of each baiting operation are to be outlined.

1.2 Justification for the proposed activity must be documented, including specific reference to the matters listed in NPWS Field Management Policy 2.6.20.

1.3 A topographic map is to be provided for each subject site where aerial baiting is to be conducted. Where possible, such maps should be at a scale of 1:25000. These maps are to indicate the location of proposed aerial baiting runs (transects along which baits will be deployed). Other information such as land tenure boundaries, major landscape features including rivers and wetlands, and areas of high human activity such as townships, roads and recreational areas must also be detailed. Each map must represent the area within at least a 10 km radius of the subject sites (hereafter referred to as the study area).

1.4 A vegetation map of each study area must be provided. These maps are to be at the same scale as the maps provided in point 1.3 above and will show the location and type of vegetation communities present within the study areas. The vegetation units mapped should follow a standard classification.

1.5 A description of the environmental features of each study area is to be provided (eg. climate, geology, topography and vegetation). Consideration is also to be given to the previous land uses and the effect of these land uses on each of the study areas. Relevant historical events may include fire, clearing, logging, recreational use and agricultural activities.

[This information is provided in Sections 2, 6.3 and 6.4].

Site assessment and the habitat of threatened species

1.6 For each study area a list of threatened fauna species potentially impacted upon by the proposal shall be provided. In determining these species, consideration shall be given to their ecology and behaviour, the habitat types known to occur within the study area, recent records of species in each locality, predictive habitat models prepared as part of the Comprehensive Regional Assessment (CRA) process and the known distribution of species. Databases such as the NPWS Atlas of NSW Wildlife and Australian Museum may be used to assist in compiling the list.

The following species shall be included (but is not restricted to) in the list of subject species:

1.6.1 Threatened species of primary concern:

Tiger Quoll	*Dasyurus maculatus*
Eastern Quoll	*Dasyurus viverrinus*
Brush-tailed Phascogale	*Phascogale tapoatafa*

1.6.2 Threatened species of secondary concern:

Common Planigale	*Planigale maculata*
White-footed Dunnart	*Sminthopsis leucopus*
Rufous Bettong	*Aepyprymnus rufescens*
Long-nosed Potoroo	*Potorous tridactylus*
Brush-tailed Rock-wallaby	*Petrogale penicillata*
Smoky Mouse	*Pseudomys fumeus*
Eastern Chestnut Mouse	*Pseudomys gracilicaudatus*
Hastings River Mouse	*Pseudomys oralis*
Bush Stone-curlew	*Burhinus grallarius*
Red Goshawk	*Erythrotriorchis radiatus*
Black-breasted Buzzard	*Hamirostra melanosternon*
Square-tailed Kite	*Lophoictinia isura*

1.7 Locality records for each of the subject species listed above shall be represented on a special map for each of the study areas (at the same scale as that provided in answering point 1.3). As far as practicable, these maps should identify the location of any key habitat components for relevant species of fauna (eg. know den and latrine sites for the Tiger Quoll).

1.8 The spatial extent and quality of known habitat or potential habitat for each of the subject species in each of the study areas shall be represented on the same maps prepared for point 1.7. Habitat mapping is to incorporate relevant predictive habitat models prepared as part of the CRA process where such data has been produced for the study area.

1.9 For each of the subject species a general description of their habitat requirements shall be provided, and the degradation of such habitat within the study areas by introduced species discussed.

[This information is provided in Sections 3, 4 and 5].

2. Assessment of likely impacts

The assessment matters listed below shall be addressed.

2.1 For each of the subject species of fauna listed above, the SIS shall state the following:

- The extent of habitat potentially occupied by that species that will be exposed to aerial baiting in each study area, as well as an indication of the extent of that habitat outside of each study area.

- The potential impact of such aerial baiting on the local population of that species. Attention should be given to discussing the likelihood of individuals locating, consuming and then being killed by poison baits and whether this likelihood will differ according to the sex and age class of that individual, or in relation to the time of year during which animals are exposed to baits (eg. in relation to reproductive activity, associated movement patterns of adults and dispersal of juveniles). This is to include reference to relevant literature and research concerning the effect of 1080 on native fauna (eg Belcher 1998 *Wildlife Research* 25: 33-40).

- A discussion of the significance of potential impacts of the proposed action on that species in a local, sub-regional and regional context is to be provided. This is to include consideration of any indirect impacts such as the fragmentation or isolation of populations. For areas where CRA predictive habitat modelling has been undertaken and Species Equity Target Areas (SETAs) produced by CRA expert workshops, SETA biological boundaries are to be used in defining sub-regions. The SETA boundaries are barriers considered to restrict movement of animals so that the majority of population dynamics occurs within SETAs. Where CRA predictive habitat modelling is not available the consultant preparing the SIS is to liaise with the relevant NPWS Contact Officers (see below) in defining appropriate sub-regions.

- The likely contribution (deleterious or otherwise) of the proposed aerial baiting to the threatening processes already acting on populations of those species in each study area.

Particular detail regarding the above points is to be provided for subject species listed in point 1.6.1.

2.2 In considering the impact (both direct and indirect) of the proposed aerial baiting on local and regional population (as required by Section 110 (2)(g)), estimates of the impact on the local population in terms of the number of individuals affected should be provided wherever possible (it is acknowledge that in many cases only approximate estimates can be provided). An evaluation of the impact of such losses on the regional viability of each species should also be provided. Particular detail is to be provided for subject species listed in point 1.6.1.

2.3 A discussion of other populations of threatened species in the general vicinity of the proposed aerial baiting shall be provided, with particular detail provided for species listed in point 1.6.1. The long-term security of these populations shall be examined as part of this discussion (eg. in the case of baiting in Kosciuszko National Park, populations of Tiger Quolls in the adjacent Alpine National Park, Victoria). The relative significance of each study area for each listed subject species in each locality shall be discussed.

2.4 A discussion of the occurrence or potential occurrence of populations of the Dingo *Canis lupus dingo* within each study area, the significance of populations at a local, sub-regional and regional scale, and the potential impact of aerial baiting on Dingo populations shall be provided. This discussion is to include reference to NPWS Field Management Policy No.2.6.

[This information is provided in Sections 2.5, 4 and 5].

3. Amelioration

The following issues shall be addressed:

3.1 While no relevant Recovery Plans or Threat Abatement Plans have been approved in accordance with the TSC Act as yet, draft Recovery Plans or Species Management Plans may have been prepared for some of subject species of fauna identified above. Where a plan is relevant to any such species, consideration shall be given to the information contained in these plans and whether any recommendation is applicable to the proposal. Either of the NPWS Contact Officers listed below should be contacted to determine whether Draft Recovery Plans or Species Management Plans are available for any of the listed subject species.

3.2 Any measures proposed to mitigate the effect of the proposal on local populations of the subject species (such as the timing or spatial extent of the aerial baiting) shall be detailed. The potential effectiveness of any such amelioration is to be discussed.

3.3 The range of possible alternatives to aerial baiting for the control of wild dogs in each of the study areas shall be discussed in detail. Alternatives considered are to include:

- the use of mound baiting as practised elsewhere on NPWS Estate, and
- the employment of local field staff with suitable experience to undertake tracking, trapping and destruction of wild dogs.

Discussion is to include comparison of the relative specificity, effectiveness and cost efficiency of each alternative, and the relative impact of each on subject species known or likely to occur within each study area, with particular detail provided for species listed in point 1.6.1, and impact on Dingo populations. In discussing alternatives to aerial baiting, and the measures proposed to mitigate its effect, consideration shall be given to developing long-term management strategies to protect areas within each study area which are of particular importance for local populations of the subject species.

3.4 A comparative assessment is to be provided of the potential benefits and adverse impacts of the proposed action, and recommendations detailed concerning whether and by what means wild dog control should be undertaken in each of the subject areas.

3.4 An outline of a programme shall be provided detailing proposed on-going monitoring of the success or otherwise of the recommended action in controlling wild dogs and the effectiveness of mitigation measures in protecting subject species, with particular reference to those species listed in point 1.6.1.

[This information is provided in Sections 2, 4.9, 6 and 7].

4. Additional Information

4.1 In providing a list of other approvals required to undertake the proposed action, an indication of when these approvals are likely to be obtained shall be included. **[Approvals described in 1.1]**

4.2 If, during the preparation of the SIS, obvious deficiencies in knowledge relating to the proposed action are identified, then these should be listed together with discussion of the implications for any conclusions reached, including application of the precautionary principle, and possible research actions that might be undertaken to clarify the situation.

[This information is provided in Section 7].

Definitions

The definitions given below are relevant to these requirements:

- **activity** has the same meaning as in the *Environmental Planning and Assessment Act 1979.*
- **development** has the same meaning as in the *Environmental Planning and Assessment Act 1979.*
- **Director-General** means the Director-General of National Parks and Wildlife.
- **locality** means the area within a 10 km radius of the study area.
- **NPWS** means the NSW National Parks and Wildlife Service.
- **region** has the same meaning as that contained in the TSC Act.
- **subject site** means the area which is proposed for development/activity.
- **study area** is the subject site and any additional areas which are likely to be affected by the proposal, either directly or indirectly.
- **subject species** means those threatened species which are considered known or likely to occur in the study area.

All other definitions are the same as those contained in the TSC Act.

Matters which have been limited or modified

I consider that the following Section 110 matters need **not** be addressed by your SIS.

- Reference to endangered populations and endangered ecological communities. The TSC Act does not currently list any endangered populations or endangered ecological communities in proximity to the subject study areas.
- Section 110(2)(e). This section is a replication of 110(2)(a).
- Reference to critical habitat. There is currently no declared critical habitat in NSW.
- Section 110 (2)(g). The matters raised in this section of the Act have been clarified by the requirements."(outlined previously).

Appendix 1: Section 109 & 110 of the Threatened Species Conservation Act, 1995

Division 2 Species impact statements

109 Form of species impact statements

(1) A species impact statement must be in writing.

(2) A species impact statement must be signed by the principal author of the statement and by:

(a) the applicant for the licence, or
(b) if the species impact statement is prepared for the purposes of the Environmental Planning and Assessment Act 1979, the applicant for development consent or the proponent of the activity proposed to be carried out (as the case requires).

110 Content of species impact statements

(1) A species impact statement must include a full description of the action proposed, including its nature, extent, location, timing and layout and, to the fullest extent reasonably practicable, the information referred to in this section.

(2) A species impact statement must include the following information as to threatened species and populations:

(a) a general description of the threatened species or population known or likely to be present in the area that is the subject of the action and in any area that is likely to be affected by the action,

(b) an assessment of which threatened species or populations known or likely to be present in the area are likely to be affected by the action,

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(b) an assessment of which threatened species or populations known or likely to be present in the area are likely to be affected by the action,

(c) for each species or population likely to be affected, details of its local, regional and State-wide conservation status, the key threatening processes generally affecting it's habitat requirements and any recovery plan or threat abatement plan applying to it,

(d) an estimate of the local and regional abundance of those species or populations,

(e) a general description of the threatened species or population known or likely to be present in the area that is subject of the action and in any area that is likely to be affected by the action [sic, see (a) above],

(f) a full description of the type, location, size and condition of the habitat (including critical habitat) of those species and populations and details of the distribution and condition of similar habitats in the region,

(g) a full assessment of the likely effect of the action on those species and populations, including, if possible, the quantitative effect of local populations in the cumulative effect in the region.

(h) a description of any feasible alternatives to the actions that are likely to be of lesser effect and the reasons justifying the carrying out of the action in the manner proposed, having regard to the biophysical, economic and social considerations and the principles of ecologically sustainable development,

(i) a full description and justification of the measures proposed to mitigate any adverse effect of the action on the species and populations, including a compilation (in a single section of the statement) of those measures.

(j) a list of any approvals that must be obtained under any other Act or law before the action may be lawfully carried out, including details of the conditions of any existing approvals that are relevant to the species or population.

(3) A species impact statement must include the following information as to ecological communities:

(a) a general description of the ecological community present in the area that is subject of the action and in any area that is likely to be affected by the action,

(b) for each ecological community present, details of its local, regional and State-wide conservation status, the key threatening processes generally affecting it, its habitat requirements and any recovery plan or any threat abatement plan applying to it,

(c) a full description of the type, location, size and condition of the habitat of the ecological community, and details of the distribution and condition of similar habitat in the region,

(d) a full assessment of the likely effect of the action on the ecological community, including, if possible, the quantitative effect of local populations in the cumulative effect in the region,

(e) a description of any feasible alternatives to the action that are likely to be of lesser effect and the reasons justifying the carrying out of the action in the manner proposed, having regard to the biophysical, economic and social considerations and the principles of ecologically sustainable development,

(f) a full description and justification of the measures proposed to mitigate any adverse effect of the action on the ecological community, including a compilation (in a single section of the statement) of those measures,

(g) a list of any approvals that must be obtained under any other Act or law before the action may be lawfully carried out, including details of the conditions of any existing approvals that are relevant to the ecological community.

(4) A species impact statement must include details of the qualifications and experience in threatened species conservation of the person preparing the statement and of any other person who has conducted research or investigations relied on in preparing the statement.

(5) The requirements of subsections (2) and (3) in relation to information concerning the State-wide conservation status of any species or population, or any ecological community, are taken to be satisfied by the information in that regard supplied to principal author of the species impact statement by the National Parks and Wildlife Service, which information that Service is by this subsection authorised and required to provide."

2. AERIAL BAITING FOR WILD DOG CONTROL IN NPWS RESERVES

NPWS Field Management Policy 2.6 recognises that wild dogs from NPWS managed areas sometimes impact on livestock on adjacent areas (2.6.13). As a consequence, it will undertake wild dog control on the perimeter of Service lands (2.6.21) to reduce the impact to livestock on adjacent land (2.6.20) when:

- there is adequate evidence that wild dogs coming from Service lands are involved in killing or harassing livestock;
- there are existing, properly maintained barrier fences which have failed to prevent the movement of wild dogs from Service to adjoining lands, or the erection of such a fence is not feasible;
- there is adequate evidence that wild dog control measures on adjacent non-Service land have failed to solve the problem;
- the impact on the dingo population will not threaten the viability of that population within the Service estate; and
- there are cost-effective methods of wild dog control that will not have significant deleterious effects on populations of other native fauna protected under the *National Parks and Wildlife Act 1974.*

Aerial baiting may be carried out only along the perimeter of Service areas and only (according to NPWS Field Management Policy 2.6.46) where the following criteria are met:

- Difficult access makes ground control programs impractical;
- The use of aerial baiting will form an integral part of a properly planned and executed pest control program;
- The program considers potential environmental impacts upon non-target native species;
- The program considers the conservation status of the dingo population to ensure that the baiting program will not substantially threaten dingo numbers in that area; and
- It is the most cost-effective means of control.

At present there are five NPWS Reserves in NSW where aerial baiting is still considered by some staff to be the only practical or cost-effective method for controlling wild dogs in critical areas. These Reserves and the areas of concern are shown in Table 1.

Table 1: Areas within NPWS Reserves where aerial baiting is considered the only practical or cost-effective method for wild dog control.

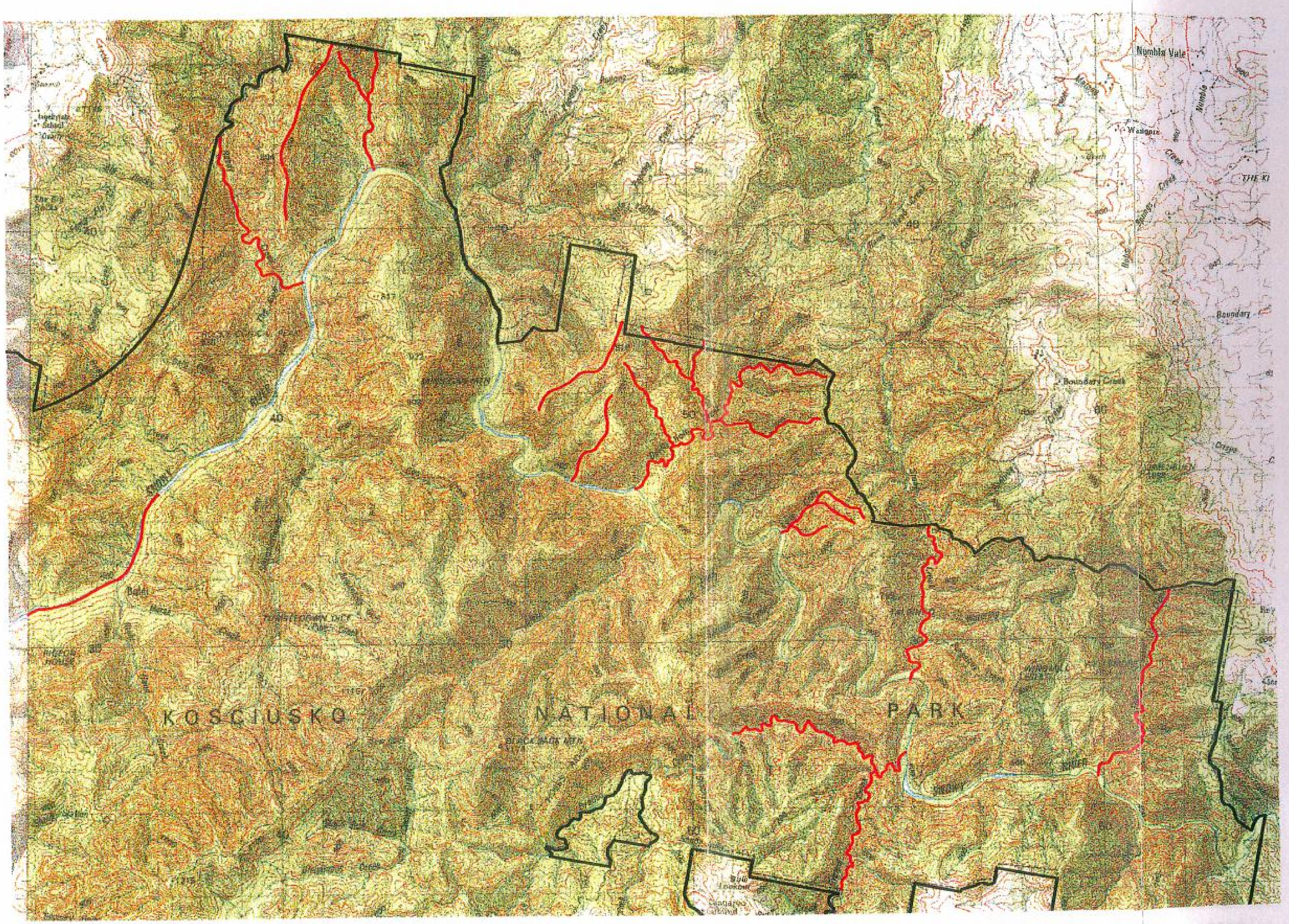
NPWS District	Reserve	Area
Jindabyne	Kosciuszko NP	Paupong/Numbla Vale area of the Byadbo Wilderness
Armidale	Oxley Wild Rivers NP	Key portions of the northern and western parts
Glen Innes	Washpool NP	Key portions of the eastern part
Port Macquarie	Werrikimbe NP	Key portions of the eastern part
Port Macquarie	Willi Willi NP	Key portions of the eastern part

2.1 Kosciuszko National Park

Until June 1997 aerial baiting was an integral part of a suite of methods used for wild dog control in different parts of Kosciuszko National Park (KNP). In March 1997 Jindabyne District (NPWS) prepared a Review of Environmental Factors (REF) document to seek approval to phase out aerial baiting in all areas of the Park except for the Paupong, Numbla Vale and Corrowong areas. These areas, on the south-eastern boundary of the Park include the northern and eastern sections of the Byadbo Wilderness Area (Fig. 1). In June 1997 approval to proceed with aerial baiting in the Byadbo Wilderness Area was refused. During the next 12 months wild dogs attacked over 400 sheep on adjacent properties despite belated but intensive ground baiting and trapping programs (O'Brien and Cawthorn 1998; P. O'Brien, NPWS, Jindabyne District, pers. comm. 1999)). These programs were mainly carried out on the adjacent properties because of the lack of vehicle access within the Park boundaries.

In June 1998 Jindabyne District obtained a General Licence in accordance with the provisions of Section 120 of the National Parks and Wildlife Act, 1974 (a Section 120 licence) to aerial bait along 10 particular sections in the Byadbo Wilderness Area. These sections were the Snowy River (2 runs), Devils Hole Creek, Black Jack Creek, Long Gully, Stony Creek, Kangaroo Ground Creek, Byadbo Creek, Toms Farm Creek and Snodgrass Creek (Fig. 1).

P23.



Kosciuszko National Park
Proposed aerial baiting runs

1 0 1 2 3 4 5 6 7 Kilometers

Scale 1:100000

Fig. 1. Byadbo Wilderness Area, showing major topographic features and the location of proposed aerial baiting runs

2.1.1 Proposed Aerial Baiting Program

Jindabyne District wants to continue to annually aerial bait particular sections of the Byadbo Wilderness Area in the future as part of a cooperative program with the Cooma and Bombala Rural Lands Protection Board. The sections proposed for aerial baiting in June 1999 were parts of the Snowy River; Reedy Creek, Highland Yard Creek, Devils Hole Creek, Long Gully and their adjacent ridgelines; and Stony Creek, Toms Farm Creek, Kangaroo Ground Creek and Byadbo Creek (Fig. 1, Table 2). All the baiting lines except the one along the Snowy River (near Biddi to the west) extend from or near the Snowy River towards the boundary of KNP and the cleared land in the Paupong, Numbla Vale and Corrowong areas.

The proposed aerial baiting would be carried out once per year during June. The total length of the bait lines proposed for 1999 was 60.5 km (Table 2). The approximate area baited (assuming a 500m wide "catchment" area on either side of the bait lines) would be 6050 ha. This represents 8.7% of the total area (69,700 ha) of Byadbo Wilderness Area or 0.9% of Kosciuszko National Park. Meat baits (beef or horsemeat), weighing about 230g and injected with 6mg of 1080 poison, would be distributed along the baiting lines from a helicopter. Some of the baits would be partially dried by laying them on a drying table in a shed for about 4 days before injecting them. These baits are used because they last longer in the field and are easier to handle, even if they are more time-consuming and expensive to prepare. The number of these specially prepared baits dropped during aerial baiting varies depending on the balance remaining after ground baiting by the Cooma and Bombala RLPB outside the park. In 1998 they comprised about 30% of the total numbers that were aerially distributed. Each of the lines represent "known wild dog movement corridors" (O'Brien and Cawthorn 1998) and are mostly situated along gullies and creek lines or dry ridges (Fig. 1, Table 2). Staff from the NPWS Jindabyne District intended to drop 600 baits (about 138 kg) during June 1999, each at approximate 100m intervals. No replacement baiting was planned.

Due to the rugged terrain in which the aerial baiting would be carried out, and the consequent limited access, monitoring of the effectiveness of the baiting program is somewhat limited. Planned or current monitoring includes observations of signs of dogs at bait stations and on specially installed sand pads or by trappers within the aerially baited area and in other parts of Byadbo. It also occurs, together with the monitoring of dog attacks on livestock, on adjacent land outside the Park boundaries. Monitoring is carried out throughout the year, including prior to and after aerial baiting.

The aerial baiting would be carried out in coordination with trapping and mound baiting outside the Park by the Cooma and Bombala Rural Lands Protection Board and the Paupong/Numbla Vale Wild Dog Association.

Table 2: Summary of proposed aerial baiting in Byadbo Wilderness Area during 1999.

Run Name	Run Length	Description
1. Reedy Creek	5km	NW to SE running creek line from Ingebirah Peak (40m asl) to 559 m asl on eastern ridge. 100% gully/creek line.
2. Box Ridge	5 km	1.5 km due east of Reedy Creek. Runs N to S from 900m to 500 asl. 100% ridgeline.
3. Highland Yard Creek	4 km	Runs N to S from plateau, 800m to 300m asl. Located < 2 km east of Box Ridge. 100% gully/creek line.
4. Wild Woman Ridge.	3 km	NE to SW running ridgeline from 900 to 700m asl. Approximately 7 km SE of Highland Yard Creek. 100% ridgeline.
5. Eastern Wild Woman Ridge	2.5 km	Small creek line <2 km E of Wild Woman Ridge. Rises from lower eastern slope of Wild Woman Ridge. 33% gully, 33% ridgeline, 34% midslopes.
6. Devils Hole Creek	14 km	Creek line with 4 x 2nd order streams and 2 x 3rd order streams. From 400m to 600m asl. 100% gully/creek line.
7. Creek line east of Devils Hole.	2 km	2 km SE of Devils Hole Creek. Runs NE to SW to Snowy River. From 600m to 400m asl.
8. Long Gully Creek	4 km	1 x 1st order and 2 x 2nd order streams. Runs E to SW, from 700m to 400m asl to Snowy River. 100% gully/creek line.
9. Stony Creek	4 km	1st order stream. Runs N to S, 460m to 340m asl to Snowy River. 100% gully/creek line.
10. Toms Farm Creek	5 km	1st order stream. Runs N to S from 700m to 400m asl to Snowy River. 100% gully/creek line.
11. Byadbo Creek	5 km	1st order stream flowing W to E from 500m to 400m asl. 100% gully/creek line.
12. Kangaroo Ground Creek	3 km	2nd order stream flowing into Byadbo Creek. Runs S to N from 600m to 400m asl. 100% gully/creek line.
13. Snowy River - Biddi	4 km	Banks of Snowy River above high water mark near Biddi. 100% river banks.
Total	**60.5km**	

The private land adjoining the Byadbo Wilderness Area is predominantly sheep grazing country with a long history of stock losses due to wild dog attacks (P. O'Brien, NPWS, Jindabyne District, pers. comm. 1998). During January to November 1998, 388 sheep were killed and 68 sheep bitten by wild dogs in the Dalgety/Paupong Wild Dog Control Association area. Most of these attacks occurred during January to May. No attacks occurred during June and July but 44 sheep were attacked in August, after the aerial baiting program in June 1998

2.1.2 Justification for Aerial Baiting Program

Jindabyne District (O'Brien and Cawthorn 1998) maintain that their proposed wild dog control program is consistent with NPWS Wild Dog Policies 2.6.20 and 2.6.46 as follows:

- There is adequate evidence that wild dogs emanating from Service lands are killing and harassing stock on neighbouring properties. The recent spate of attacks in the Paupong and Numbla Vale areas are well documented and clearly demonstrate the extent of the impact dogs are having on the neighbouring rural community.

- There are existing properly maintained fences along sections of the Park but due to the inaccessible nature of the terrain fencing is not a practical option along many sections of the boundary of the Byadbo Wilderness Area.

- Neighbouring landholders have undertaken wild dog control measures on non-Service land and have failed to solve the problem. Aerial baiting, ground baiting and trapping programs conducted by the Cooma and Bombala Rural Lands Protection Board have resulted in a degree of success but attacks are continuing and neighbour relations are being affected.

- That given the small proportions of the Byadbo Wilderness Area (8.7%) and KNP (0.9%) in which aerial baiting is proposed, any impact on the dingo population is unlikely to threaten the viability of that population within either Service area. Dingoes and their derivatives are known to occur throughout Byadbo and KNP except above the tree line along the main range (P. O'Brien, NPWS, Jindabyne District, pers. comm. 1999). They also occur in Brindabella National Park, Scabby Nature Reserve, Namadgi National Park (ACT), Alpine National Park (Victoria) and Snowy River National Park (Victoria). Together these reserves form a contiguous biogeographical area of 15,000 km^2. Consequently, any impact on the population in Byadbo is unlikely to be of local, regional or national significance.

- That the proposed aerial baiting program is part of an integrated wild dog management program that includes strategic mound baiting and trapping. It is designed to supplement control methods carried out on private property where these have not been effective in the prevention of livestock loss.

- That difficult access makes ground control programs impracticable. They argue that the proposed areas are all located in very rugged county in which access by foot is difficult and not possible for motor bikes or quad bikes. Access by river is also apparently unsuitable because of the lack of vehicle based entry points and the grade of this section of the river. Mound baiting from horse back is possible but is a very time consuming exercise requiring three contractors working 7 hours per day for 3-4 days per week up to 6 months per year to cover areas previously aerially baited (P. O'Brien, NPWS, Jindabyne District, pers. comm. 1998). Such contractors, particularly younger people familiar with the local terrain and skilled in horse-riding, dog-trapping and poisoning, have been difficult to find. Radio communication is also poor in the proposed aerial baiting areas, particularly in the valleys, and there is no mobile phone coverage. As a result, OH&S issues must be considered in any trapping and mound baiting operations.

- It is the most effective means of control. Jindabyne District maintain that, given their annual costs of approximately $70,000 for wild dog control, aerial baiting is the most cost-effective method to use in the proposed area (P. O'Brien, NPWS, Jindabyne District, pers. comm. 1999). They do not consider that a one-off mound baiting program with no replacement of baits is a cost-effective alternative to aerial baiting. In their opinion, a one-off mound baiting may reduce fox numbers, but is unlikely to have much or any effect on dog numbers. Installing about 200 bait stations in a single day (to partially mimic the proposed aerial baiting) would cost about $9,000 and involve a major, large-scale logistics operation. Aerial baiting and normal mound baiting in the same area would cost about $1,500 and $35,000, respectively (M Bowden, NPWS, Jindabyne, pers. comm. 1999).

The only criterion from Wild Dog Policy 2.6.20 that is not fully answered is whether aerial baiting is likely to have a significant deleterious effect on populations of other native fauna protected under the *National Parks and Wildlife Act 1974.* That is the objective of this SIS. Some difference of opinion may also occur over whether there is "adequate evidence" that the wild dogs involved in killing or harassing livestock are coming from Service lands.

2.1.3 Environmental Features

The northern and eastern sections of Byadbo Wilderness Area where aerial baiting is proposed consist of steep, rugged country centred on the Snowy River and its tributaries (Fig. 1). The area ranges from 300-1174m in altitude.

The mean annual rainfall is approximately 600mm, with a slight summer maximum. Light snow falls occur in winter but do not persist. The mean temperature is 21°C in summer and 4°C in winter.

The soils in the region are grey-brown podsolics, brown podsolics and colluvial brown earths (Costin, 1954). They overlay granite, gneiss and metamorphic sediments. The topsoil (A horizon) of grey-brown podsolics is either not present or poorly developed and is generally bare and highly eroded.

The main vegetation communities in the area are a dry forest system, a white cypress pine system and woodland (Fig. 2). The dry forest system is mainly comprised of red stringybark, *Eucalyptus macrorhyncha*, brittle gum, *E. mannifera*, and broad-leaved peppermint, *E. dives*. The white cypress system is dominated by white cypress, *Callitris glauca*, with black cypress, *C. endlicheri* present where the soil is shallow and stony. The woodland is dominated by white box, *E. albens*, with white cypress and some black cypress present. The sparse understory is mainly wild cherry, *Exocarpus cupressiformes*, and red wattle, *Acacia silvestris* (O'Brien and Cawthorn 1998). Some of the area was grazed in the past but the terrain and the availability of water for stock probably limited the extent of this. Vegetation recorded in the vicinity of a spotted-tailed quoll den

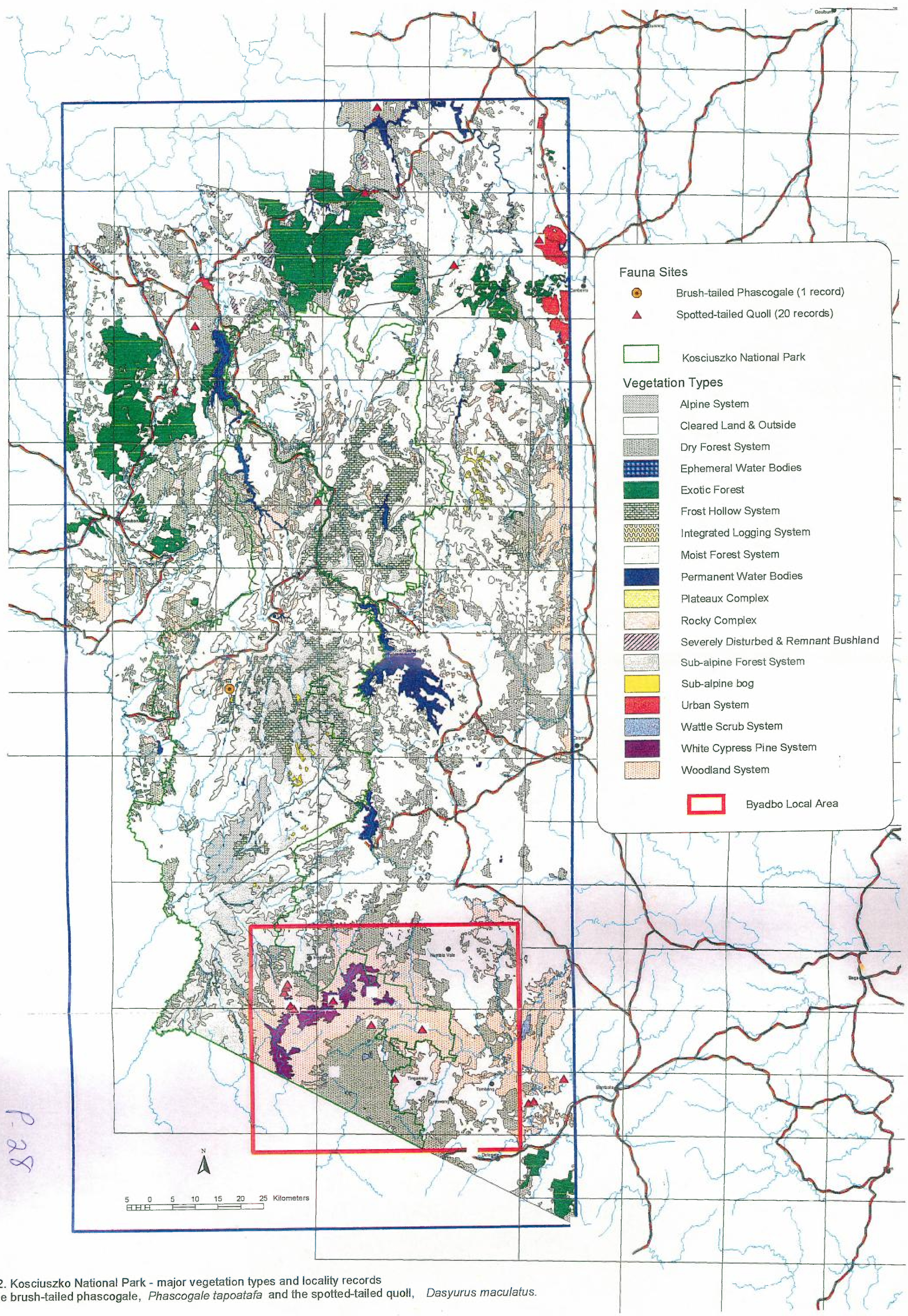


Fig. 2. Kosciuszko National Park - major vegetation types and locality records for the brush-tailed phascogale, *Phascogale tapoatafa* and the spotted-tailed quoll, *Dasyurus maculatus*.

included Mount Wheeler mallee, *Eucalyptus saxatilis,* dogwood, *Cassinia aculeata* and red wattle.

Byadbo Wilderness Area has a large population of foxes, *Vulpes vulpes*, and feral goats, *Capra hircus* (P. O'Brien, NPWS, Jindabyne, pers. comm. 1999). The foxes are likely to compete with or prey on native animals, including threatened species. The goats are also likely to negatively affect species such as the spotted-tailed quoll either directly by excluding them from rocky ledges and cave den sites and latrines, or indirectly by enhancing the food supply (eg. kids) for foxes and wild dogs. Jindabyne District currently spends about $3,000 per annum on goat control programs. These programs involve shooting goats from a helicopter on an opportunistic basis, usually only once or twice a year, depending on the availability of helicopters. While such 'control' efforts are unlikely to have a significant effect on the goat population (so one must question the basis of the control program), the resulting carrion is unlikely to enhance fox numbers in the long term.

2.2 Oxley Wild Rivers National Park

The future use of aerial baiting for wild dog control in the Oxley Wild Rivers National Park (OWRNP) is still under review. In April 1997 Armidale District (NPWS) submitted a REF for aerial baiting along parts of the northern and western sections of the Park. This was approved but a revised REF involving less baits (Waters *et. al.* 1998), submitted in April 1998, seeking to repeat the baiting in much the same sections was refused. As a consequence, Armidale District sought and obtained a Section 120 licence under which aerial baiting in the sections was carried out during June 1998.

2.2.1 Proposed Aerial Baiting Program

Armidale District wants to continue aerial baiting along parts of the northern and western perimeter of OWRNP (Fig. 3). The areas concerned (Table 3) can be broadly grouped into four baiting areas involving the Yarrowitch, Winterbourne, Cooney Creek and Jeogla Wild Dog Associations.

Future aerial baiting would be carried out once per year during May or June in conjunction with strategic ground baiting. The total length of the proposed bait lines is 62 km. The approximate area baited (assuming a 500m wide "catchment" area on either side of the bait lines) would be 7900 ha. This represents 6.6% of the current total area (119,673 ha) of OWRNP. Recent additions of 3,000-4,000 ha to the Park are not included as they are yet to be gazetted. Meat baits (beef or horsemeat), weighing about 250g and injected with 6mg of 1080 poison, would be distributed along the baiting lines from a helicopter. The baits would be laid along the tops of ridges and at the top end of gullies where "wild dog movements are most likely" (Waters *et. al.* 1998). The altitude and speed of the helicopter are reduced and a global positioning system (GPS) is used to increase the precision of the baiting operation.

Table 3: Summary of proposed aerial baiting runs in Oxley Wild Rivers National Park.

Area	Map	Length	Description of Area
Gara /Dangars	Armidale	7 km	Steep gorge country with dry sclerophyll woodland and grassy understory. No vehicular access to most of the gorge. Baiting is generally carried out along the ridge lines/spurs extending from the river to the gorge rim.
Chandler	Armidale	8 km	Steep hillslope and gorge country with dry sclerophyll woodland and grassy understory. Small areas of dry rainforest occur in some gullies and on concave slopes. Vehicular access to the gorge is extremely limited – most of the area is only accessible by foot or horseback. Baits are generally laid along river flats, creek lines and ridgeline/spurs running down to the river.
Waters	Armidale	9 km	Steep hillslope and gorge country with dry sclerophyll woodland and grassy understory. Small areas of dry rainforest occur in some gullies and on concave slopes. No vehicular access to most of the gorge. Baits generally laid along river flats, creek lines and on one ridge, where wild dogs are known to travel.
Tabletop	Armidale	6 km	Undulating to rugged tableland area with dry sclerophyll woodland with an open understory. No vehicular access to the ridgelines or boundary areas where baiting is carried out.
Jeogla	Carrai	10 km	Very steep gorge country with dry sclerophyll woodland and grassy understory. Small areas of dry rainforest occur in some gullies and on concave slopes. *Casuarina* species occur along the riverbanks. No vehicular access to the gorge. Aerial baiting is mostly carried out along the river flats and on a few ridgelines/spurs running down to the river.
Budds Mare	Yarrowitc h	6 km	Undulating to rugged tableland with generally dry sclerophyll forest and open understory. There is limited vehicle access along the southern boundary of the park where there is some baiting but only difficult foot access to both of the ridgelines where the remainder of baiting is carried out.
Apsley	Yarrowitc h	10 km	Steep upper gorges of the Apsley and Tia rivers with sheer cliffs in some areas. The vegetation is generally dry sclerophyll woodland, limited grassy understory with Casuarina and Melalueca species occurring along the riverbanks. Aerial baiting is limited to the flatter areas along the river. The rugged terrain prevents any vehicular access to the gorge and makes other forms of access (horse or foot) very difficult.
Warnes River	Cowarral	6 km	Rugged gorge country with dry sclerophyll woodland and some grassy understory. Baits are generally laid along spur lines and flats adjacent to Warnes River. Inaccessible to vehicles – access is limited to horseback or foot.
Total	**62 km**		

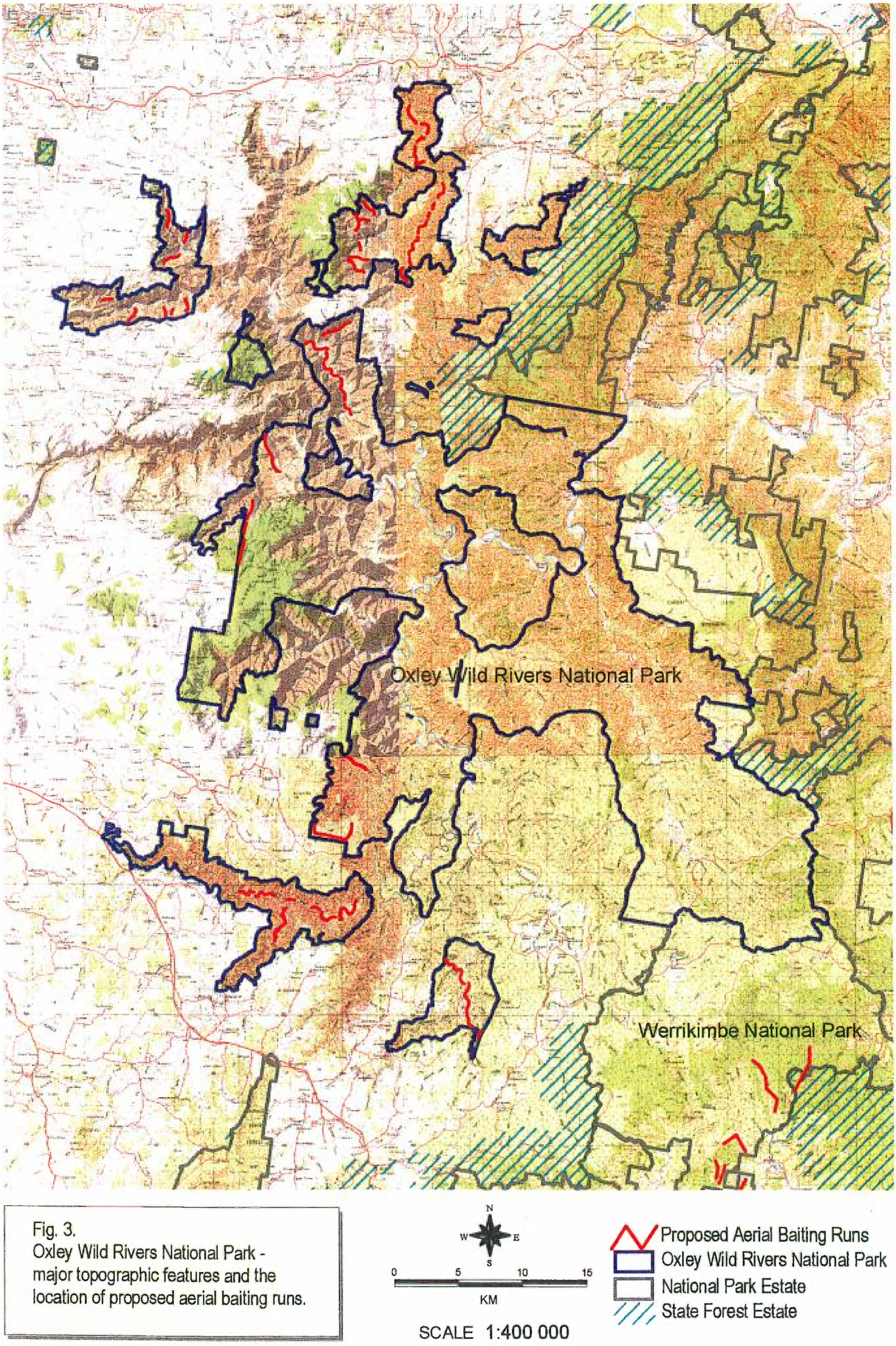


Fig. 3.
Oxley Wild Rivers National Park - major topographic features and the location of proposed aerial baiting runs.

NPWS staff from the Armidale District intended to drop a total of 155kg of baits (approximately 620 baits) during May-June 1999. Each bait was to be dropped at intervals of 100m resulting in a maximum rate of 2.5kg bait per kilometre (10 baits per km). This number of baits and total length of bait lines represents a 22.5% reduction on the figures for 1998. Some ground baiting (which is little different in practice from aerial baiting) has been carried out in the past and was initially proposed for 1999. However, if the aerial baiting was approved, all poisoning programs would have been restricted to mound and aerial baiting (K. Pines, NPWS, Armidale District, pers. comm. 1999). Aerial baiting, however, would be gradually phased out over the next 3-5 years and replaced by fencing and mound baiting, in accord with the Districts' previously stated policy over wild dog control. The reduction from 255 kg of bait laid in 1997 to the proposed 155 kg of bait in 1999, due to the erection of new fences and adoption of mound baiting, despite the inclusion of new areas in the Park, supports this policy. If the aerial baiting was prohibited, increased ground baiting in many areas would have been necessary, as there were insufficient resources available to change completely to mound baiting.

In accessible areas where mound baiting is used, monitoring is carried out using sand pads over an 8 week period – 4 weeks either side of baiting. This provides an indication of the movement of target and non-target species within the area and an indication of the effectiveness of aerial baiting in adjoining areas.

In the inaccessible areas that are aerially baited, where mound baiting is not feasible, monitoring of effectiveness is based on the level of livestock predation on adjoining properties and sightings of wild dogs. This is determined from the monthly reports provided to the Rural Lands Protection Board by the Wild Dog Associations and from general observations by Service staff.

Also, during the last two years, one or two selected aerial runs, usually along more accessible ridge lines, have been surveyed one or more times, within three weeks of completion of the baiting. The purpose of the survey is to attempt to determine the persistence of the baits and to find the carcasses or signs of target or non-target species.

2.2.2 Justification for Aerial Baiting Program

Aerial baiting is proposed within two kilometres of the Park boundary adjacent to cleared grazing areas with a recent and regular history of wild dog attacks on livestock. Armidale District (Waters *et. al.* 1998) argue that such a proposal is consistent with NPWS Wild Dog Policies 2.6.20 and 2.6.46 in that:

- There is adequate evidence that wild dogs coming from Service lands are killing or harassing livestock on neighbouring properties. This is based on monthly reports prepared by the four Wild Dog Associations for the Armidale Rural Lands Protection Board which Waters *et. al.* (1998) say demonstrates an ongoing pattern of livestock predation by wild dogs "emanating from Service land". Between April 1997 and March 1998 1076 sheep and 2 cattle were killed or maimed by wild dogs in the four Wild Dog Association areas.

- There are existing properly maintained barrier fences along sections of the perimeter of the Park that vary in their effectiveness in preventing the movement of wild dogs from Service land to adjoining properties. In other cases the aerial baiting is seen as short-term protection while new fences are built or existing fences are upgraded.

- The proportion of OWRNP (6.6%) that would be subject to aerial baiting is so small that by itself, it is unlikely to threaten the viability of the dingo population within OWRNP.

- The proposal is part of an integrated wild dog management program that includes strategic fencing, ground and mound baiting. It is designed to supplement control methods carried out on private property where these have not been effective in the prevention of livestock losses.

- That aerial baiting is the most cost-effective method of wild dog control in the terrain involved. Estimated costs of baiting the proposed areas by different methods are $4,000 (aerial baiting), $9,000 (ground baiting) or $54,000 (mound baiting) (K. Pines, NPWS, Armidale District, pers. comm. 1998). Because it would be impossible to carry out mound baiting in the actual area nominated for aerial baiting, a large number of more accessible sites would have to be selected to provide a similar level of protection to neighbours. The mound baiting figures are based on running the bait stations for a period of at least two months, with each station serviced at three-day intervals. Additional staff and vehicles would be required if only mound baiting was adopted.

- Finally, Armidale District (Waters *et. al.* 1998) states that "Any effects on non-target species will be limited to impacts on individuals. The activity is not likely to have any significance impacts on native fauna." The validity of this statement will be examined in Sections 3 to 5 of this SIS.

2.2.3 Environmental Features

The areas in which aerial baiting is proposed are parts of the Park near cleared grazing land with a recent and regular history of wild dog attacks on stock. Collectively, they represent part of the Macleay Gorges, an extensive area of steep slopes (ranging from 150-1300m in altitude) and rugged escarpments plus small sections of adjacent plateau. Six of the areas in which baiting is proposed consist of steep hillsides and gorge country (Table 3). Two are undulating to rugged tablelands and one includes the steep upper gorges of the Apsley and Tia rivers with occasional sheer cliffs. All range between 400-800m in altitude.

The general climate in the area is one of cold winters and mild summers. The average rainfall is 750mm, with predominant falls during the summer. Summer thunderstorms occur, which can cause local flooding and erosion.

OWRNP covers part of the Great Escarpment that runs the length of eastern Australia. The parent geology of the area comprises granites and metamorphic rocks, including greywacke, slates, phyllite and schists. The soils on the ridges are mostly poorly developed skeletal soils (Waters *et. al.* 1998).

The Park supports a mosaic of different types of rainforest and sclerophyll communities (Fig. 4). Dry rainforest (the most significant occurrence protected in reserves in NSW) occurs in gullies and concave slopes. Both subtropical and warm temperate rainforest occur, but are very limited in their distribution. Twenty-five sclerophyll communities have been identified in the Park (Waters *et. al.* 1998).

The vegetation in all the proposed aerial baiting areas is dry sclerophyll woodland with an open or grassy understory (Table 3). Small areas of dry rainforest occur in some gullies and on concave slopes in three areas and *Casuarina* and *Melaleuca* species occur along the river banks in two of the areas.

OWRNP is used by visitors for a variety of recreational activities including bush walking, rock climbing, picnicking and camping. There are a number of huts in the Park. Sections of the proposed baiting runs are located in the Macleay Gorges Wilderness.

Feral dogs, foxes and feral cats, *Felis catus*, are present around the perimeter of OWRNP and potentially compete with or prey on threatened species. Feral goats are also present in some areas, including those subject to aerial baiting, Feral goat control in the form of aerial or ground shooting is regularly carried out in those areas. The resulting carrion may be fed on by s-t quolls but equally also by foxes, wild dogs and cats.

Most of the areas involved were originally leasehold and subject to a burning/grazing regime for almost 100 years until being included in the Park. The ruggedness of some of the areas limited the grazing impact but irregular, uncontrolled fires occurred, particularly along river flats.

Vehicular access to the proposed areas for aerial baiting is either limited to the southern boundary of the Park in the Budds Mare area, or non-existent. Most areas are only accessible by foot or on horseback. Even this form of access is difficult in the Apsley and Budds Mare areas (Table 3).

2.3 Washpool National Park

No aerial baiting for wild dog control has been undertaken in Washpool National Park (WNP) or the adjacent Gibraltar Range National Park (GRNP) since 1996. A 1997 REF for mound baiting to control wild dogs in 6,000 ha of country on the north-eastern border of WNP was approved in May 1997. Mound baiting was undertaken in this area during 1998.

2.3.1 Proposed Aerial Baiting Program

Glen Innes District want an assessment of the suitability of aerial baiting a small area of country near the south-eastern boundary of WNP for wild dog control. Adjoining landholders regard this area as a major access route for wild dogs preying on their stock (Fig. 5). Glen Innes District considers using the method

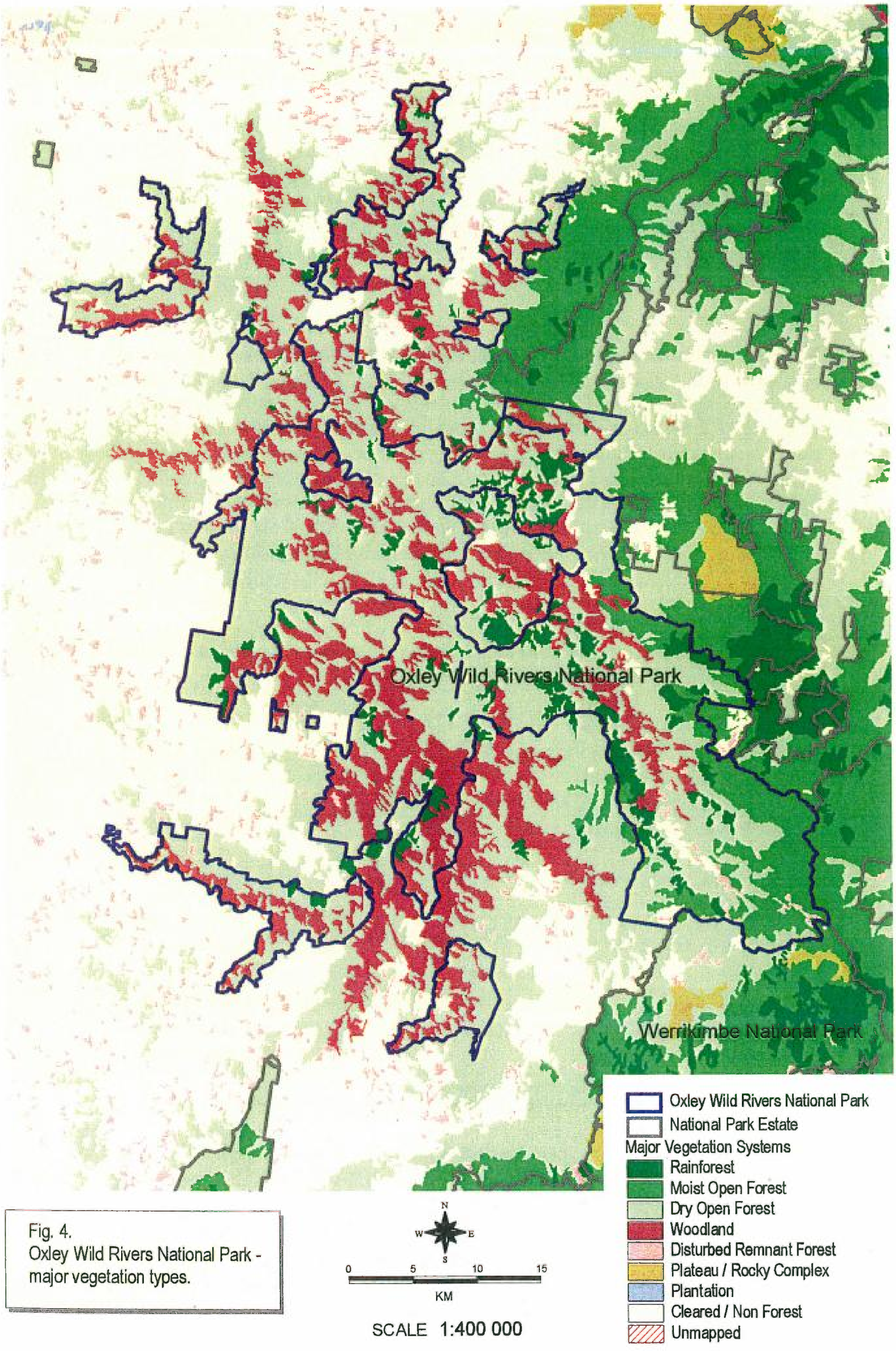


Fig. 4.
Oxley Wild Rivers National Park - major vegetation types.

only "as a last resort option if all other options are pursued and exhausted." (J. Floyd, NPWS, Glen Innes District, pers. comm. 1999). The proposed aerial baiting would be carried out once per year in June but only " if there is a lot of dog activity and we are stretched for resources and time". *It would not be carried out if there were only low dog activity in the area.* Twice yearly mound baiting would be continued along the fire trails further north. Two baiting lines are proposed. One is along Hianana Creek and Litany Gully about 500m west of the Lionsville Fire Trail (Fig. 5). The other, starting near the headwaters of Viper Creek, extends along a gently sloping plateau 500-2500m east of the firetrail. The purpose of both lines is to provide a reasonably linear barrier to dogs heading east towards private property.

The total length of the bait lines is 10 km (Table 4). The approximate area baited (assuming a 500m wide "catchment" area on either side of the bait lines) would be 1000 ha. This represents 1.9% of the total area (51,834 ha) of WNP. Meat baits weighing 400g would be injected with 3mg 1080 in each end (total 6mg per bait). Glen Innes District wish to use the larger baits as they feel the lower concentration of 1080 involved would provide less of a hazard to any non-target animals that ate the bait (S. Boyd-Law, NPWS, Glen Innes District, pers. comm. 1998). Between 10-40kg of baits (ie.25-100 baits) would be thrown by hand from a helicopter at 100-250m intervals. Most of the baits would be dropped on ridges but some would be dropped in gullies.

Table 4: Summary of proposed aerial baiting runs in Washpool National Park.

Area	Run Length	Description of Area
Hianana Creek/Litany Gully	5 km	Very steep, inaccessible area, consisting of mainly dense wet sclerophyll forest, with rainforest understory occurring. Access by foot only.
Viper Creek Area	5 km	Access by foot only. Moderately undulating area, consisting of predominantly wet sclerophyll forest. Little temperate rainforest in this area.
Total	**10 km**	

Monitoring of the effectiveness of the aerial baiting program would be confined to comparison of dog signs at mound bait stations and stock losses before and after the control program.

2.3.2 Justification for Aerial Baiting Program

The Mann River Wild Dog Association believe attacks by wild dogs, particularly by part-grown dogs, on livestock on private land to the east of WNP is increasing, despite a large amount of aerial baiting. They view this as sufficient reason for aerial baiting within WNP and not necessarily a reflection of the effectiveness of their control programs on private land. During 1996-97 dogs on private land to the east of WNP killed 16 cattle (Graham-Higgs *et. al.* 1997). During the 20 months

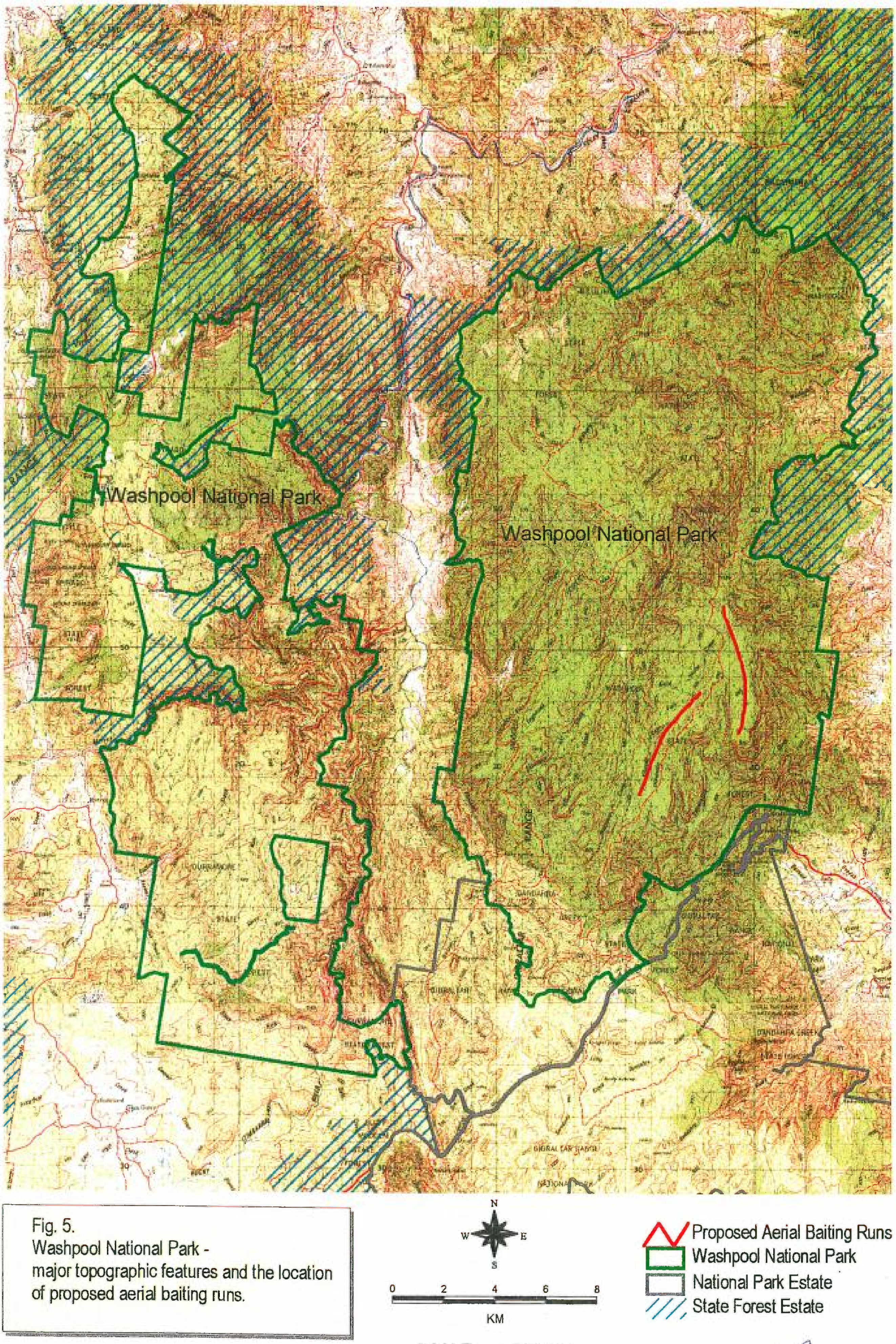


Fig. 5.
Washpool National Park -
major topographic features and the location of proposed aerial baiting runs.

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from July 1997 to March 1999 there were sightings of at least 20 wild dogs to the east of WNP and GRNP (S. Boyd-Law, NPWS, Glen Innes District, pers. comm. 1999). Other dogs were also heard or sighted but the Mann River Wild Dog Association did not report the numbers involved. Dogs killed one calf and mauled three others during this period. There were also four reports of them killing other calves and cows but no figures were provided. Wild dogs also killed two pet dogs during the period.

- One reason Glen Innes district wish to consider the use of aerial baiting is to improve relations with neighbouring landholders who have "suggested" the area is a "source area" for dogs that attack livestock on their land to the east. Whether such subjective opinion is "adequate evidence that wild dogs coming from Service lands are involved in killing or harassing livestock" on adjacent land (NPWS Wild Dog Policy 2.6.20) is a moot point. There is no doubt that dingos occur in the proposed aerial baiting area but only in low numbers according to mound baiting results (S. Boyd-Law, NPWS, Glen Innes District, pers. comm. 1998). Much of the area is covered by dense wet sclerophyll forest and well-developed rain forest, which J. Shaw (NPWS, Glen Innes District, pers. comm. 1998) believes may restrict the movements of wild dogs. In comparison the adjacent land to the east, subjected to high levels of logging disturbance and repeated burning exhibit more open forest communities with a grassy open understorey that may be more suitable for wild dog foraging and movements (J. Shaw NPWS, Glen Innes District, pers. comm. 1998). S. Boyd-Law (NPWS, Glen Innes District, pers. comm. 1998) believes that wild dog numbers may be higher in the Park/private property fringe areas than further inside the Park.

- From the point of view of NPWS Wild Dog Policy 2.6.46 there is only limited evidence that aerial baiting could form an integral part of an overall wild dog control plan. There are no barrier fences along the eastern boundary of WNP (2.6.20). Glen Innes District considers the erection of an adequate barrier fence is not possible due to the area's remoteness, inaccessibility and presence of substantial rock outcrops and tall moist forest (Graham-Higgs *et. al.* 1997). However, mound baiting is currently carried out to the north of and in the possible aerial baiting area.

- On a Park, sub-regional or regional scale, aerial baiting in the proposed area is unlikely, by itself, to threaten the viability of the dingo population. According to S. Boyd-Law (NPWS, Glen Innes District, pers. comm. 1999) the dogs present in WNP appear to be both pure dingoes and hybrids but it is too difficult to determine the relative proportions of each. While at a local level any population of purebred dingoes is likely to be significant, they are likely to be less important at a regional level.

- On a cost–effective basis aerial baiting offers several advantages. Although the Lionsville Fire Trail runs through the proposed aerial baiting area, the section involved is in very poor condition and can not be used by motor or quad bikes or 4WD vehicles. At present mound baiting is carried out along this section of the fire trail. This involves walking a distance of five kilometres each way to lay eight baits. Free feeding is conducted every second day for a minimum period of two weeks, followed by baiting, which, depending on dog activity, usually extends over another two weeks. Because the area concerned is a four hour drive to and from Glen Innes, it takes a full day just to monitor eight bait stations. As this occurs for a four-week period, there is considerable cost in resources and personnel involved. The estimated cost of aerial baiting the area is $408 versus $3,930 for mound baiting. Trapping the area instead of mound baiting would also cost about $4,000. (S. Boyd-Law, NPWS, Glen Innes District, pers. comm. 1998).

- The only criterion not addressed fully is the potential impact of the aerial baiting on non-target animals. This is what Glen Innes District hope to obtain from this report.

2.3.3 Environmental Features

Washpool National Park (51,834 ha) is located on the eastern edge of the Great Escarpment of the New England Tablelands above the Clarence Valley. To the south it adjoins GRNP (21,599 ha). The majority of both Parks are bordered by state forest and freehold (private) land, and some reserved crown land.

The climate is cool temperate with warm summers and moderately cold winters. The mean maximum monthly temperature is 24°C and the mean monthly minimum is 0°C. The annual rainfall is 2450mm.

Both Parks are predominantly underlaid by granite from the New England Batholith. Granite tors (rocky outcrops) occur on the higher peaks, especially in GRNP. Detailed soil mapping has not been carried out in the Reserves. Red and Brown earths and red and yellow podzolics exist with a high degree of intermixing, depending on the variations in the soil's parent material, topography and vegetation. The soils are highly erodible. Sheltered gullies have deep fertile soils based on the altered sediments and volcanic rock.

Elevation within WNP ranges from 240-1120m. The slopes are predominantly gradual to moderate (ie. generally < 18°) with some steep slopes particularly in WNP. Plateaux and deep valleys across large area of both Parks provide a significant diversity in both habitats and species present.

Both Parks contain a mosaic of vegetation communities including moist closed forests, dry, cool temperate and warm temperate rainforests, sedge swamps (on broad valley bottoms), and sub-alpine heaths (Fig. 6). The diversity of vegetation is strongly related to natural grasslands (in frost hollows) and the underlying geology, soils, elevation, slope and aspect. A number of species occurring within the Parks are either rare, restricted in their distribution or at their known geographic limit. Six flora species are listed in Schedule 1 and 2 of the *Threatened Species Conservation Act 1995* (TSC Act). WNP contains the largest stand of coachwood, *Ceratopetalum apetalum* in the world, and the largest stand of

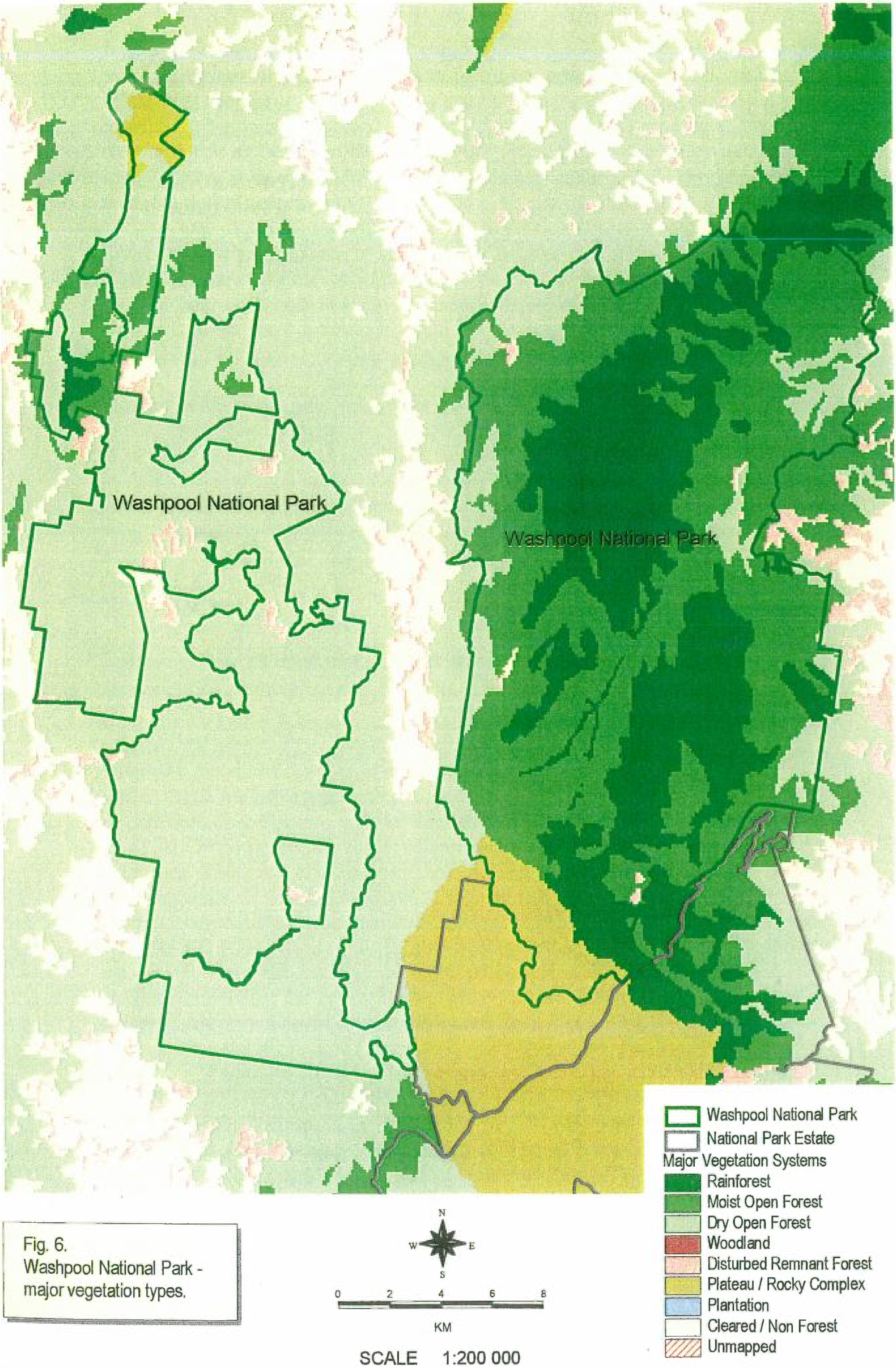

Fig. 6.
Washpool National Park - major vegetation types.

rainforest within a protected Wilderness area in NSW. Sub-tropical rainforests occur in isolated pockets restricted to the most protected moist aspects in gully heads with deep soils. These pockets can be found up to 1030m above sea level. Lowland sub-tropical rainforest stands are found on alluvial terraces and spurs on the south side of Coombadjha Creek, in the southeast of WNP. Dry rainforest of shrubby form is limited to the middle and lower reaches of Washpool Creek, in areas of slightly deeper soils.

Another outstanding feature of both Parks is the wet sclerophyll forests, often with a well-developed rainforest understory. Areas of fire determined understory, ranging from open grasslands to broad-leafed shrubs, dominated by New England blackbutt, *Eucalyptus andrewsii,* occur on the poor soils over 600m in altitude, particularly on the more exposed ridges and slopes.

Most of WNP exists as a wilderness area, with limited vehicular access and past impact from forestry activities. A Draft Fire Management Plan for GRNP and WNP has been prepared by NSW NPWS, which includes fire management guidelines for difficult vegetation communities and threatened fauna. Scattered but dense patches of the weed, *Lantana camara* occur near the eastern boundary of WNP, particularly along the Washpool Creek. Some feral cats have been observed along forest roads and tracks in tall closed forest and open forest, but their distribution is not known (Graham-Higgs *et. al.* 1997). Foxes apparently do not occur in the area.

2.4 Werrikimbe and Willi Willi National Parks

Up until 1996 the Kempsey Rural Lands Protection Board (KRLPB) and the Macleay Valley Wild Dog Association conducted annual to bi-annual 1080 baiting programs for wild dog control over much of the land that is now WWNP and WkNP. The main purpose was to reduce livestock losses due to attacks by wild dogs in the upper Macleay and Hastings River valleys to the east. During 1997-98 22 of 74 (30%) properties surveyed experienced stock losses or maulings due to wild dogs. The stock affected were 120 cattle, *Bos taurus*, under 6 months of age, 11 older cattle, 6 sheep, *Ovis aries*, 22 goats and 30 chickens (Port Macquarie District National Parks and Wildlife Service, 1999). The approximate economic cost was $23,955. Many of the properties surveyed are not NPWS neighbours but are distant from the national park boundaries (Fig 7). Only 5 (7%) of the properties (amongst the largest in the survey) recorded wild dog sightings as very common and only three of these experienced stock losses.

2.4.1 Proposed Aerial Baiting Program

Port Macquarie District, at the instigation of KRLPB, want an assessment of the suitability of aerial baiting for wild dog control in parts of both Parks and the nearby Jasper and Koorebang Nature Reserves (Fig. 7). KRLPB staff have selected 9 baiting runs (Table 5) and would carry out the actual baiting themselves during May or June every one to two years. One of the proposed runs (NP8 in Table 5) extends partly outside the boundary of WkNP (Fig. 7).

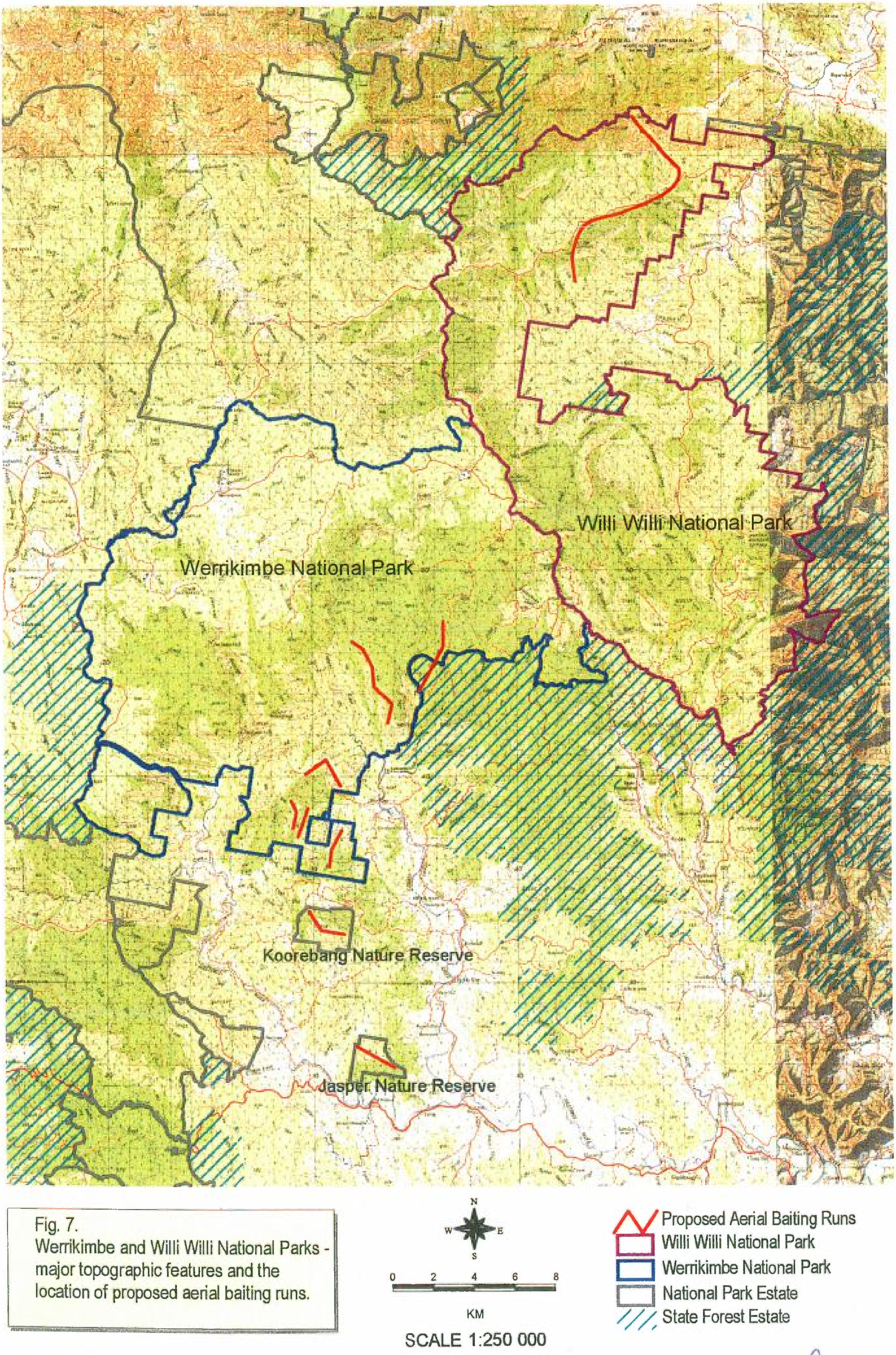

Fig. 7.
Werrikimbe and Willi Willi National Parks - major topographic features and the location of proposed aerial baiting runs.

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Table 5: Summary of proposed aerial baiting in Werrikimbe and Willi Willi National Parks and Jasper plus Koorebang Nature Reserves.

Reserve & Run Name	Run Length	Description	Topography
Willi Willi	11.8 km	W to E along major ridge of Mt Flat Top to Mt Double Head (1000m asl) then across McCoys Creek (160m asl) to Jacobs Ladder (800m asl)	50% major ridge, 40% minor ridge, 10% gully
Jasper NP1	2.4 km	SW facing slope and ridge below 600m high peak, (down to low point at 420m asl)	50% mid slope, 50% major ridge
Koorebang NP2	2.4 km	SE running ridge from plateau area (900 down to 480m asl)	100% ridgeline
Werrikimbe NP3	2.1 km	N facing ridge from major local peak (1026 down to 550m asl)	50% ridge top, 50% minor ridge
Werrikimbe NP4	1.3 km	N and E facing head of a gully and lower mid slope (630 to 520m asl)	50% gully, 50% lower to mid slope
Werrikimbe NP5	1.4 km	Top of N to NW running ridgeline above significant escarpments (760 to 840m asl)	100% ridge top
Werrikimbe NP6	2.6 km	NE running ridgeline on 'plateau' area (800m asl) then descending a minor ridge to SE (down to 500m asl)	50% ridge top, 50%minor ridge
Werrikimbe NP7	5.9 km	Follows a significant NW to SE ridge complex from just below a major plateau area (ranges from 900 to 280m asl)	100% ridge top
Werrikimbe NP8	4.8 km	Run lines parallels major (gravel) access road approximately following NE to SW running major ridgeline, but bait run crosses minor ridges and a number of gully heads	20% major ridge, 50% mid slope, 30% gully
Total	**34.7 km**		

The total length of the proposed bait lines is 34.7 km (Table 5). The approximate area baited (assuming a "catchment" area of 500m on either side of the bait lines) would be 3470 ha. The baited area in WWNP would represent 5.8% of the total Park area (20,170 ha) and that in WkNP, 7.8% of the total Park area (29,271 ha).

Meat baits (kangaroo, horse meat or ox liver) weighing approximately 250g would be injected with 6mg of 1080 prior to baiting. In WWNP, 29.5kg of baits or 90 baits would be dropped by hand from a helicopter; each bait at approximately 130m intervals (ie. 1.9kg or 7.7 baits per kilometre). The helicopter would travel at a rate of 50 knots. Most baits (90%) would be dropped on ridges, but a few (10%) would be dropped in gullies (Table 5).

In WkNP 43.7 kg of baits or 175 baits would be dropped from a helicopter at the same intervals. The sites baited would vary between gullies, lower and mid slopes and minor or major ridge tops (Table 5). Twenty-four baits (6kg) would be dropped in the Jasper Nature Reserve and 24 in the Koorebang Nature Reserve.

In both cases no coordinated monitoring of the effectiveness of the baiting operations appears to have been considered. Instead monitoring will simply rely on anecdotal comments from the rural community together with an infrequently completed section of the annual KRLPB "Stock Return and Rates" form.

2.4.2 Justification for Aerial Baiting Program

The justification for the possible aerial baiting programs in WkNP and WWNP are not particularly strong, particularly given the criteria in NPWS Wild Dog Policies 2.6.20 and 2.6.46.

- The principal reason for the proposed aerial baiting program in WkNP and WWNP given by Port Macquarie District (A. Marshall NPWS, Port Macquarie District, pers. comm. 1998) is so NPWS can meet a somewhat unquantified but stated need for the baiting expressed by the local rural community. This need is based on landholder's perceptions that wild dog populations migrate or radiate out of the Parks onto local productive grazing land (principally beef production), even though this is not necessarily supported by stock loss reports. While this reason is one of the criteria for carrying out wild dog control on Service land (NPWS Wild Dog Management Policy 2.6.20) it is not listed in the criteria for aerial baiting (Policy 2.6.46).

- There is also only limited evidence that the proposed aerial baiting "will form an integral part of a properly planned and executed pest control program" (Policy 2.6.46). There are no barrier fences between the Parks and private land because their erection is not considered practical in the country involved. Some mound baiting is carried out but the proposed aerial baiting may only superficially) complement the largely uncoordinated baiting on land adjacent to the Parks.

- The areas in which the baiting would be carried out are rugged and remote, and aerial baiting would be cost-effective in terms of staff time and energy. Aerial baiting along the nine proposed runs is likely to cost about $3,000. Based on the estimated rate of $250-$300 per km for mound baiting in the nearby Kumbatine National Park (A. Marshall NPWS, Port Macquarie District, pers. comm. 1999), it could cost about $8,700-$10,400 to carry out mound baiting in the proposed aerial baiting areas.

There appears to be some lack of endorsement or support by NPWS staff in Port Macquarie District for justification of the proposed aerial baiting. They question the validity of some of the assumed results of past baitings and the need for aerial baiting given the small amount of evidence of wild dogs in the Parks over the past three years.

2.4.3 Environmental Features

Werrikimbe National Park

Werrikimbe National Park (29,271 ha) situated on the edge of the New England Tablelands extends eastward into the deeply incised valleys of the Forbes and Hastings Rivers. OWRNP bounds the park to the north-west and WWNP bounds the park to the north-east (Fig 7).

The park lies within the New England Fold Belt of eastern Australia. The parent rock material consists mainly of Myra Bed metamorphosed sedimentary rocks of lower Devonian age, or volcanic intrusive rocks of the upper Permian. The landform has developed from the headward erosion of deep V-shaped valleys cutting back along streams into the undulating New England Tableland. This has produced a diverse landscape that includes meandering streams, undulating plateau country and rolling hills in tableland areas, and rugged ridges, cliffs, deep gorges, waterfalls and canyons along the escarpment. The range in elevation is 220 to over 1000m.

The diverse landform and differences in parent material, combined with marked temperature and rainfall gradients across the park are major factors contributing to both the variability of the soil and the flora and fauna diversity present. There is a diverse mosaic of plant communities present, including subtropical, warm temperate and cool temperate rainforest, tall open and open forest, woodland, heath, grass-tree scrub, sedge swamp and meadow swamp (Fig. 8).

Subtropical rainforest is found only in a few sheltered locations, mainly along streams. It is characterised by luxuriant growth, a great variety of tall, closely spaced trees, abundant epiphytic ferns and orchids, large vines and special growth forms such as strangling figs, buttresses and large simple or compound leaves. The major tree species are black booyong, *Heritiera actinophylla,* a Socketwood, *Daphnandra micrantha*, brown beech, *Pennantia cunninghamii,* and brush bloodwood, *Baloghia inophylla.* Warm temperate rainforest is found at altitudes above 700m, especially in the Hastings and Forbes catchments around Mount Werrikimbe. Major tree species are black booyong, coachwood, sassafras, *Doryphora sassafras* and yellow carabeen, *Sloanea woollsii,* with rosewood, *Dysoxylum fraserianum,* corkwood, *Caldcluvia paniculosa,* prickly ash, *Orites excelsa*, crabapple, *Schizomeria ovata,* and lilly pilly, *Acmena smithii,* also being common. Cool temperate rainforest dominated by Antarctic beech, *Nothofagus*

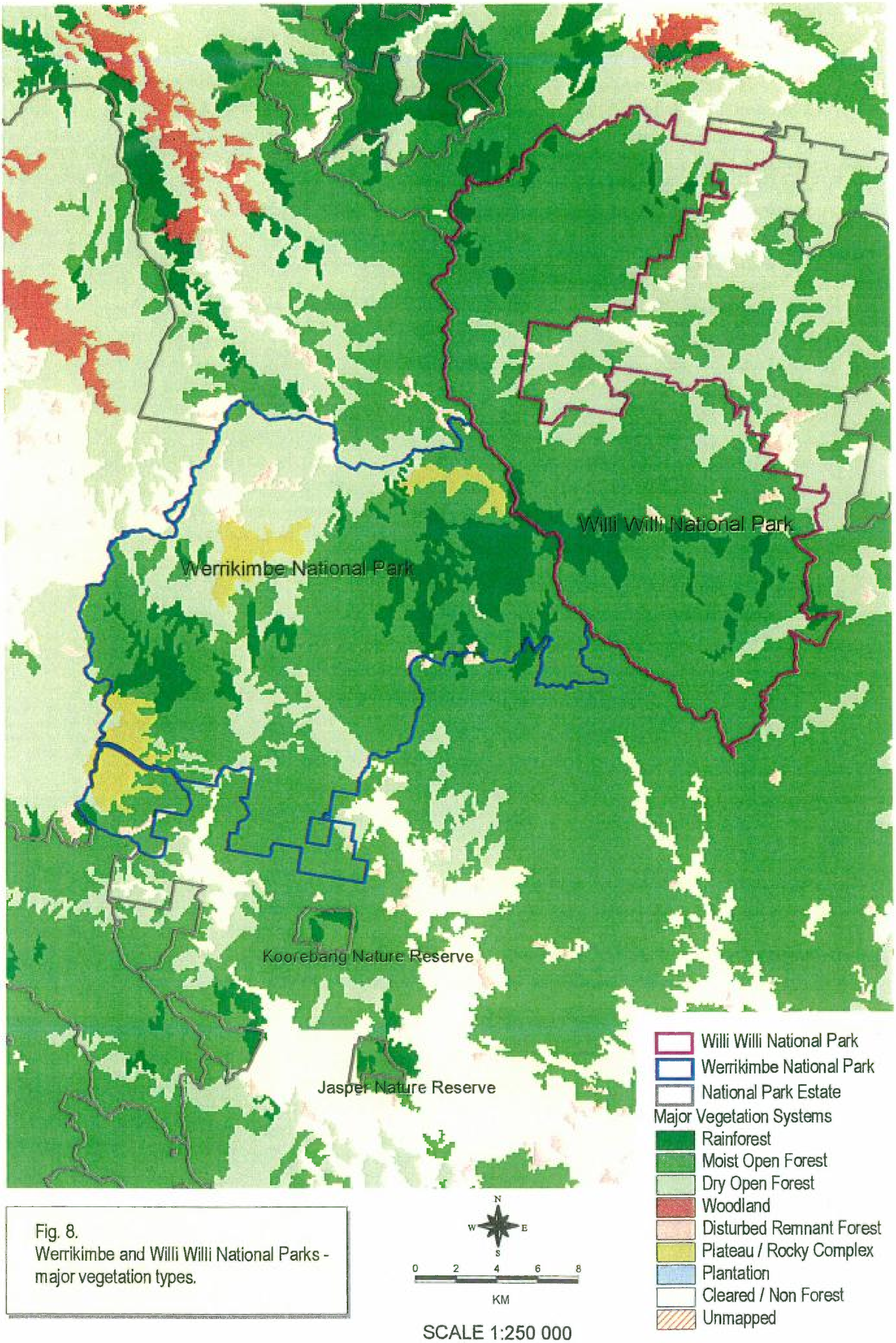

Fig. 8.
Werrikimbe and Willi Willi National Parks - major vegetation types.

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moorei, occurs in the cooler high rainfall areas, generally at elevations exceeding 1000m. In contrast to the subtropical rainforest, it supports relatively few tree species. Tall open forest is present in the drier lower reaches of the Hastings and Forbes Rivers. This type of forest consists of several associations of tall species, including blue gum, *Eucalyptus saligna,* tallowood, *E. microcorys*, New England blackbutt, *E. campanulata,* turpentine, *Syncarpia glomulifera*, diehard stringybark, *E. cameronii,* messmate, *E. obliqua* and brush box, *Lophostemon confertus.* Open forest, occurs on plateau areas. It consists of small to medium-sized, often stunted, cold adapted eucalypts, sometimes opening out into woodland, but mainly forest with a characteristic xeromorphic shrub layer. New England blackbutt, associated mostly with diehard stringybark, broad-leaved peppermint, *E. dives* and red bloodwood, *Corymbia gummifera*, characterise these forests. Sub-alpine woodland of low eucalypts is also found on the plateau areas of the park. The dominant tree species here are snow gum, *E. pauciflora* and broad-leaved peppermint. Usually found with a xeromorphic shrub layer, this woodland is also occasionally found with only a grassy understory. Heath communities have a very restricted distribution. Much of the heath is on poor shallow rocky soils usually derived from granite, but a denser wet heath is occasionally found on damp peaty soils in swampy depressions. Small and large patches of sedge and meadow swamp, and sphagnum bog occur on the high plateau surface in the upper reaches of streams.

Werrikimbe National Park gained international attention in 1986 when it was placed into the World Heritage Register in recognition of its diverse rainforest communities. Most (26,500 ha) of the Park has been declared wilderness.

Willi Willi National Park

Willi Willi National Park (20,170ha) is bounded by WkNP to the west, State forest to the south, vacant Crown land to the north and freehold and leasehold land to the east and north-east. It shares a similar climate to WkNP.

The geology of WWNP is similar to WkNP except for the inclusion of the Boonanghi Bed sedimentary mudstones, sandstones and minor conglomerates and the Byabarra Bed sandstones, conglomerates and minor limestone. The igneous (porphyry and rhyolite) intrusions of Mount Boss and Mount Banda Banda are responsible for much of the rugged topography of both Parks.

The vegetation is similar to that in WkNP (Fig. 8), with areas of subtropical rainforest at Flat Top Mountain, along the ridge towards Double Head and on the sheltered eastern slopes and gullies further south. The proposed aerial baiting run in WWNP follows a road along the Flat Top – Double Head ridge (Fig. 7). Warm temperate – subtropical rainforests occur on the deeper soils of mountaintops in the same area and near Kemps Pinnacle. Isolated areas of cool temperate rainforest occur at higher altitudes (950-1000m) on the moist, upper eastern slopes of the Carrai Plateau along the western boundary of WWNP.

2.5 Conclusions

There is adequate evidence that large numbers of livestock (mainly sheep) on properties adjoining KNP and OWRNP are being attacked and killed by wild dogs. The evidence for the areas adjoining the three other Parks is less substantial, perhaps because most of the livestock present are cattle. However, there is no scientific or objective evidence that wild dogs from ***within*** any of the Parks are responsible for the attacks, only local opinion. Consequently, one must question whether the first criterion of Wild Dog Policy 2.6.20 is being met as a justification *for any form* of wild dog control in any of the Parks.

There is also evidence that wild dog control measures on adjacent non-Service land in every District have failed to solve the problem of wild dog impact on livestock. Research results (McIlroy *et. al.* 1986b; Fleming *et. al.* 1996) indicate that the effectiveness of wild dog poisoning campaigns can vary considerably and rarely achieve the critical threshold level necessary for sustained control. The need to maintain current control efforts year after year in most Service and off-Service estate is sufficient proof of this.

The impact of current control programs on the *dingo* population in each Park is unknown, partly because of the lack of accurate information on their purity, numbers and distribution. Overall, given the small proportions of each Park being aerially baited and the apparent lack of effectiveness of annual control programs, it is highly unlikely that the proposed aerial baiting, by itself, will threaten the viability of the "dog" population within each Park. As R. Harden, NPWS, stated in the Armidale District 1998 REF (Waters *et. al.* 1998) "For the past 30 years extensive aerial baiting programs have been undertaken throughout forested areas of the tablelands and the Macleay Gorges. These programs have involved treatment areas, bait quantities and poison concentrations of at least an order of magnitude greater than what is currently being undertaken in the Macleay Gorges and adjacent lands". Obviously wild dog populations remained viable during these 30 years, given that there is still a problem with them in the same area. Whether that applies to dingo populations is another matter when other factors, particularly cross-breeding with feral dogs may also be involved.

About half of the wild dog population sampled in south-eastern Australia during the 1960-70s were hybrids between dingoes and domestic dogs plus the descendants of cross-bred progeny (Newsome and Corbett 1982). More recent surveys in the early 1980s (Jones 1990) confirmed the trend of increasing hybridisation in the region. A study of the genetics of the dingo\wild dog population in KNP is currently in progress (A Leys, NPWS, Sydney, pers. comm. 1999). Although populations in northern Australia and other remote areas still contain mainly pure dingoes, hybrids are also occurring there. On Fraser Island 17% of a recent sample of 35 culled wild dogs were hybrids (Woodall *et. al.* 1996). If the current rate of hybridisation continues, pure dingoes may well be extinct before the end of the 21st century (Jones 1990; Corbett 1995).

Methods suggested to slow hybridisation include stricter controls on the keeping of dingoes as pets (eg. permits, neutering), neutering of domestic dogs in remote areas and management of pure dingoes on large islands such as Fraser Island and

Melville Island. To date no methods have been suggested to selectively remove hybrids from predominantly pure dingo populations. Conceivably, it might be possible to carry out a continual live trapping program and assess the purity of all dogs caught by DNA fingerprinting techniques or by skull measurements from X-rays (cat scans). For the majority of populations on the mainland, including NSW, however, there is no quick, reliable, practical technique currently available. Most importantly, there is no difference in the toxicity of 1080 to wild dogs, hybrids or dingoes (McIlroy 1981b).

In conclusion, Jindabyne and Armidale Districts provide evidence of the existence of properly maintained barrier fences along parts of their Park perimeters and the non-feasibility of erecting fences on other parts of the perimeter. The two other Districts simply regard barrier fences as non-feasible options in the rugged country along the Park boundaries. On a cost basis, Jindabyne District claim aerial baiting in Byadbo Wilderness Area would be more than 23 times cheaper than mound baiting ($1,500 versus $35,000) and at least six times cheaper than a one-off mound baiting with no replacement of baits ($9,000). They argue that the local community would have little faith in the replacement of aerial baiting by a one-off mound baiting with no bait replacement because of the limited number of baits distributed and their likely high removal by foxes. In some ways, though, this seems little different than the ground surface baiting carried out on private land adjacent to the Parks by the Cooma and Bombala RLPB. Armidale District claim aerial baiting would be almost 14 times cheaper than mound baiting in OWRNP ($4,000 versus $54,000). The differences between both their and Jindabyne District's estimates of costs for aerial versus mound baiting are substantial and could be used for research (See Section 7, Future Research). Aerial baiting in WNP would be about 10 times cheaper than mound baiting ($408 versus $3930) but would not result in substantial savings. The situation in WkNP and WWNP is not clear (See Section 2.4.2) but aerial baiting might be about three times cheaper than mound baiting?

Overall, Jindabyne and Armidale Districts appear to have the strongest cases for future aerial baiting programs. In all cases what is not stated is whether the proposed aerial baiting programs will have a deleterious effect on native wildlife, especially threatened species. The objective of the next two Sections is to describe whether that is likely to occur or not.

3. SPECIES POTENTIALLY AT RISK FROM WILD DOG BAITING IN NEW SOUTH WALES

For many years the sensitivity of animals to 1080 poison (sodium monofluoroacetate) has formed thc basis for assessing the potential risk they face of being killed by the poison during pest-control programs. In many cases measurements of sensitivity can provide this function, clearly indicating which species are particularly tolerant and likely to survive ingestion of poison baits, and which species are highly sensitive and likely to be killed if they eat baits or other poisoned animals. However, sensitivity is only one of a number of factors that can determine whether an animal is poisoned or not during a pest-control program.

The aim of this Section is to briefly review these factors, and use them as a basis to evaluate which native species in the New South Wales are potentially at risk from *any* form of wild dog baiting.

3.1 Sensitivity To 1080

Sensitivity to an acute poison such as 1080 is normally expressed in terms of lethal doses, or statistical estimates of the doses, in milligrams of poison per kilogram of the bodyweight of individuals, that will kill various proportions of a large population of animals. The median lethal dose (LD_{50}), or dose per individual that will kill 50% of a population, is the most common measurement used (McIlroy 1981a), despite the fact that the effect of different levels of mortality on the persistence of many non-target populations, particularly those of rare or endangered species, is not known. In such cases, much lower measurements of sensitivity (eg. LD_{10}'s or $_{20}$'s), if known, might form a better basis for assessing the potential risk they face from a 1080-poisoning program.

LD values of 1080 are not physical constants, like its density or solubility, nor strictly a value of the sensitivity for the species as a whole. Instead they and their fiducial limits are only an indication of the values that might be expected from repeated dosing trials on the same population of animals under the same experimental conditions.

Measurements of sensitivity to 1080 can vary according to differences in the experimental procedure used to obtain them (McIlroy 1981a) and may not necessarily indicate sensitivity under field conditions. Some animals have been shown to be more sensitive to 1080 at high or low ambient temperatures, probably because of the effects of temperature on their metabolic rate (McIlroy 1981a, Oliver and King 1983). Age and breeding conditions may also affect an animal's sensitivity to 1080. Very young animals, such as pouch young of marsupials, and female waterfowl in breeding condition, for instance, can be more sensitive to 1080 than other members of their populations (McIlroy 1981a). Amphibians and rcptiles, which have lower metabolic rates than birds and mammals, are less sensitive to 1080, while passerine birds, which mostly have higher metabolic rates than non-passerines, often appear to be more sensitive to 1080 than non-passerines (McIlroy 1984).

The key point arising from these differences in sensitivity is not that one set of results for a species is correct and others are erroneous, but that the actual sensitivity to 1080 of animals in the field may bear no close relationship to pharmacological sensitivity.

3.1.1 Sensitivity of Australian Animals to 1080

Australian animals vary considerably in their sensitivity to 1080 poison. Eutherian carnivores, marsupial herbivores in eastern Australia and eutherian herbivores are the most sensitive groups, followed by rodents, marsupial carnivores, omnivores, birds, amphibians and reptiles (McIlroy 1986). Most native animals in western Australia have a much greater tolerance to 1080 than equivalent species in eastern Australia. The extent of these tolerances appear to depend upon the length of time and extent to which the diets of their ancestral populations included parts of plants containing naturally occurring fluoroacetate or animals that feed on the plants. They also depend on the gene flow between different populations of each species (Oliver *et. al.* 1979).

Dogs (LD_{50} c. 0.06mg kg^{-1}) and dingos (LD_{50} 0.11 mg kg^{-1}) are the most sensitive animals to 1080 out of the 110 species in Australia for which LD_{50} data are available (McIlroy 1986). Overall, eutherian carnivores are significantly more sensitive to 1080 than marsupial carnivores.

3.2 Susceptibility To 1080-Poisoning Programs

Other factors besides sensitivity to 1080 can determine the effect of 1080-poisoning programs on animal populations. Body size is particularly important. For example, Australian magpies, *Gymnorhina tibicen,* and wedge-tailed eagles, *Aquila audax,* share a similar sensitivity to 1080 (LD_{50}'s of 9.93 and 9.49mg kg^{-1}, respectively, McIlroy 1984). However, because of its larger size (eg. 3.3kg weight), an eagle would have to ingest almost 10 times as much 1080 as a magpie (0.3kg weight) to receive the equivalent of an LD_{50}. Similarly, although small marsupial carnivores such as brown Antechinus, *Antechinus stuartii* and dusky Antechinus, *A. swainsonii* are 17 and 29 times more tolerant, respectively, than the dingo, they require, because of their small size, only about 0.07 and 0.20mg of 1080, respectively, for a LD_{50}, compared to 2.2mg for a 20kg dingo.

The susceptibility of different animals during 1080-poisoning program also depends on how much bait or portions of poisoned animals they eat. Although it is difficult to grade hypothetical risk without information on actual intake of poison material, data on daily feeding rates can be obtained for many animals using the allometric equations of Nagy (1987), from studies of free-living animals (eg. Green *et. al.* 1989), and from laboratory trials using actual bait materials (eg. Soderquist and Serena, 1993). This information indicates that many animals have the potential to eat lethal amounts of bait or poisoned animals (McIlroy 1986, McIlroy and Gifford 1992). Whether they do or not depends on many factors, particularly how many baits or poisoned animals they encounter and how much of this material and 1080 they ingest.

The probability that a particular individual or species will encounter a bait or poisoned animal depends on the amount of bait used and its distribution, and the population densities, ranges and movements of the animals concerned in relation to the baited area. It can also depend upon whether the baiting methods have been modified to increase specificity (eg. use of lures or attractants) or to reduce non-target hazard (eg. use of repellents, dyeing or covering baits, or exposing them only during darkness), and the length of time they remain available to particular animals before decomposing or being eaten by insects or other animals. For example, foxes, and large birds such as Australian ravens, *Corvus coronoides,* can remove 92-100% of meat baits laid on the ground for wild dogs within four days (McIlroy 1982a, McIlroy *et. al.* 1986a). While such removal may lessen the chances of other non-target animals, such as spotted-tailed quolls, encountering the baits, it can decrease the effectiveness of the poisoning program against the target animal.

Not all animals that encounter baits or poisoned animals will eat them. Some birds and mammals, for example, may only eat carrot, or grain or pollard pellet baits; others may eat all three types, and some also may eat meat baits (Brunner and Browne 1979, Brunner 1983, McIlroy 1986). Others may ignore the baits, preferring other types of food (Calver *et. al.* 1989). Feeding rates can vary according to age, growth or reproductive stage, season, habitat, behaviour, the palatability of the bait or portion of corpse eaten, and thc availability of other food (Eastman and Calver 1988, Calver *et. al.* 1989, Soderquist and Serena 1993).

The amounts of 1080 animals ingest from feeding on baits or poisoned animals can differ according to the size or quality of the bait (Batcheler 1982) and the concentration of 1080 in them or in the organs and tissues of poisoned animals. The amounts of 1080 in baits or poisoned animals is also likely to decline over time through leaching by rainfall, partial consumption by insects, or defluorination of the 1080 by micro-organisms during decomposition (McIlroy *et. al.* 1988). The amounts of 1080 absorbed by animals can also depend upon whether the animal can vomit or regurgitate toxic material or quickly develop an aversion to eating it. Fat-tailed dunnarts, *Sminthopsis crassicaudata,* for example, appear to be able to smell or taste 1080 and either reject baits or stop eating before ingesting a lethal amount (Sinclair and Bird 1984). Calver *et al.*. (1989) found that individual of four species of rodents reduced their consumption of bait containing 1080 relative to non-toxic bait, although this did not prevent three of five laboratory rats, *Rattus norvegicus,* and one of three sandy inland mice, *Pseudomys hermannsburgensis,* from being killed.

3.3 Species Potentially At Risk From Wild Dog Baiting In New South Wales

A range of animals may eat baits or portions of baits intended for control of foxes and wild dogs in NSW. These include reptiles, such as varanid lizards, small and large passerine birds, raptors, many dasyurid mammals, bandicoots and rodents.

There is no published evidence, however, that show the baiting programs significantly affect any of their populations.

3.3.1 Reptiles

Sand goannas or Goulds' monitors, *Varanus gouldii*, lace monitors, *V. varius,* shingle-back lizards, *Tiliqua rugosa* and blotched blue-tongued lizards, *T nigrolutea*, have all either been observed scavenging, or are likely to scavenge meat baits intended for wild dogs (McIlroy *et. al.* 1985). All, however, are very tolerant to 1080 and would need to ingest more that five baits per individual to receive an LD_{50}. No information is available for snakes. Most snakes are extremely unlikely to eat baits, preferring to capture live prey. Pythons have been observed feeding on animals killed on roads, but only on rare occasions (J. Wombey, CSIRO, pers. comm. 1998). In the U.S.A., gopher snakes, *Pituophis catenifer,* fed small rodents poisoned with 1080 often regurgitated the rodents (Brock 1965). None suffered any lethal effects.

3.3.2 Birds

Many birds could be attracted to wild dog baits, either because of the insects feeding on the baits or because they will readily feed on meat, particularly if it still has traces of fat adhering. Although the 19 species of small passerines, such as grey shrike-thrushes, *Colluricincla harmonica*, for which there are LD_{50} data, are 6-164 times more tolerant to 1080 than the dingo, their much smaller size can make them susceptible to 1080-poisoning (McIlroy 1984). A white-browed scrubwren, *Sericornis frontalis*, for example, needs to ingest only about 0.05mg of 1080, or approximately 1.9g of a 230g bait, to receive the equivalent of LD_{50}. Although some of the passerines, for which there are LD_{50} data, such as pied currawongs, *Strepera graculina*, and Australian ravens, are also more tolerant to 1080 than the dingo, they only need to consume about quarter to two thirds of a bait to receive the equivalent of a LD_{50} (McIlroy 1984). Raptors such as black kites, *Milvus migrans*, and wedge-tailed eagles would need to consume almost two and more than five baits, respectively, to receive the equivalent of an LD_{50} (McIlroy 1984).

Birds observed interfering with, eating or removing wild dog baits in eastern NSW include lyrebirds, *Menura novaehollandiae,* grey shrike-thrushes, Australian magpies, pied currawongs, Australian ravens and wedge-tailed eagles (McIlroy *et. al.* 1986a,b). During one wild dog ground-baiting program McIlroy *et. al.* (1986a) noted that birds removed at least 18% of the meat baits within two days of their distribution. Half the baits taken were deliberately placed in partly hidden sites, such as under shrubs or besides logs, in attempts to prevent birds from finding them. During two other wild dog ground-baiting programs McIlroy *et. al.* (1986b) found that up to 92% of the baits were removed within the first four days, principally by foxes and birds, and 99% within 18-21days. The remainder of the baits were never taken and finally rotted away. The birds also pecked at 32 baits and dragged another 65 away from where they had been dropped.

Despite their interest in eating or removing wild dog baits, there is no evidence that 1080-poisoning programs significantly affect bird populations. McIlroy *et. al.*

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(1986a) monitored populations of 36 bird species during one wild dog trail-baiting campaign in a mountain forest area of NSW and populations of seven particular bird species during a second trail-baiting campaign. In each case, there was no evidence that any of the populations had been significantly affected by the baiting.

3.3.3 Mammals

The native mammals most likely to feed on wild dog baits are rodents, bandicoots and dasyurids.

Rodents

Based on the LD_{50} data provided by McIlroy (1982b), individuals of most species of rodents that eat meat baits containing 1080 intended for wild dogs could face a considerable risk of being poisoned. The crucial factor governing the actual effect on populations will be how many individuals find and eat the baits. Some *Rattus fuscipes* and *R. lutreolus* are known to eat meat baits, (McIlroy 1982a and unpublished data). Each needs to ingest only 3-4% of a bait to receive the equivalent of an LD_{50}. Despite this, McIlroy *et. al.* (1986a) found that a trail-baiting campaign against wild dogs did not significantly affect population numbers of *Rattus fuscipes*. There were no significant changes in sex or age ratios before or after the poisoning campaign and the high recapture rate afterwards suggests that the population was largely sedentary except for some transient sub-adult rats.

Bandicoots

Little is known about the diet of bandicoots except that they have a preference for invertebrates such as earthworms and insects (Heinsohn 1966), but are generally regarded as omnivorous (Hume 1982). Captive long-nosed bandicoots, *Perameles nasuta* ate 100-200g of minced meat per day (Lyne 1971). Brunner (1985) found that free-living short-nosed bandicoots, *Isoodon obesulus* and long-nosed bandicoots did not dig up and eat grilled liver baits buried 2-15 cm under soil. Phillips (1994) however found that captive eastern barred bandicoots, *Perameles gunnii* ate Foxoff ® baits. Three of six individuals dug up and ate baits buried 10 cm deep and six of 13 individuals consumed baits laid on the surface. Two adult males, as they became familiar with the baits, began to consume the entire bait overnight. Based on the LD_{50} data available (McIlroy, 1983b), individual short-nosed and long-nosed bandicoots would have to eat more than one wild dog bait (eg. 1.3-1.5 baits, respectively) to receive the equivalent of LD_{50}.

Small Dasyurids

The dasyurids, or native marsupial carnivores, are the species most likely to be affected by wild dog baiting. Although the smaller mouse-like dasyurids are mainly insectivorous, at least some of them are known to eat meat, including in some instances wild dog baits (McIlroy 1981b, 1982a). For example, fat-tailed dunnarts, stripe-faced dunnarts, *Sminthopsis macroura,* brown antechinus, dusky antechinus and kowari, *Dasyuroides byrnei* can eat from 6-27g of non-poisoned meat bait per day in captivity (McIlroy 1981b). This might equal about 10-40g for free-living individuals (McIlroy 1981b). Such amounts eaten from poison baits (ie.

6mg of 1080 in a 230g bait) would contain from 0.26-1.04mg of 1080, or 3-16 times the amounts representing LD_{50}s for the species. However, at least fat-tailed dunnarts are reluctant to eat meat containing 1080 (Sinclair and Bird 1984). They, like other small dasyurids, usually eat repeated small meals rather than one large one. It is possible, therefore, that they may ingest sub-lethal doses in the first feeding session on a poison bait which would make them feel sufficiently unwell not to eat any further bait. McIlroy (1981b, 1982a), using rhodamine B dye in wild dog baits, found that some brown antechinus would not eat the baits even when they were within their home ranges. Other antechinus had obviously eaten non-lethal amounts, while others were never trapped after experimental baitings.

Results from two field studies involving wild dog baiting in areas containing brown and dusky antechinus indicate that the poisoning campaigns had little significant long-term effect on the antechinus populations. The first study involved 200 poison baits (mean weight 52 kg) spaced regularly 20m apart on a 6.8 ha grid and 200 non-poison baits spread similarly on another grid 3 km away in mountain forest in south-eastern NSW. Population numbers of brown antechinus on the poison grid decreased by 82% (17 to 3 individuals). In comparison, population numbers of the species on the non-poison grid decreased by only 15% (McIlroy 1982a). In both cases there were no changes in the sex ratio of the population before and shortly after the baits were laid (eg. no natural male die-off). Shortly after the baiting, new individuals began immigrating into the poison area and within seven weeks there was no significant difference again (as occurred before baits were laid) between the trappable population in both areas. By September, as normally occurs after mating, all the males had died in both areas and the females were close to parturition.

In a second study in the same region a few years later, population numbers of brown and dusky antechinus were monitored before and after a trail-baiting campaign against wild dogs (McIlroy *et. al.* 1986a). In July 275 poison baits (each containing 7.5mg of 1080, the amount used for wild dog control at that stage) were laid along 32 km of trail at a density of 8.5 baits km^{-1}. One poison bait was deliberately laid in the centre of each of 20 trapping areas for antechinus along the trail; some others were laid within 50m. Each trapping area consisted of 20 traps spaced 7m apart, set 10-20m off a fire trail. Trapping results indicated that the trail baiting had no significant effect on population numbers of brown antechinus (McIlroy 1986a). Twenty seven individuals were caught in each trapping area before and after the baiting. Numbers of dusky antechinus decreased from six to three after the baiting (three marked males and one marked female disappeared, but one new female was trapped).

In both studies, theoretical assessments of risk before each baiting indicated that if each *Antechinus stuartii* found and fed on a poison bait, it would be poisoned. These assessments were based on the LD_{50} for brown antechinus (ie. 1.85mg kg^{-1}), the mean weight of individuals in each population prior to baiting (ie. 19.4g for the large grid animals and 20.8g for trail-baited animals), the concentration of 1080 used (0.2mg g^{-1} and ca. 0.035mg g^{-1}, respectively), plus the amount of bait each individual could possibly eat (McIlroy 1981b). In each case not all individuals in the population were killed but it is evident that the higher density of baiting and/or higher concentration of 1080 involved in the large grid baiting had a greater effect on reducing brown antechinus numbers than the trail baiting. It is highly likely that the proposed aerial baiting in the five selected NPWS Reserves, involving 6mg of 1080 in approximate 250g baits (ie. a concentration of only 0.024mg g^{-1}) and a maximum of 10 baits per kilometre would have even less effect on *Antechinus* populations.

Large dasyurids

Although large dasyurids such as the eastern quoll, *Dasyurus viverrinus*, and the spotted-tailed quoll, *D. maculatus* are much more tolerant to 1080 than wild dogs (34 and 17 times, respectively), they still face a risk of being poisoned if they eat dog baits. Each species generally requires less than 6mg of 1080 to receive a LD_{50} and they can probably eat about 268-271g of bait (or in other words, one bait) per day in the wild (McIlroy 1981b). No 1080 toxicity data are available for brush-tailed phascogales, *Phascogale tapoatafa* and it is difficult to predict its LD_{50} from that of other dasyurids (McIlroy 1986). King *et. al.* (1989) estimated an LD_{50} of 17.5 mg kg^{-1} for *Phascogale calura* from south-western Australia but this and other dasyurid species in the region have acquired a greater tolerance to 1080, presumably through feeding on prey that have fed on plants containing naturally occurring fluoroacetate.

As described earlier, there are many other factors besides species sensitivity to 1080 that can govern the effect of wild dog baiting on populations of native animals. In the next Section, greater attention will be given to those factors in regard to the three large dasyurids species in NSW Reserves as well as other threatened species.

3.4 Conclusions

The field studies carried out to date indicate that theoretical assessments cannot allow for all the variables involved and possibly over-estimate the risk native non-target animals face from wild dog baiting programs. Key factors are the number and distribution of baits in relation to the population density of each potential non-target species and the length of time the baits remain available to each species before they are eaten by other animals (eg. insects, birds and foxes) or rot away or the 1080 is leached out by dew or rainfall. In many cases, with more common species, it is highly likely that even if some individuals are poisoned, immigrants will quickly replace them. At present there is no conclusive proof from field studies, that 1080-baiting programs against wild dogs are significantly affecting populations of any common native animals in NSW. However such a situation may not apply to rare of threatened species. Field monitoring of the impact of wild dog control programs on them can be difficult to carry out because of their sparseness, the need for large, replicated treated areas as part of experimental design, and the number of variables that may be involved. In such cases theoretical assessments based on potential susceptibility can still be important for assessing, the risk these species face of being poisoned.

4. THREATENED SPECIES POTENTIALLY AT RISK FROM AERIAL BAITING FOR WILD DOG CONTROL IN SELECTED NPWS RESERVES

The object of this Section is to evaluate the potential impact of the proposed aerial baiting for wild dog control in the five NPWS Reserves on the three threatened species of primary concern and 12 threatened species of secondary concern listed in the Director-General's Requirements (1.3). Comments will also be included on other threatened species listed by Northern Zone as occurring inside *or within 10km* of the four northern Parks (Appendix 1) and on non-threatened species present in the Parks that may eat wild dog baits or poisoned animals.

Table 6 shows which of the 15 threatened species listed in the Director-General's Requirements have been recorded in the five Parks. Some of the numbers of species listed for OWRNP, WkNP and WWNP in Appendix 1 may refer to individuals recorded within 10km of the three adjoining Parks and extracted by two or even three database searches for the three Parks (N Sheppard, NPWS, Northern Zone pers. comm. 1999).

Table 6: Occurrence of threatened species in selected NPWS Reserves

Species	KNP	OWRNP	WNP	WkNP	WWNP
S-t. quoll	*	*	*	*	*
E. quoll					
B-t. phascogale				*	
C. planigale					
W-f. dunnart					
R. bettong		*	*	*	
L-n. potoroo			*	*	
B-t. rock-wallaby	*	*			
S. mouse	*				
E.c. mouse		*		*	
H.R. mouse		*		*	
B. stone-curlew					
R. goshawk					
B-b. buzzard					
S-t. kite	*		*		

The evaluation is based on the biology and ecology of the species concerned and their known or possible sensitivity to 1080 poison. Aberrant feeding behaviour by captive individuals, such as reports of macropodids eating minced meat, have been ignored as unlikely to represent the normal behaviour of free-ranging individuals. The threatened amphibians listed in Appendix 1 have been excluded from the evaluation because they are extremely unlikely to eat wild dog baits and because of the high tolerance of amphibians to 1080 (McIlroy *et. al.* 1985). The bats have also been excluded because they are unlikely to feed on wild dog baits and there is no knowledge about the sensitivity of bats to 1080.

4.1 Reptiles

No threatened reptiles are listed in the Director-General's Requirements. Northern Zone has indicated that there are two records of the threatened Stephen's banded snake, *Hoplocephalus stephensii*, in or within 10km of WNP (Appendix 1). This is a nocturnal, partly arboreal species usually encountered in wet sclerophyll or rainforests that feeds on live lizards, birds and small mammals (Cogger 1975). It is unlikely to eat wild dog baits and even if it ate live small mammals or birds that had fed on wild dog baits, is probably safe, because of the general tolerance of reptiles to 1080 (McIlroy *et. al.* 1985, McIlroy and Gifford 1992).

K. Pines (Armidale District, NPWS, pers. comm. 1998) has recorded some *Varanus* spp and one *Tiliqua scincoides* feeding on mound baits, but in each instance the feeding was restricted to one or two bait stations. Lace monitors can consume several meat baits laid close to each other along ground trails for fox or wild dog control, particularly when a scent "drag" (eg. an animal carcase) is used between each bait (J. McIlroy, unpubl.data). It is unlikely in most circumstances, however, that a lace monitor would find and eat more than five aerially distributed baits (the equivalent of an LD_{50}) if they were spaced at intervals of 100m. In addition, most large reptiles, particularly lace monitors, are unlikely to be physically active in the proposed aerial baiting areas (at least in KNP and OWRNP) during May-June when the baiting is proposed because of the low ambient temperatures.

4.2 Birds

Northern Zone has listed 18 threatened species of birds as being recorded in or within 10km of the four northern parks (Appendix 1). Twelve of these species (eg. glossy black cockatoo, *Calytorhynchus lathami*, rose-crowned fruit-dove, *Ptilinopus regina*, and the parrots) are unlikely to eat wild dog baits or poisoned animals. Three of the remaining six species are also listed in the Director-General's Requirements as of secondary concern

The first of the remaining six species, the squared-tailed kite, *Lophoictinia isura*, has been recorded in KNP and WNP (Table 6), and, according to Appendix 1, in or within 10km of OWRNP. It is thinly scattered throughout Australia in open forests and woodlands, but not in heavily forested areas (Cupper and Cupper 1981). The second species, the relatively rare red goshawk, *Erythrotriorchis radiatus*, has been listed in Appendix 1 as occurring in or within 10km of WNP. It is generally a coastal species. The black-breasted buzzard, *Hamirostra melanosternon*, (listed in the Director-General's Requirements as of secondary concern) is mainly found in open woodland in inland Australia and not in densely forested country (Cupper and Cupper 1981). It is not listed in Appendix 1 or known to occur in KNP.

As with the masked owl, *Tyto novaehollandiae,* sooty owl, *T. tenebricosa* and powerful owl, *Ninox strenua,* (three of the other threatened species listed in Appendix 1), the square-tailed kite and red goshawk prefer live prey and are not known to feed on baits or carrion (Cupper and Cupper 1981; P.Olsen, ANU, pers. comm. 1998). Individuals of the five species might conceivably catch a small mammal (eg. a rodent or dasyurid) that had been feeding on a wild dog bait, but the probability of secondary poisoning would be very low. Many raptors vomit after eating poisoned material (Ward and Spencer 1947). This could reduce the risk or them ingesting a lethal dose. While the LD_{50}'s for the three owl species, the squared-tailed kite and the red goshawk are not known and can not be accurately extrapolated from those of other hunting raptors (McIlroy 1986), they probably fall within the 95% confidence limits of 5.06-13.10mg 1080 per kg body weight estimated for other raptors (McIlroy 1986). The highest concentration of 1080 measured in the tissues, organs and stomach contents of 7 brown antechinus, 9 dusky antechinus and 8 bush rats, poisoned by 1080 during laboratory trials was 0.06mg per gram of muscle (McIlroy and Gifford 1992). This is well below the threshold concentration of 0.24-0.26mg of 1080 per gram of animal tissues or organs that could result in a black kite, *Milvus migrans* or wedge-tailed eagle, *Aquila audax* receiving a LD_{50}. Most of the tissue and organ samples from the poisoned mammals contained either no measurable amounts or only minor traces of 1080 (McIlroy and Gifford 1992). There is no evidence of raptors ever experiencing secondary poisoning from 1080. In the U.S.A. nine species of raptors and other birds were observed feeding on animals poisoned by 1080. None of the birds were affected (Hegdal *et. al.* 1986).

The sensitivity to 1080 of the last threatened bird species listed in both the Director-General's Requirements and Appendix 1, the bush stone-curlew, *Burhinus grallarius* is not known. It generally feeds on invertebrates such as beetles and grasshoppers. A Steed (NPWS, Northern Zone, pers. comm. 1999) states there is one record of the species in WNP. The exact location and type of habitat being used by the curlew was not provided. It would seem unlikely, however, that such a species whose favourite habitat is grassy woodland and has been reported to be absent or rare in wet sclerophyll and rainforests would be affected by the possible aerial baiting program in eastern WNP.

In summary, based on their known distribution, feeding behaviour and possible tolerance to 1080, it is unlikely that any of the threatened bird species in the five Parks are likely to be seriously threatened by aerial baiting programs against wild dogs.

4.3 Macropodids

Three macropodid species, the rufous bettong, *Aepyprymnus rufescens*, long-nosed potoroo, *Potorous tridactylus*, and brush-tailed rock wallaby, *Petrogale penicillata*, are listed as of secondary concern in the Director-General's Requirements. Appendix 1 also lists the parma wallaby, *Macropus parma*, and red-legged pademelon, *Thylogale stigmatica* as threatened species that occur in or within 10km of the four northern parks. All are herbivores and therefore extremely unlikely to feed on baits for wild dogs. Each species is likely to benefit from reduction in the numbers of foxes and wild dogs in the areas in which they occur.

4.4 Rodents

The eastern chestnut mouse, *Pseudomys gracilicaudatus,* a threatened species, occurs in OWRNP (Table 6) and has been listed as present in or within 10km of WNP (Appendix 1). It has also been recorded in WkNP (Kendall and Kendall Ecological Services Pty Ltd 1998). It is mostly found at low level densities in dense wet heathland and swampy areas in NSW (Fox 1995). It is very sedentary; most have home ranges of less than 0.5 ha. It eats stems of plants, seeds, fungi and insects (but rarely the latter during winter when aerial baiting for wild dog control would occur).

The Hastings River mouse, *P. oralis*, another threatened species, occurs in OWRNP and at two high altitude locations in WkNP (Table 6). It has also been recorded in or within 10km of WNP and WWNP (Appendix 1). Both sites in WkNP are in tall open forest with a dense ground cover of ferns, grasses and sedges. Little is known of the habits and ecology of the Hastings River mouse, but it appears to be granivorous (Kirkpatrick 1995).

The smoky mouse, *P. fumeus*, a third threatened species, is not listed as occurring in any of the five Parks (Table 6, Appendix 1). There are records of it in south-eastern Australia (Fig. 9). This includes a sample of its hair obtained from a hair tube at the Pilot to the west of the Byadbo Wilderness Area during 1994-95 (ACT Government 1999). Smoky mouse hairs were also found in the scat of a s-t quoll at Ravine, further north in KNP in 1996 and three individuals were found dead (most likely from cat predation) at Yarrangobilly during 1998. It feeds on seeds, berries and (in summer) on Bogong moths but in winter, when aerial baiting would be carried out, eats underground truffle-like fungi.

Although there is no evidence that any of these three species of mice eat baits intended for wild dogs, the possibility exists. Other rodents such as *Rattus fuscipes* and *R. lutreolus* are known to eat meat baits intended for wild dogs (McIlroy 1982b). Unfortunately there is no information on the sensitivity of the three species to 1080. Four other *Pseudomys* species have LD_{50}'s ranging from 1.15 – 39.31 mg kg^{-1} (McIlroy 1982b). At present there is no evidence that any of the three species involved are likely to be present in the proposed aerial baiting areas. L. Broome (NPWS, Queanbeyan, pers. comm. 1999) remarked that given the known habitat of the smoky mouse and the vegetation in the Byadbo area, it was unlikely that any substantial populations, or indeed any populations, of the species occurred in the area. In OWRNP the nearest proposed bait run to where the eastern chestnut mouse has been recorded is 6.25km away and the 24 reports of the Hastings River mouse are 16.6 km from the nearest proposed baiting run. Port Macquarie District do not appear to have any atlas records of the eastern chestnut mouse in WkNP so the distance of the locality provided by Kendall and Kendall Ecological Services Pty Ltd. (1998) from the proposed baiting lines is unknown. The locations of the Hastings River mouse in the eastern side of WkNP that Port

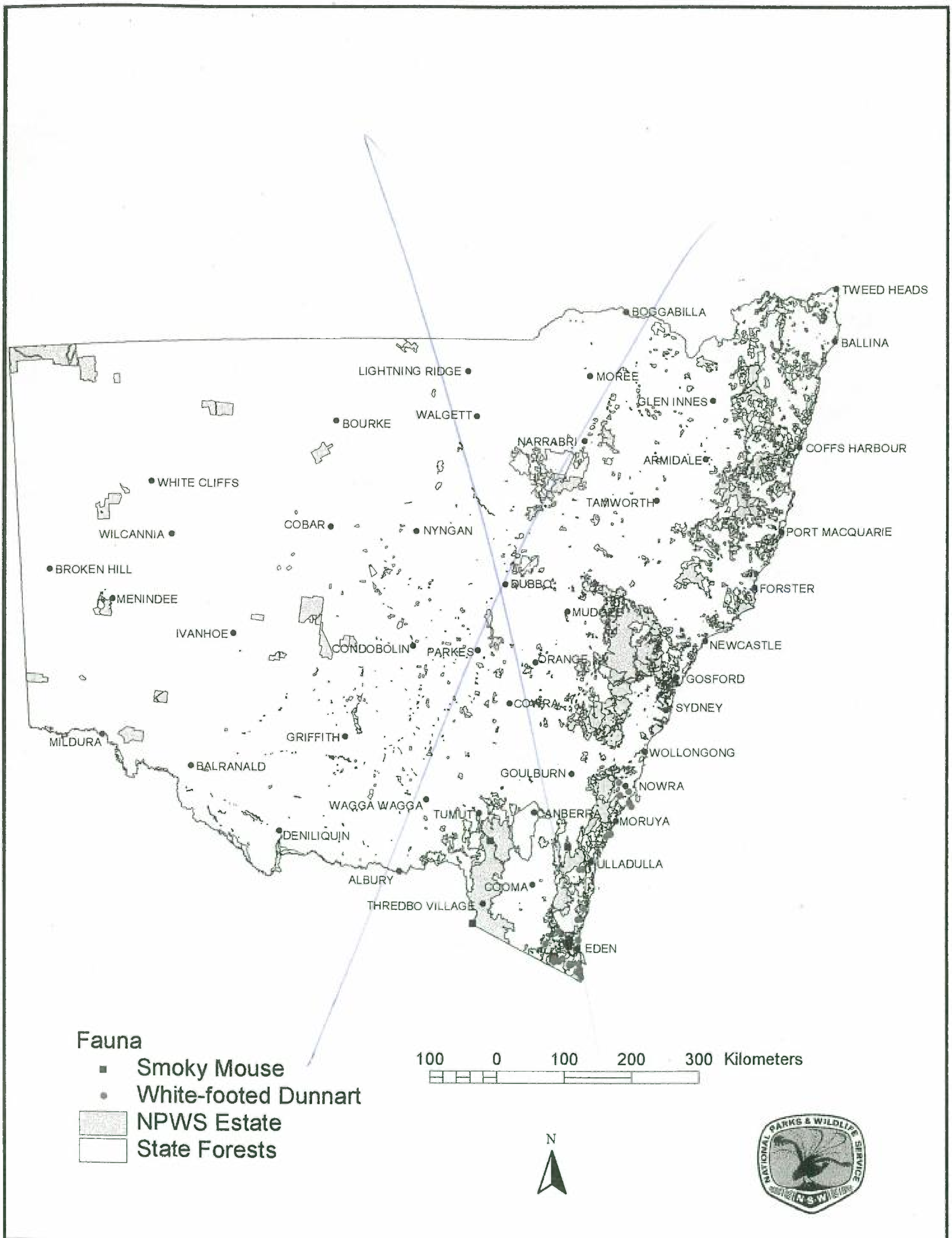

Fig. 9. Locality records for the white-footed dunnart, *Sminthopsis leucopus* and smoky mouse, *Pseudomys fumeus*, in NSW

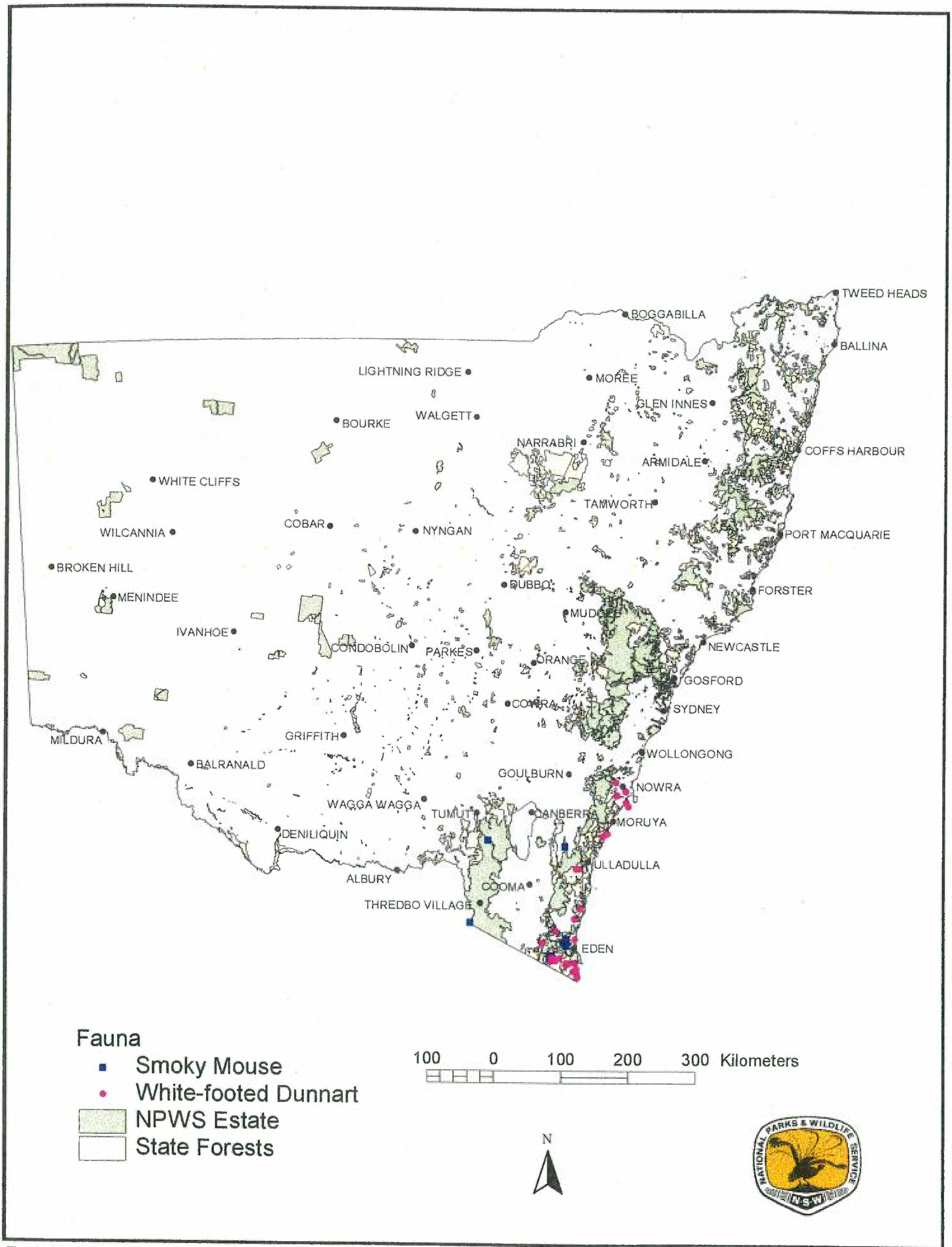

Fig. 9. Locality records for the white-footed dunnart, *Sminthopsis leucopus* and smoky mouse, *Pseudomys fumeus*, in NSW

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Macquarie District has information on are 6-7 km from the proposed aerial baiting runs.

Given the information available, it is unlikely that the proposed or possible aerial baiting programs against wild dogs would significantly affect any of the threatened rodent species or other rodent populations in the five Parks.

4.5 Small Dasyurids

The common planigale, *Planigale maculata,* and white-footed dunnart, *Sminthopsis leucopus*, are listed in the Director-General's Requirements as threatened species of secondary concern. Neither are reported as present in any of the five Parks. Common planigales are known to occur in the Willi Willi Caves Nature Reserve 3 km from WWNP but, given their particular habitat requirements and the distance of this one known location from the proposed baiting runs, appear extremely unlikely to be affected by the aerial baiting. Although the Comprehensive Regional Assessment (CRA) models indicate that marginal quality habitat is present for the species in OWRNP, WNP, WkNP and WWNP such untested modelling predictions do not appear sufficient reasons to modify the proposed or possible aerial baiting programs. At the same time any field surveys that indicated the presence of either species in the potential/possible aerial baiting areas would necessitate modifications to the aerial baiting programs. White-footed dunnarts are restricted to coastal south-eastern NSW (Fig. 9) and there is no evidence that they occur in the proposed/possible aerial baiting areas. Previous field studies with wild dog baits (McIlroy *et. al.* 1986a) indicate that the proposed aerial baiting, particularly given its spatial extent, is unlikely to have a significant impact on more common small dasyurids in the Parks, such as *Antechinus* spp. This is supported by the fact that no difference was observed in the density of brown antechinus in aerially baited and unbaited areas in north-eastern NSW (Edgar 1977, Fletcher 1977).

Unless future surveys reveal their presence within the Parks, both common planigales and white-footed dunnarts would not appear to be at risk from the proposed or possible wild dog baiting programs.

4.6 Brush-tailed Phascogale

The brush-tailed phascogale (b-t phascogale), about the size of an introduced black rat, *Rattus rattus*, is the sixth largest species of dasyurid in Australia. It is listed as a threatened species in NSW and of primary concern re the Director-General's Requirements. At present there is no Species Management Plan for the species but a start has been made on one (A. Leys, NPWS, Sydney, pers. comm. 1999).

Although they are an occasional predator of small vertebrates and penned poultry (Soderquist 1995) b-t phascogales are one of the most arboreal of the dasyurids and seldom feed on the ground. Instead they prefer to forage in large trees, feeding mainly on cockroaches, beetles, centipedes, spiders and bull ants. Consequently, they probably face a low probability of primary or secondary poisoning from aerial baiting programs for wild dog control.

As outlined in Section 3.3.3 of this report, no toxicity data are available for b-t phascogales and their LD_{50} can not necessarily be closely predicted from that of other dasyurids (McIlroy 1986). Based on the 95% confidence limits for LD_{50} s of nine closely related marsupial carnivores, the LD_{50} for b-t phascogales is likely to fall within the range 0.89-7.65 mg kg^{-1} (McIlroy 1986). This would mean that females would have to ingest approximately 0.08-1.30 mg of 1080 (males approximately 0.12-1.90 mg) to receive the equivalent of an LD_{50}. Without more accurate data on their LD_{50}, the amounts of 1080 likely to be present in the tissues of any poisoned prey that they might eat, or how much bait they might eat, it is not possible to calculate the risk they might face from 1080 poisoning any more precisely.

None of the 110 validated point locality records and 94 'invalid' records for the species in north-eastern NSW during 1988-1998 obtained from Northern Zone, NPWS showed the species as occurring in the four Northern Parks. Invalid records are those deemed not reliable enough from the CRA validation process for modelling purposes. Overall, their locality records in NSW (Fig. 10) indicate a predominantly coastal distribution, mostly in north-eastern NSW. This is expected given that, as part of the Comprehensive Regional Assessment (CRA) process, an IAP expert panel assessed coastal, grassy, dry sclerophyll forest as High Quality habitat for the species. Coastal, heathy, dry sclerophyll and swamp sclerophyll forests are considered Medium Quality or intermediate habitat and coastal, wet sclerophyll forest as Marginal Quality habitat. Soderquist (1995) noted that the species prefers open forest with sparse ground cover.

The predicted modelled distribution (Fig. 11) confirms the predominantly coastal records of b-t phascogales in northern NSW. Only small areas of potential habitat for them are predicted in the four selected northern Parks. OWRNP contains some strips of predicted high quality habitat (Fig. 12) but these are mostly situated well away from the proposed aerial baiting lines (Fig. 3), in the eastern portion of OWRNP. Fig. 12 shows the recorded localities of four b-t phascogales to the east of the Park. None appear to occur within the predicted habitats. WNP contains some small scattered areas of predicted high and intermediate quality habitat for the species in the north-east, north-west and centre, with more extensive areas to the south and south-east in GRNP (Fig. 13). The one recorded locality for the species in WNP (Fig. 13) appears to be on the edge of rainforest and moist open forest (Fig. 6). This is surprising given the species' preference for more open forest. This locality is about 2km west of one of the possible aerial baiting lines (Fig. 5).

A report by the Port Macquarie District National Parks and Wildlife Service (1999) states there is one record for the species in WkNP. This is in the Lower Mooraback area, within the western band of predicted marginal quality habitat in the Park (Fig. 14). There are also records of the species at Cedar Creek in the northern band of predicted marginal quality habitat along the border with OWRNP (Fig. 14) and to the east of Koorebang Nature Reserve. Smaller patches of predicted high quality and lesser quality habitats for the species also occur in the south-east of WkNP and in Jasper Nature Reserve (Fig. 14). Several of the proposed aerial baiting lines (ie. Jasper NP1 and WkNP3-7) are situated close to these areas. No b-t phascogales have been recorded in WWNP. There is one record (not included in Appendix 1) just to the east of the Park at its narrowest point (Fig. 14). Most predicted habitat for the species is along the eastern edge of the Park (Fig. 14), but there is a small patch in the north close to a section of the proposed aerial baiting line in WWNP (Fig. 7). B-t phascogales also occur at lower altitudes to the east of both Parks (Fig. 10).

WNP is in SETA 2 in which approximately 46% of the original CRA target habitat area has been reserved for the long-term maintenance of the species' viability. SETA's are Species Equity Target Areas. These are discrete geographic areas supporting distinct metapopulations (ie. distinct populations to which most dispersal, recolonisation and population dynamics are confined). OWRNP, WkNP and WWNP are in SETA 4. Approximately 33% of the original target habitat area for the species has been reserved in this area.

There is only one record of a b-t phascogale in Kosciuszko National Park. This is north-east of Khancoban (Fig. 2)). No evidence of them has been recorded in the proposed aerial baiting area in Byadbo Wilderness Area but the remains of three phascogales were found in s-t quoll scats from the Suggan Buggan area, just over the Victorian border to the south. At this stage there has been no modelling carried out on their favoured habitats and predicted distribution in the region.

In summary, there is no evidence at present to indicate that the proposed or possible aerial wild dog baiting programs may significantly affect b-t phascogales in the five Parks.

4.7 Eastern Quoll

The eastern quoll, once widespread throughout much of south-eastern Australia, has not been positively recorded on the Australian mainland since the 1960s. Numerous claims of eastern quoll sighting have been reported from the forests of north-eastern NSW, particularly WkNP and WWNP (D. Scotts NPWS, Northern Zone pers. comm. 1998). However, a deliberate survey for the species in Carrai State Forest, (Scotts, 1992) did not confirm its presence. The survey (in an area of reported sightings), although regarded as inadequate as an assessment by Scotts (1992) involved 302 hair sampling tubes, examination of 86 predator scats and nocturnal searches. It did indicate that the area contained a relatively high density of spotted-tailed quolls. Appendix 1 lists records of an eastern quoll in or within 10km of each of OWRNP, WkNP and WWNP but this arises because of the particular locality of one possible sighting within 10km of the three adjoining Parks. The possible sighting was made in Mount Boss State Forest to the east of the three Parks and classed as a "general observation" (ie. no specimen, probably a sight observation by a non-expert observer) (N Sheppard, NPWS, Northern Zone pers. comm. 1999).

Eastern quolls, if present in the five Parks, are unlikely to be affected by secondary poisoning. This is based on the evaluation by McIlroy and Gifford (1992) who measured concentrations of 1080 in poisoned rabbits, *Oryctolagus cuniculus* and

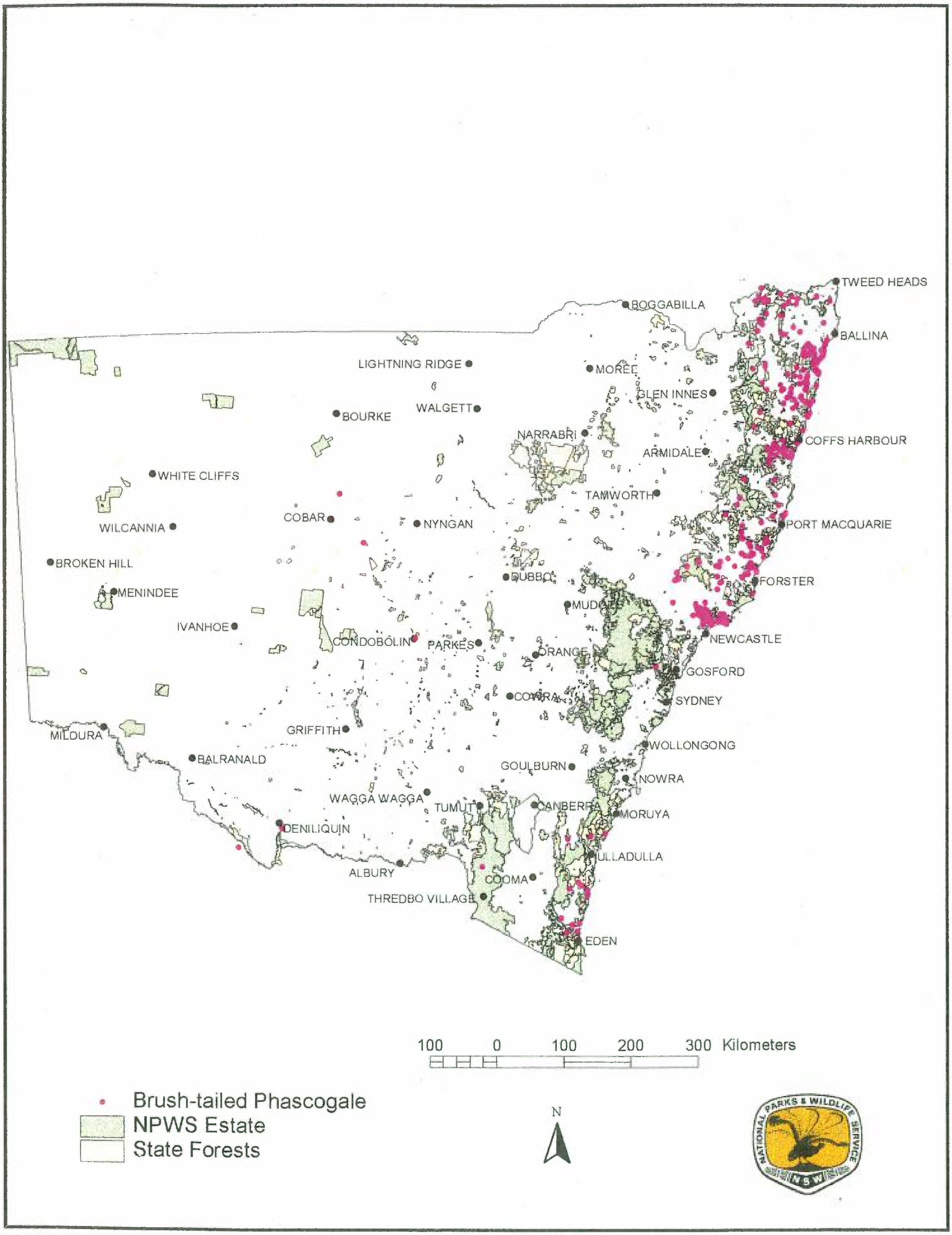

Fig. 10. Locality records for the brush-tailed phascogale, *Phascogale tapoatafa*, in NSW

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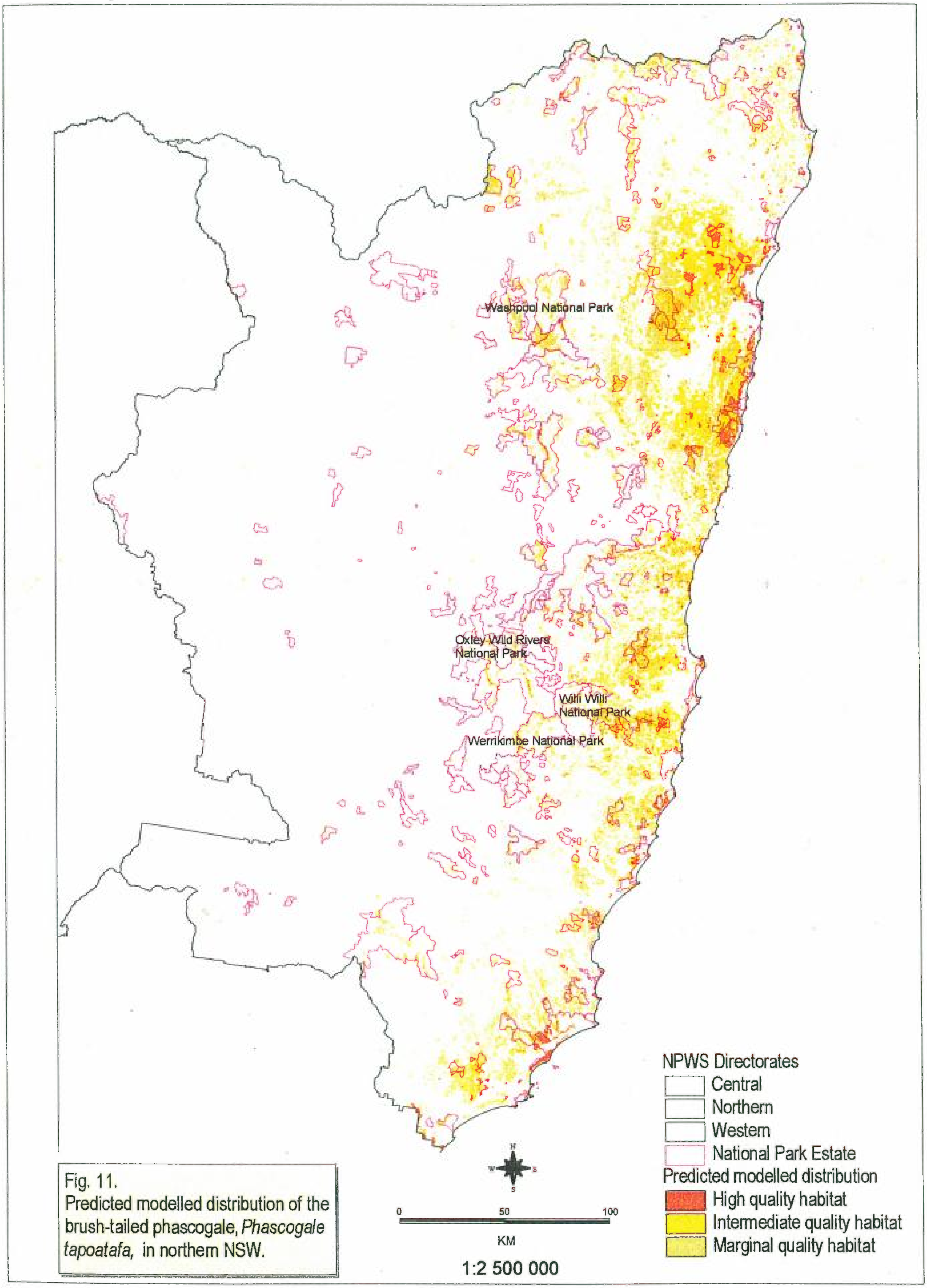

Fig. 11.
Predicted modelled distribution of the brush-tailed phascogale, *Phascogale tapoatafa*, in northern NSW.

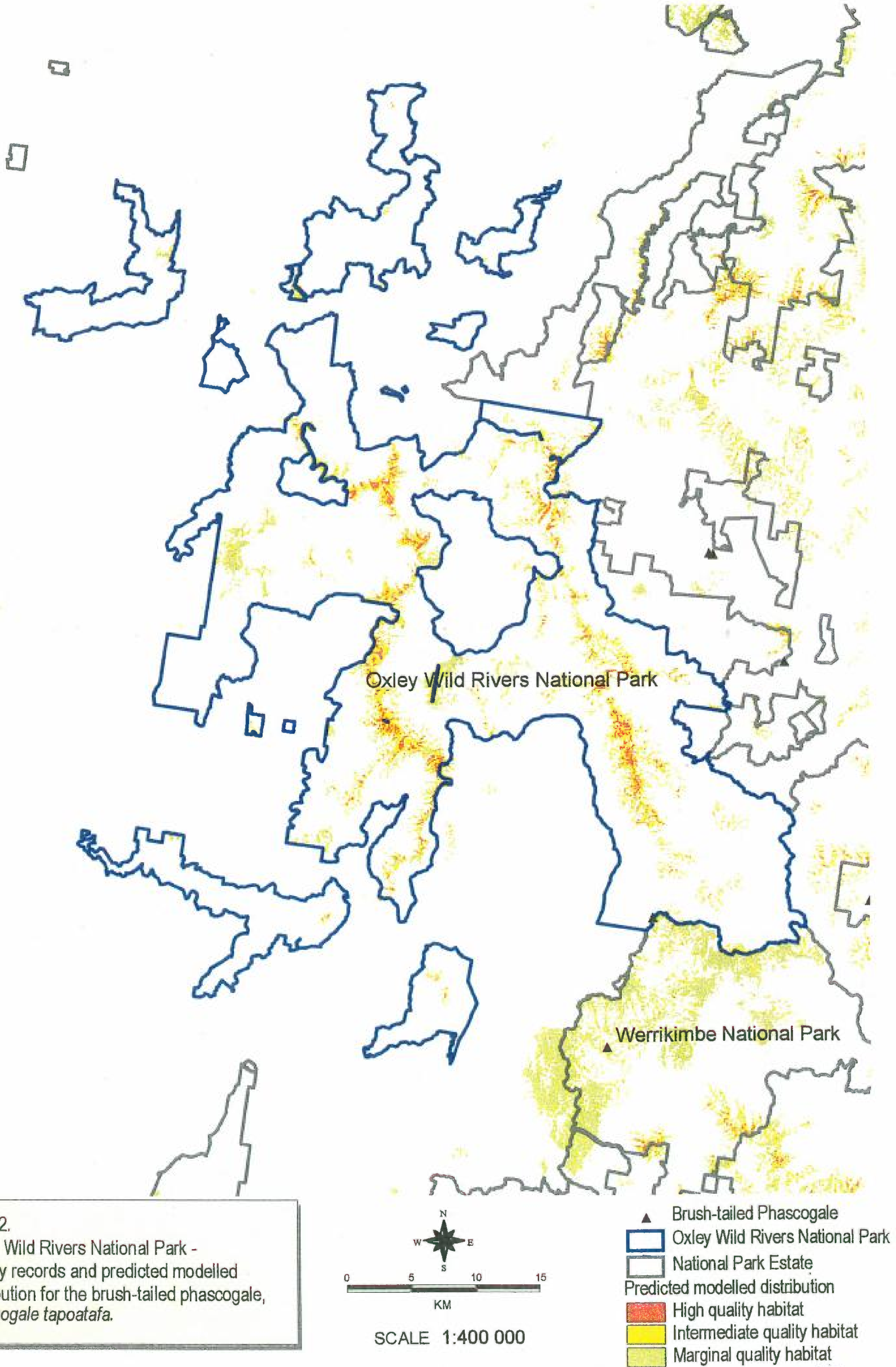

Fig. 12.
Oxley Wild Rivers National Park - locality records and predicted modelled distribution for the brush-tailed phascogale, *Phascogale tapoatafa*.

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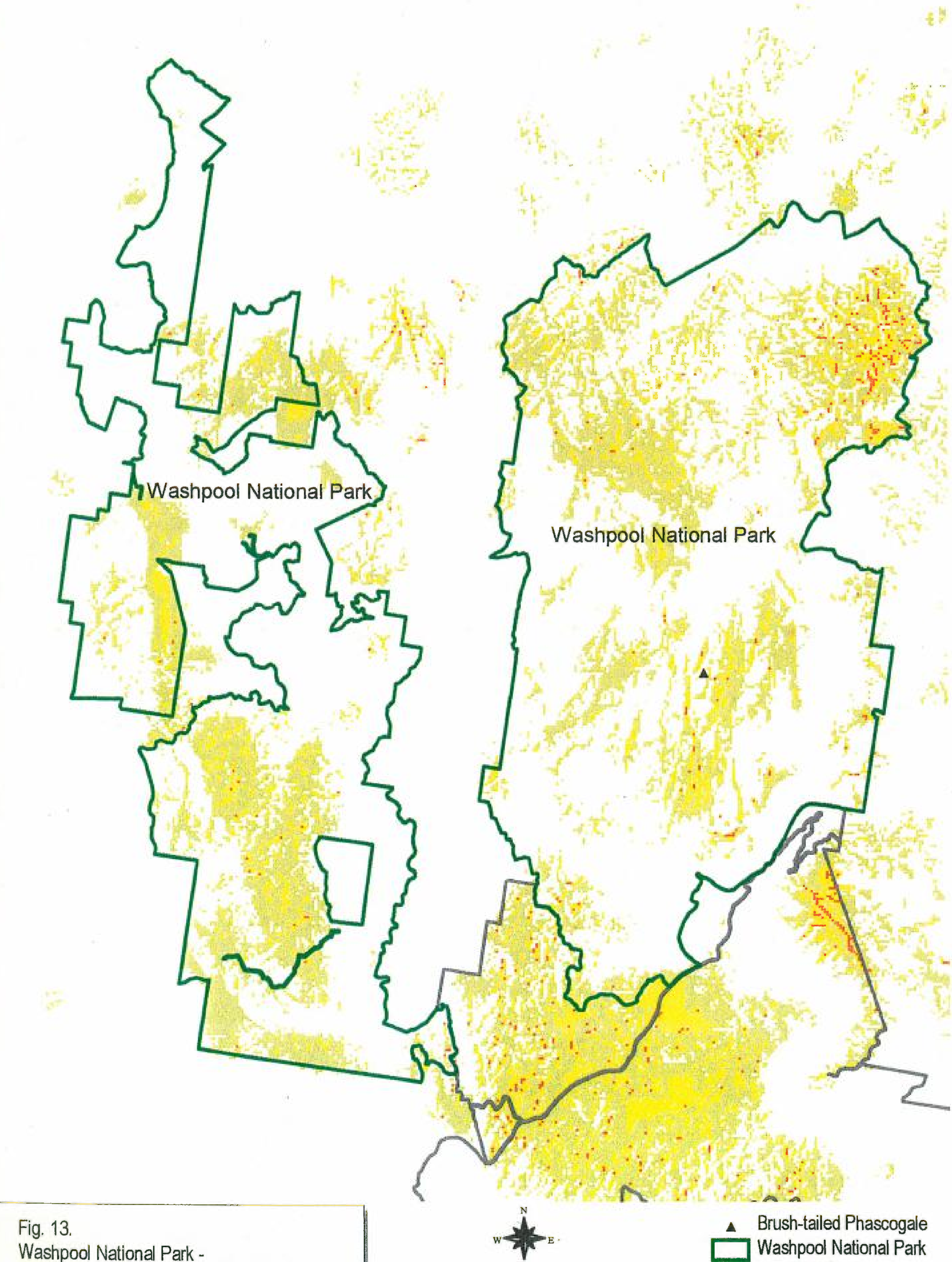

Fig. 13.
Washpool National Park -
locality records and predicted modelled distribution for the brush-tailed phascogale, *Phascogale tapoatafa.*

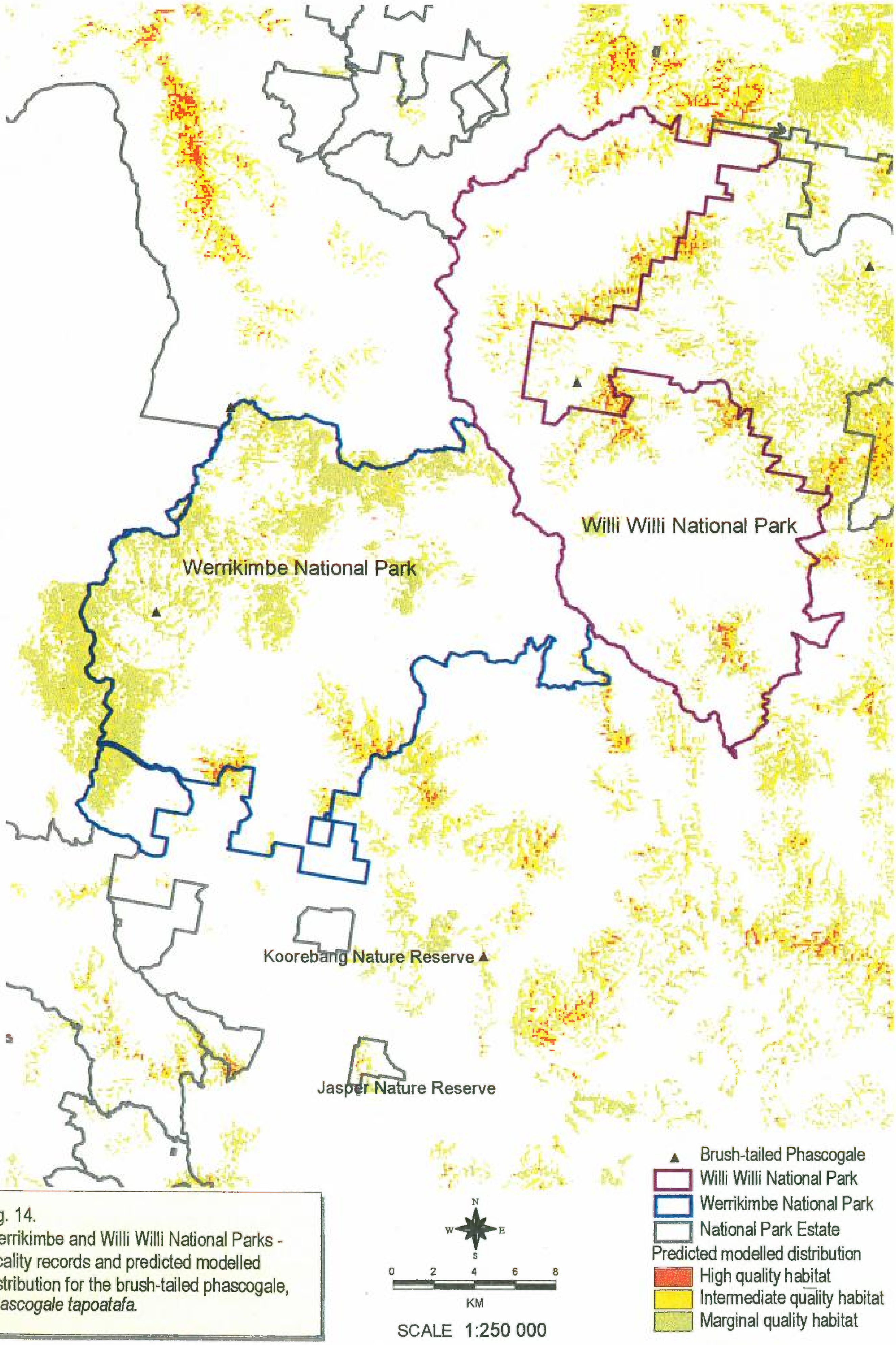

Fig. 14.
Werrikimbe and Willi Willi National Parks - locality records and predicted modelled distribution for the brush-tailed phascogale, *Phascogale tapoatafa*.

other animals. It is extremely unlikely that any prey of quolls which had previously fed on meat baits for wild dogs would contain similar concentrations of 1080 in their tissues or organs. Statham (1983) found that none of five captive eastern quolls in Tasmania that fed on field-poisoned corpses of Bennett's wallaby, *Macropus rufogriseus*, brushtail possums, *Trichosurus vulpecula,* a young rabbit or a black rat over 1-4 days showed any signs of 1080-poisoning.

The LD_{50} for male eastern-quolls is 3.73 (3.18-4.38) mg kg^{-1} (McIlroy 1981b). King *et. al.* (1989) obtained an approximate LD_{50} of 1.5 mg kg^{-1} for a mixed sex sample of six eastern quolls but acknowledged the value may have been affected by the stress associated with their serial blood sampling regime. Assuming female quolls share a similar sensitivity to 1080 to males (as do male and female rabbits and brushtail possums, see McIlroy 1981a) adult females would need to ingest 0.4-0.7 of a wild dog bait to receive the equivalent of an LD_{50}. Adult males would need to eat 0.6-1.2 baits to do the same and newly weaned young, 0.25 of a bait. These estimates are based on body weights given by Godsell (1995) and Belcher (1998). The amounts of baits involved represent about 58g from a 230g bait or 100g from a 400g bait for a newly weaned quoll; 101-156g or 176-272g, respectively for an adult female and 129-285g or 224-496g, respectively, for an adult male.

Whether eastern quolls would eat such quantities of bait is not known. Ten captive male eastern quolls ate a mean weight of 136g of meat per animal per day over 10 days without changing weight (McIlroy 1981b). Free-ranging individuals might eat approximately twice as much, or about 270g (McIlroy 1981b). Theoretically, therefore, one wild dog bait represents a hazard to most individual eastern quolls (except perhaps some large males). The question remains – is the species still present in the National Parks concerned? If eastern quolls are rediscovered anywhere within NSW it would appear a precautionary move to place an immediate moratorium on *all* wild dog baiting within their vicinity.

4.8 Spotted-tailed Quoll

The spotted-tailed quoll (s-t quoll) is the largest carnivorous marsupial on the Australia mainland. It feeds on a range of items including birds, small and medium-sized mammals and carrion from dingo or wild dog kills (Edgar and Belcher 1995). It has been recorded throughout most of eastern NSW (Fig. 15) in a wide range of habitats, including rainforest, open forest, woodland, coastal heathland and inland riparian forest. Years ago it was relatively common from the coast to the snowline in south-eastern Australia but it is now regarded as rare to uncommon. In NSW it is listed as a vulnerable species under the TSC Act.

Spotted-tailed quolls occur in all of the five selected National Parks involved in this report. However, the tall eastern forests and adjacent escarpments in north-eastern NSW appear to be the stronghold for the species on the mainland. Altogether, there have been 365 validated and 151 'invalid' point locality records for the species in this region during 1988-98. (Invalid records are those whose location accuracy and reliability were not considered sufficient for modelling purposes). Predictive modelling, as part of the NSW NPWS North East Forests

Biodiversity Study (NEFBS), indicates that the species prefers cool, moderately rugged areas. It also appears to favour areas of relatively high moisture index (typically the more productive sites) compared to areas of lower moisture index (typically less productive sites on shallower soils, in lower rainfall or more rugged areas). In northern NSW there is only a low probability of occurrence of the species in the warm (eg. coastal plains, far north-east) and low moisture (eg. north-west, western slopes) districts.

At present there is no Draft Recovery Plan or Species Management Plan for s-t quolls. Competition with introduced predators such as the fox and feral cat, continued alienation of suitable habitat by land clearing for agriculture and forestry or logging, and primary and secondary poisoning from wild dog, fox and rabbit baiting are all considered current threats to the species.

The diets of foxes, feral cats and wild dogs in eastern Australia overlap with that of the s-t quoll (Robertshaw and Harden 1985; Belcher 1995). Belcher (1995), for example, in his study of the diet of the s-t quoll in East Gippsland, found that there was a high dietary niche overlap and competition for the same prey taxa between the s-t quoll and the fox (0.91) and, to a slightly lesser degree, the feral cat (0.75). Consequently, foxes, and to a lesser extent, feral cats could be detrimentally affecting the survival of s-t quolls, either as a result of direct competition for resources (food and den sites) or through predation, especially on newly independent juveniles (Edgar and Belcher 1995). Control programs against such introduced predators, therefore, may enhance s-t quoll populations. Morris (1992) concluded that the population of the closely related chuditch or western quoll, *Dasyurus geoffroii* increased in Batalling Forest, in south-western Western Australia following a reduction in fox numbers.

The spatial relationships between wild dogs/dingoes and foxes are poorly understood. Fleming (1996) found that wild dogs/dingoes co-occurred with foxes, feral cats and s-t quolls on a regional scale in north eastern NSW. However, at a more localised level there appears to be some spatial segregation, with foxes avoiding areas frequented by wild dogs/dingoes. Aerial baiting of wild dogs and dingoes, therefore, could result in foxes spreading within the Parks and competing or preying more on s-t quolls. However, Catling and Burt (1995) suggest that fox populations in south eastern Australia are more likely to be limited by factors other than the presence of wild dogs. Therefore, in terms of Section 2.1 of the Director General's Requirements, aerial baiting of wild dogs is unlikely to contribute to extant threatening processes acting on populations of s-t quolls.

Other threats to s-t quoll, such as broad-scale clear felling of forests for timber, inappropriate burning regimes and general loss or modification of habitat should not occur within the five selected National Parks

Spotted-tailed quolls face a high potential risk of primary poisoning from wild dog baiting in the five selected National Parks but a lesser risk from fox baiting programs and of secondary poisoning from rabbit control programs. The LD_{50} for s-t quolls is 1.85 mg kg^{-1} body weight. This is lower than most of the values obtained for other dasyurids (McIlroy 1981b). Low ambient temperatures (13°C) during the LD_{50} trials on s-t quolls might have increased the sensitivity of the

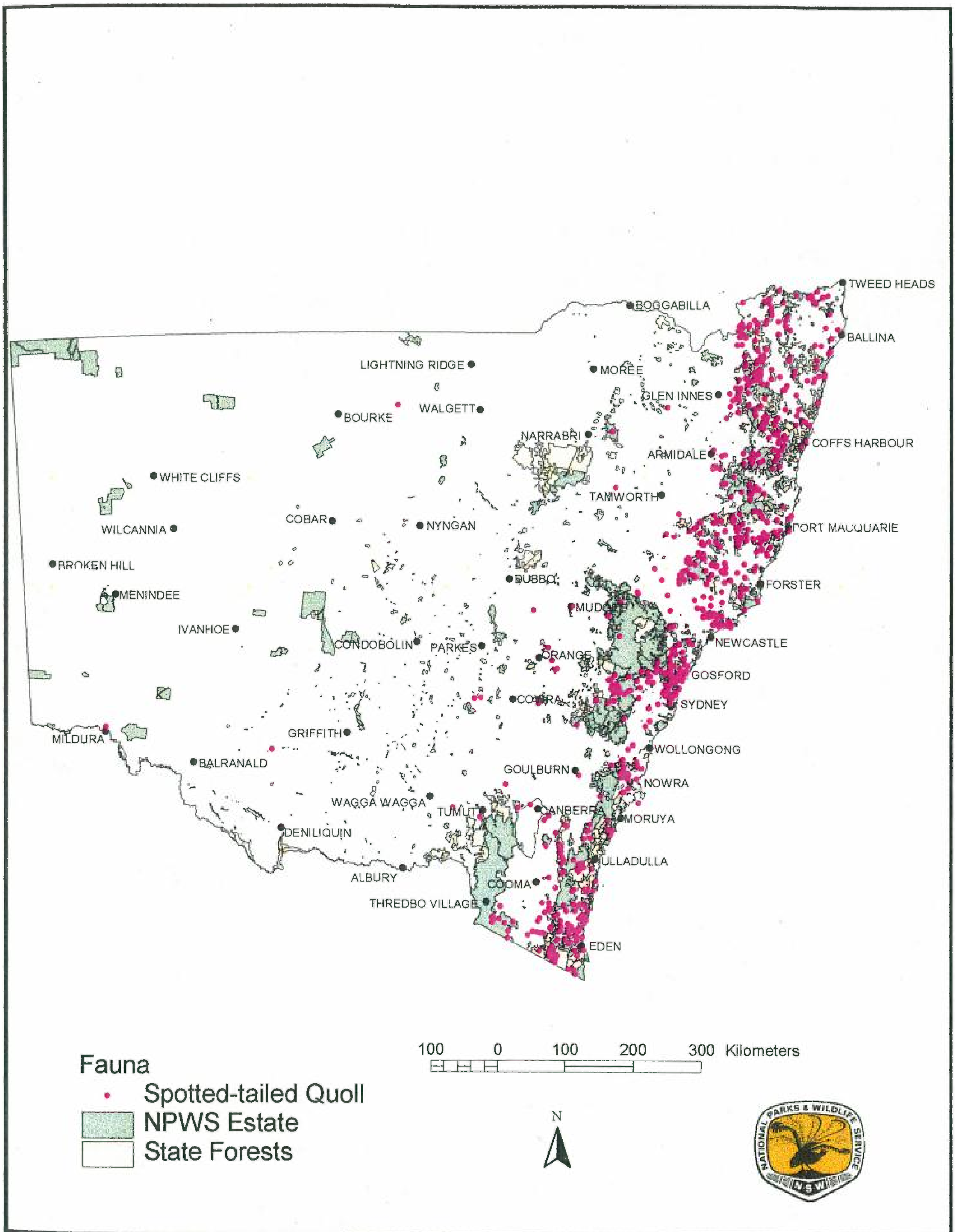

Fig. 15. Locality records for the spotted-tailed quoll, *Dasyurus maculatus*, in NSW

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treated individuals to 1080 (see McIlroy 1983a, Oliver and King 1983). Even so, much lower ambient temperatures occur in all the Parks during the winter when the aerial baiting would occur.

The approximate equivalents of LD_{50} doses for different individual s-t quolls, given the differences in weight between males and females plus juveniles and adults, are shown in Table 7.

Table 7: Approximate amounts of bait containing an LD_{50} for different-sized male and female s-t quolls.

Type of individual	Weight (kg)	Amounts of 1080 for LD_{50}	Amounts required to be eaten from 230g bait (g)	Amounts required to be eaten from 400g bait (g)	Amount of bait eaten per 24 hrs in captivity (g)
Juvenile female	0.9	1.15	44	77	64
Adult female	2.0	2.56	98	171	142
Heaviest female	4.0	5.12	196	341	213
Juvenile male	1.5	1.92	74	128	107
Adult male	2.6	3.33	128	222	185
Heaviest male	7.0	8.96	344	597	433

These figures are based conservatively on the lower fiducial value of 1.28 mg kg^{-1} for the LD_{50}. Body weights are from Green and Scarborough (1990), Edgar and Belcher (1995), Belcher (1998) and Murray (1998).

Feeding trials with captive s-t quolls indicate that they can eat an average amount of about 71g of meat per kg body weight per day (McIlroy 1981b). In other words, all age and sex classes could potentially eat sufficient amounts from one to two 230g baits (if encountered) to ingest the equivalent of an LD_{50} (Table 7). Theoretically, all age and sex classes would not be able to eat sufficient amounts from 400g baits to ingest the equivalent of an LD_{50} (Table 7). However, daily food consumption by dasyurids can vary considerably, both in the amounts that different individuals eat during any one day and in the amounts an individual eats from day to day (McIlroy 1981b). Free-ranging individuals may eat almost twice the amount they do in captivity (B Green, CSIRO, pers. comm. 1979). Belcher (1998) found that captive s-t quolls were capable of consuming 2-3 Foxoff baits (120-180g) in a single meal and more than three baits (180g) overnight. Field trials confirmed that the quolls could detect and consume fresh meat baits buried to a depth of approximately 7.5cm. Marshall *et. al.* (1999) recorded that a 1.7 kg post-lactating female s-t quoll ate three large chicken wings (*c.* 450g) after being caught in a cage trap. Andrew (1994) reported that wild s-t quolls can consume 400-600g of fish overnight and possibly more.

Based on the amounts of 1080 that represent an LD_{50} to different individuals (Table 7), Foxoff baits containing 3.0mg of 1080 also represent a potential primary poisoning hazard to most small and average-sized s-t quolls. Belcher (1995) found a dead male s-t quoll on a rock ledge near a latrine in the Suggan Buggan area (Victoria) just after a fox-poisoning program. The latrine remained unused during the next 18 months. However, although captive and wild s-t quolls have been observed consuming entire adult rabbits (Troughton 1954, R. Warneke pers. comm. to C. Belcher; both in Belcher, 1998), they are unlikely to experience secondary poisoning from poisoned rabbits or other animals (McIlroy and Gifford 1992). The latter found that s-t quolls could not theoretically eat sufficient muscle tissue from poisoned rabbits to ingest the equivalent of an LD_{50}. While theoretically they could ingest such a dose if they fed only on the liver of a poisoned rabbit, it is unlikely that the livers of poisoned rabbits nowadays contain the high concentrations of 1080 that McIlroy and Gifford (1992) found, given the much lower current concentrations of 1080 used in rabbit baits. Other animals poisoned by 1080 have been found to contain much lower concentrations of 1080 in their tissues and organs (McIlroy and Gifford 1992).

There are a number of factors that may lessen the risk s-t quolls face from the proposed aerial baiting programs in the National Parks. For instance, the LD_{50} for the s-t quoll is based on analytical grade 1080 (98% purity) whereas commercial grade 1080 is only 90-95% pure (McIlroy *et. al.* 1988). This means that the LD_{50} of commercial 1080 for s-t quolls may be slightly higher.

Considerable losses can also occur in the toxicity of 1080 baits both during their preparation and after their distribution (Korn and Livanos 1986; Kramer *et. al.* 1987; McIlroy *et. al.* 1986, 1988; Fleming and Parker 1991), possibly reducing the hazard they represent to s-t quolls. McIlroy *et. al.* (1986), for example, found that meat baits could lose an average of 64% of their initial loading of 1080 within four days of distribution. McIlroy *et. al.* (1988) and Fleming and Parker (1991) both found that the period that meat baits remained toxic to wild dogs and s-t quolls could vary considerably, depending on the time of year when the baits were distributed. Factors involved included leaching by rainfall, defluorination of the 1080 by micro-organisms, consumption of the 1080 by maggots, ants or other insects, and leakage from the baits after injection and during their decomposition. In the study by McIlroy *et. al.* (1988) involving different rainfall treatments, baits contained an LD_{50} for an average-sized (2.8kg) s-t quoll for 4-15 days during winter when maggots were absent, and for 2-4 days during summer, when they were present. Fleming and Parker (1991) similarly estimated winter-exposed meat baits would contain only a LD_{50} for s-t quolls after two days.

The risks that s-t quolls face from baiting programs will also depend upon the probability of them encountering a bait or baits. This in turn will depend on the amount of bait used and its distribution, the population density of the quolls in the area and their movements, and the length of time the baits remain available or acceptable to them.

There are no scientific data on the population densities of s-t quolls in NSW. As a crude index, the locality records indicate comparatively high numbers in north-eastern NSW and low numbers in south-eastern NSW. Overall, as expected for a top order carnivore, the predicted and known distribution maps indicate a low to moderate probability of occurrence. Males are known to range over large areas during the breeding season (May-August), the period during which aerial baiting is proposed. Firestone (1996) recorded a home range of 6 km^2 for male s-t quolls and 3.5 km^2 for female s-t quolls in the Barrington region, south of the four Northern Parks. Mansergh (1983) received a report that an individual quoll in the Tubbut area, south of Byadbo Wilderness Area, was known to have moved more than 2 km overnight. Andrew (1994) noted that males can move over 15km within three days and overlap in their home ranges. Females appear to have exclusive home ranges and can travel up to 6km in one night. Marshall *et. al.* (1999) caught one post-lactating female in WWNP during November 1998 and then again at another site 500m distant in January 1999. During the next four nights this individual moved up to 1 km per night over 1.5 km of the trapping transect. Males are considered more inquisitive than females (Settle 1978) and are active scavengers of road kills and around camping grounds and rubbish tips (Murray 1998). The food requirements of females increase considerably during the period they are nursing young (ie. part of the baiting period) and they may then hunt diurnally (Settle 1978, Murray 1998). Marshall *et. al.* (1999) caught three small post-lactating females (1.45-1.7 kg body weight) in WWNP during November 1998 and January 1999. Two had bald patches and one a small wound, possibly indicative of the stresses of rearing young. One of these females was caught six times during the nine nights of trapping involved and readily ate the baits in the traps. They also caught one juvenile female (0.7 kg) and two juvenile males (0.8-0.85 kg) during the January trapping period. These three juveniles had probably just become independent before then and might have been struggling to find enough food? Young quolls begin feeding on meat at about 100 days of age, are weaned at about 120 days of age or 0.35 kg body weight and become fully independent at 18 weeks of age (Settle 1978, Edgar and Belcher 1995, Belcher 1998).

Winter may be a demanding time for s-t quolls in terms of food supply and they may readily feed on baits, if encountered. This may be particularly true for individuals in poor condition and possibly also for juveniles from the previous breeding season that have just reached sexual maturity but have not yet established home ranges. Young born before or during the baiting period are less likely to be affected by the baiting (unless their mothers are poisoned) as they do not begin to eat meat until about mid-August onwards ((Settle 1978, Belcher 1998). Settle (1978) recorded that individuals captured during winter in Carrai State Forest, 80 km west of Kempsey, were in poor condition and known to scavenge on the carcasses of dead livestock. However, the period of risk to s-t quolls from aerial baiting can be affected by removal of baits by other animals and decomposition of baits. For example, McIlroy *et. al.* (1986a, 1986b) found that fist-sized (approximately 230g) meat baits laid along the ground at a spacing of 6.3-8.5 baits km^{-1} over distances of 25.4-32.2 km during winter in hill country in south-eastern NSW, were rapidly removed by different animals. From 69-92% were removed over the first four days and 98-99% after 16-32 days (different trials). Foxes removed the greatest proportion of baits, followed by birds, dogs, feral pigs *Sus scrofa*, and cats. In situations where foxes had been poisoned just prior to the baiting, birds removed a greater proportion of baits. Fleming (unpubl. data, in Fleming and Parker 1991) similarly found that 93% of meat baits laid along tracks in the northern NSW tablelands were removed after 7 days and 99.5% were removed after 42 days.

No signs of s-t quolls were observed in the above trial areas where bait removal was monitored. However, McPhee *et. al.* (1995), Fleming (1996) and Belcher (1998) all found that s-t quolls could detect, dig up and consume fresh meat baits buried up to 7.5cm deep at spacings of 300-400m apart. Fleming (1986) recorded only one s-t quoll taking a poison bait and McPhee *et. al.* (1995) noted that quolls removed only two non-poisoned meat baits. Although in both cases the quolls only removed a few baits compared to the number removed by target animals, the point is that s-t quolls do encounter and eat baits intended for fox or wild dog control. Further support for this statement is provided by the fate of a s-t quoll in Tallaganda State Forest during July 1998. On 8 July 1998 the Braidwood Rural Lands Protection Board conducted an aerial baiting run for wild dog control on private land on the eastern boundary of Tallaganda State Forest, in south-eastern NSW. On 14 July 1998 J. Darrant (State Forests, NSW) trapped a male s-t quoll weighing 3.1 kg at a site within Tallaganda State Forest, approximately 4 km from the northern end of the bait run (A. Claridge NPWS, Queanbeyan, pers. comm. 1999). At that stage J. Darrant noted that the quoll was vomiting, a characteristic early symptom of 1080-poisoning for the large dasyurids (McIlroy 1981b). The quoll was released, re-trapped and released again the next day, and on 16 July 1998 tracked to a nearby rock outcrop where it died. Upon post-mortem examination it was found to be in excellent condition, with good fat deposits. Subsequent analysis of tissue samples from the quoll by G. Wright (Landcare Research, Lincoln, New Zealand, pers. comm. 1999) revealed that the stomach contents of the quoll contained 33ppb of 1080 and the muscles of it contained 85 ppb of 1080. While these measurements are not scientific proof that the quoll actually died from 1080-poisoning, they do indicate it had consumed 1080 poison from some source.

It is not clear whether the quoll visited the bait line 4 km away or perhaps, through poor navigation, baits were dropped much closer to the quoll's final location? Irrespective of this, the analysis results are the first scientific evidence showing that some free-ranging s-t quolls may be feeding on aerially distributed baits intended for wild dog control.

4.9 Conclusions

The s-t quoll is the only subject species identified by the determination process outlined under the Director General's Requirements Section 1.6 as being potentially at risk from the proposed aerial baiting for wild dog control in the five selected Parks. Brush-tailed phascogales and eastern quolls conceivably face some risk but there are either no recent records to indicate the species occur or still occur in the selected Parks or sufficient information to evaluate that risk further.

While theoretical considerations of risk based on LD_{50}s, body weight and amounts of bait likely to be eaten are a very conservative approach that may overestimate risk, it needs to be stressed that s-t quolls are listed as *vulnerable* under the TSC Act. At present there are no draft Recovery Plans or Species Management Plans for s-t quolls relevant to the aerial baiting proposals in each of the five National arks. Given the ignorance we have of their population densities within the five Parks and the effect of aerial baiting on their populations, both within the Parks and on adjacent land, some caution is necessary in advocating the continued use of aerial baiting for wild dog control in areas where s-t quolls are known to occur.

The objective of the next Section is to evaluate whether the aerial-baiting campaigns against wild dogs proposed in the five selected Parks during 1999 are likely to enhance or negatively affect the s-t quoll populations present.

5. EVALUATION OF THE RISK THAT SPOTTED-TAILED QUOLLS FACE FROM PROPOSED AERIAL BAITING PROGRAMS FOR WILD DOG CONTROL IN SELECTED NSW NATIONAL PARKS

5.1 Kosciuszko National Park

5.1.1 General Distribution

No predictive habitat modelling is available for s-t quolls in the NPWS Southern Zone. Consequently, it is not possible to show the amount and quality of preferred habitat for them in KNP or elsewhere in the region. However, based on the information available from north-eastern NSW, the Byadbo Wilderness Area may be marginal habitat for the species. The NEFBS predictive modelling indicated that the species do not favour less productive sites on shallow soils in low rainfall, rugged areas. Mansergh (1983) found that s-t quolls generally occur only in areas that receive more than 600mm mean annual rainfall. The mean annual rainfall for the Byadbo Wilderness Area and the Tingaringy/Suggan Buggan area nearby in Victoria (where s-t quolls also occur) is only about 600mm. Both areas are considered to be rainshadow areas (Belcher 1995, Reside 1997) with shallow, rather bare, highly eroded soils (Costin 1954). Mansergh (1983) also noted that s-t quolls were only occasionally recorded in woodland.

In Byadbo Wilderness Area s-t quolls have been recorded in the white cypress pine system, the dry forest system and the woodland system (Fig. 2). These are the major vegetation types in the area. The greatest concentration of records appears to be along the Barry Way on the western side of the area. This may reflect a greater probability of people observing individuals, including road kills, on or near the road. There are three records of s-t quolls just to the east of Byadbo Wilderness Area (Fig. 2). These are in woodland fringing pastoral areas, a favoured habitat according to Settle (1978). The species also occurs in the adjacent Tingaringy National Park and the Suggan Buggan area to the south in Victoria. The dominant vegetation in this area is also dry forest and rainshadow woodland (Murray 1998). Little is known about their distribution, abundance and status of the population (ie. whether it is increasing, decreasing or remaining stable) in this area but Murray (1998) considers the population density is low.

There are no records of s-t quolls further north in KNP and only four records around its northern perimeter (Fig. 2). This is surprising given the higher rainfall and extent of moist forest vegetation in the area and the similarity of many of the habitats to the cool, moderately rugged areas favoured in north-eastern NSW. Their apparent absence, however, probably reflects the lack of deliberate surveys for the species in the area as well as poor recording of signs or reports of them.

For example, a s-t quoll scat has been found at Ravine near Yarrangobilly in KNP (ACT Government 1999). A male was also found killed by a vehicle on a road in a mature *Pinus radiata* plantation by J. McIlroy between Tumut and Wee Jasper in 1969. This specimen is lodged in the Australian National Wildlife Collection, CSIRO, Canberra.

Without survey data and predictive habitat modelling it is not possible to conclude whether s-t quolls in the Byadbo Wilderness Area represent the northern limit of a low density population originating in East Gippsland to the south. If so, then if wild dog aerial baiting programs negatively affect s-t quoll populations, the species' distribution could contract to Victoria where no aerial baiting programs are carried out. Alternatively, if the species is much more common to the north than current records indicate, any deleterious effect of wild dog control programs on the regional distribution of s-t quolls in southern NSW will be much less marked.

5.1.2 Risk to Spotted-tailed Quolls in the Proposed Baiting Area

Because of the lack of survey data, it is not possible to estimate the extent of potential habitat for s-t quolls that will be exposed to aerial baiting in Byadbo. Figs 1 and 2 show that the proposed aerial baiting will occur mostly in the very extensive woodland vegetation system, with some baiting also in the northern half of the white cypress pine vegetation system. There is one record (from 1982) of a s-t quoll close to a proposed baiting line in this latter system and a more recent record of a s-t quoll in the woodland system at Windmill Ridge, within 2km of a proposed baiting line (Figs 1 and 2). The other localities of s-t quolls (including two in the dry forest vegetation system) recorded since 1979 are more than 5km from the proposed baiting lines (Figs 1 and 2).

Based on available data, it appears that Byadbo Wilderness Area is the stronghold for s-t quolls in southern NSW (Figs 2 and 18). The population also represents the only known one within NSW living in dry woodland and rainshadow cypress pine forest. Consequently, any impact of aerial baiting on the population is important locally, regionally and on a State-wide basis. This is particularly so given that there are no draft Recovery Plans or Species Management Plans for s-t quolls (or other Threatened Species) relevant to the aerial baiting proposal for the Byadbo Wilderness Area.

In the revised 1998 Jindabyne District REF O'Brien and Cawthorn (1998) stated (6.1.3) "The District has implemented a survey of Tiger Quolls in the area proposed for baiting." They also stated "Where aerial baiting is proposed to continue, known quoll locations will be avoided". Both statements may give a false picture of the current distribution of s-t quolls in the proposed baiting and adjacent areas. The only survey results available are those by Reside (1997). This limited survey for scats and other signs of s-t quolls was carried out at only *four* sites in Byadbo Wilderness Area. These were at Black Jack Mountain and Windmill Ridge (where signs of s-t quolls were found) and at Snodgrass Creek and Byadbo Creek (where no signs were found). All four general localities can be found on the map in Fig. 1. Black Jack Mountain is distant from the proposed aerial baiting area but Windmill Ridge is between the proposed Toms Farm and

Stony Creek baiting runs. Byadbo Creek and Snodgrass Creek were included as baiting runs in the 1998 REF. Byadbo Creek is still included in the 1999 proposal but Snodgrass Creek has been omitted.

The crux is that no comprehensive, systematic surveys for s-t quolls have been carried out in the proposed aerial baiting area. Consequently, the statement "Where aerial baiting is proposed to continue, known quoll locations will be avoided." means little as there is only one known location in the proposed general baiting area.

At the same time O'Brien and Cawthorn (1998) stated, on the basis of the four site inspections, that "This survey found Tiger Quolls in the region are restricted to high rocky areas away from the river corridors favoured by dogs." Reside (1997) makes a similar statement that "The Quoll is now restricted to the higher and steeper escarpments away from the Snowy River where few Foxes roam". By the latter, I presume he meant that few foxes roam the higher escarpments?

Given this information it would appear that aerial baiting might be more effective if concentrated on the river corridors "favoured by dogs"? Reside (1997) found abundant signs (tracks, scats and killed prey) of both wild dogs and foxes along the sandbanks of the Snowy River and its tributaries. Instead only one baiting run (7% of the total proposed baiting length shown in Table 2) is along the Snowy River. Another 9.3 runs (77% of the total proposed baiting length) are focused on gullies or creek lines (the type of habitat known to provide movement corridors for s-t quolls in northern NSW). Approximately 2.3 runs (15% of the total baiting length) would be focused along ridges and 0.3 of a run (1%) on the middle of a slope. The *raison d'etre* for this appears based on the observations of experienced trappers and local landholders of the movements of dogs in the area compared to comprehensive, objective survey data on their distribution and movements, and those of foxes and s-t quolls.

Although Reside (1997) and O'Brien and Cawthorn (1998) reported no signs of s-t quolls along the Snowy River, others maintain they are present (A. Murray, DNRE, Victoria, pers. comm. 1999). Given the survey results of Scotts (1992) in Carrai State Forest which showed that the species favoured riparian habitats it could be likely that the preferred habitat for s-t quolls is along the Snowy River but they are being pushed back from this habitat by foxes and wild dogs.

The inevitable conclusion is that the proposed baiting would be carried out in an area where there is inadequate knowledge about the distribution and abundance of s-t quolls. The question is whether the proposed baiting area is the last refuge of a low-density population already besieged by foxes and wild dogs at lower altitudes or its preferred habitat? The decision that has to be made is that given the lack of information available, is it prudent to aerial bait an area where s-t quolls may be 'just hanging on' when theoretical evidence suggests that at least individuals in a population could be poisoned by the baits?

5.2 Oxley Wild Rivers National Park

5.2.1 General Distribution

The main areas of predicted high quality habitat for s-t quolls in the OWRNP region are along the eastern boundary (particularly in other National Park and State Forest Estates) and to the south in WkNP (Figs 19 and 21). Some smaller areas also occur in the Tabletop area near the western boundary of OWRNP and in the nearby Budds Mare and Front Tableland areas (Fig. 16). There are very few locality records for s-t quolls in the majority of the Park. Most occur in or near the two most northern sections of the Park that contain little predicted suitable habitat for the species. K. Pines (NPWS, Armidale, pers. comm. 1998) reported high numbers of fresh scats and latrines plus s-t quoll hairs in hair tubes in the Chandler and Oaky River gorges. They were particularly evident along sections of both rivers below dry rainforest and in gullies, but not along the ridges. Fresh scats and hair were also found in the Enmore Section and McDirty's Creek and a very high density of latrines in the Gara River area. A Collins (NPWS, Armidale, pers. comm. 1998) discovered two new latrines along the Chandler River south of Wollomombi Gorge following floods in August-September 1998. Both these latrines and the signs of s-t quolls in the Chandler and Gara River areas lie along traditional aerial baiting runs that were last baited in June 1998.

Kruuk and Jarman (1995) similarly found active s-t quoll latrines in the gorge of Salisbury Waters below Dangars Falls during 1991-1992. They observed s-t quolls visiting the woodlands and pastures above and around the gorges via the slopes and also moving along the rocky riverbed of Salisbury Waters. Some of the slopes just downstream of this area which have been baited for over 10 years are included in the proposed baiting area (Fig. 3).

K. Pines (NPWS, Armidale, pers. comm. 1998) has trapped fully grown adult male and female s-t quolls as well as younger males and females, including recently weaned individuals, at Long Point, particularly in the camping ground and picnic areas. Presumably the quolls were scavenging, as also appears to occur at other visitor areas in the region such as Dangars Gorge and Point Lookout.

5.2.2 Risk to Spotted-tailed Quolls in the Proposed Baiting Area

In OWRNP the only predicted high quality habitat areas for s-t quolls that will be exposed to aerial baiting are a small proportion in the Tabletop and Budds Mare areas (Figs 3 and 19). Most proposed aerial baiting will occur in habitats predicted not to be suitable for s-t quolls (such as the northern portions of the Park where s-t quolls have frequently been recorded) or in poorer quality habitat. No baiting runs will occur in the narrow areas of predicted high quality habitat along the south-eastern boundary of the Park or where it abuts WkNP.

Of the 27 runs or portions of runs shown in Fig. 3, 8 (30%) appear to be along rivers and the bottom of gorges, 3 (11%) up gullies, 13 (48%) up ridges (especially from gorges), 1 (4%) on a steep face and 2 (7%) along the Park boundary. This is certainly a different mixture than the sites described by Waters *et. al.* (1998) who stated "Baits will be laid along the tops of ridges and at the top end of gullies

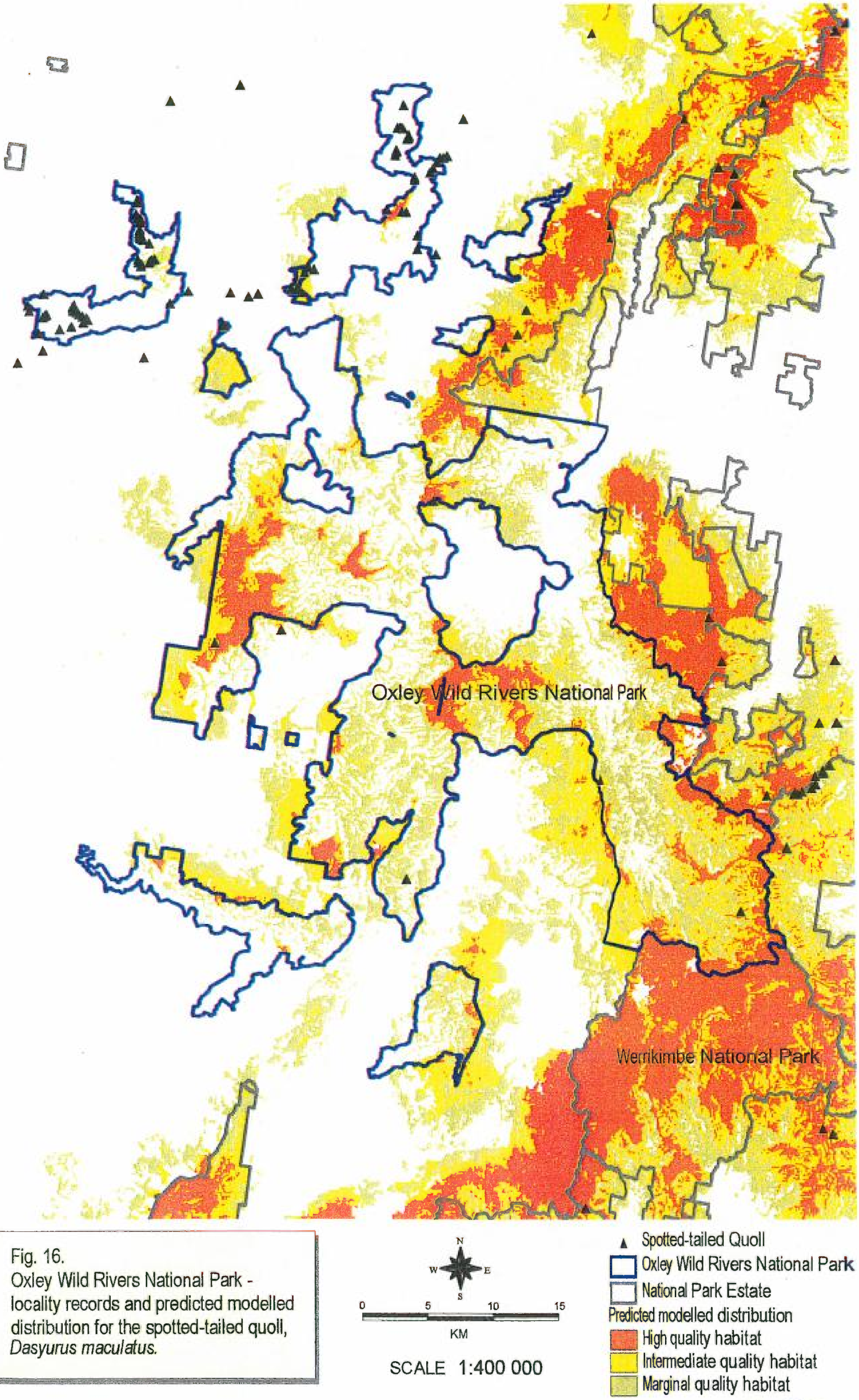

Fig. 16.
Oxley Wild Rivers National Park - locality records and predicted modelled distribution for the spotted-tailed quoll, *Dasyurus maculatus*.

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where wild dog movements are most likely.". They also appear to include the types of habitats s-t quolls are known to occupy (See Section 5.2.1 above). Despite this, there is evidence that s-t quolls are still active in areas that are aerially baited each winter. The key question is whether the populations are declining, remaining stable or increasing (See Section 7, Future Research). The prime area where monitoring should be undertaken is probably in the Winterbourne State Forest section near the proposed Tabletop baiting run and the Budds Mare area (Fig. 3).

5.3 Washpool National Park

5.3.1 General Description

According to Graham-Higgs *et. al.* (1997) "High numbers of the Tiger Quoll are known to occur within the Washpool and Gibraltar Range National Parks." Such a statement is supported by the predictive distribution modelling (Fig. 17) that indicates most of WNP contains high quality habitat for the species. Most of the locality records for the species in WNP are in the north but there are five records for localities close to the possible aerial baiting lines (Figs 5 and 20). The concentration of records just to the south of WNP correspond with the Gwydir Highway between both parks where perhaps live individuals or those killed by vehicles are more readily observed?

5.3.2 Risk to Spotted-tailed Quolls in the Proposed Baiting Area

The possible aerial baiting in WNP would occur in only a very small proportion of the predicted high quality habitat for s-t quolls (Figs 5 and 20). Given the small area and short (10 km) bait runs involved, the baiting program is unlikely to pose a major threat to the s-t quoll population in WNP. The validated records indicate they are reasonably widespread in the Park and in surrounding areas, including GRNP where no aerial baiting is planned. The possible aerial bait lines, however, are in an area where individuals have been observed. Consequently, there is the possibility that some individual s-t quolls could be poisoned if the aerial baiting takes place.

5.4 Werrikimbe and Willi Willi National Parks

5.4.1 General Distribution

Much of WkNP is predicted to contain high quality habitat for s-t quolls (Fig. 18). There are fewer areas of high quality habitat in WWNP, mainly in the southern portion abutting WkNP (Fig. 18). Koorebang Nature Reserve contains a small amount of predicted high quality habitat for s-t quolls but the habitat in Jasper Nature Reserve is predicted to be of only immediate or marginal quality for the species (Fig. 18).

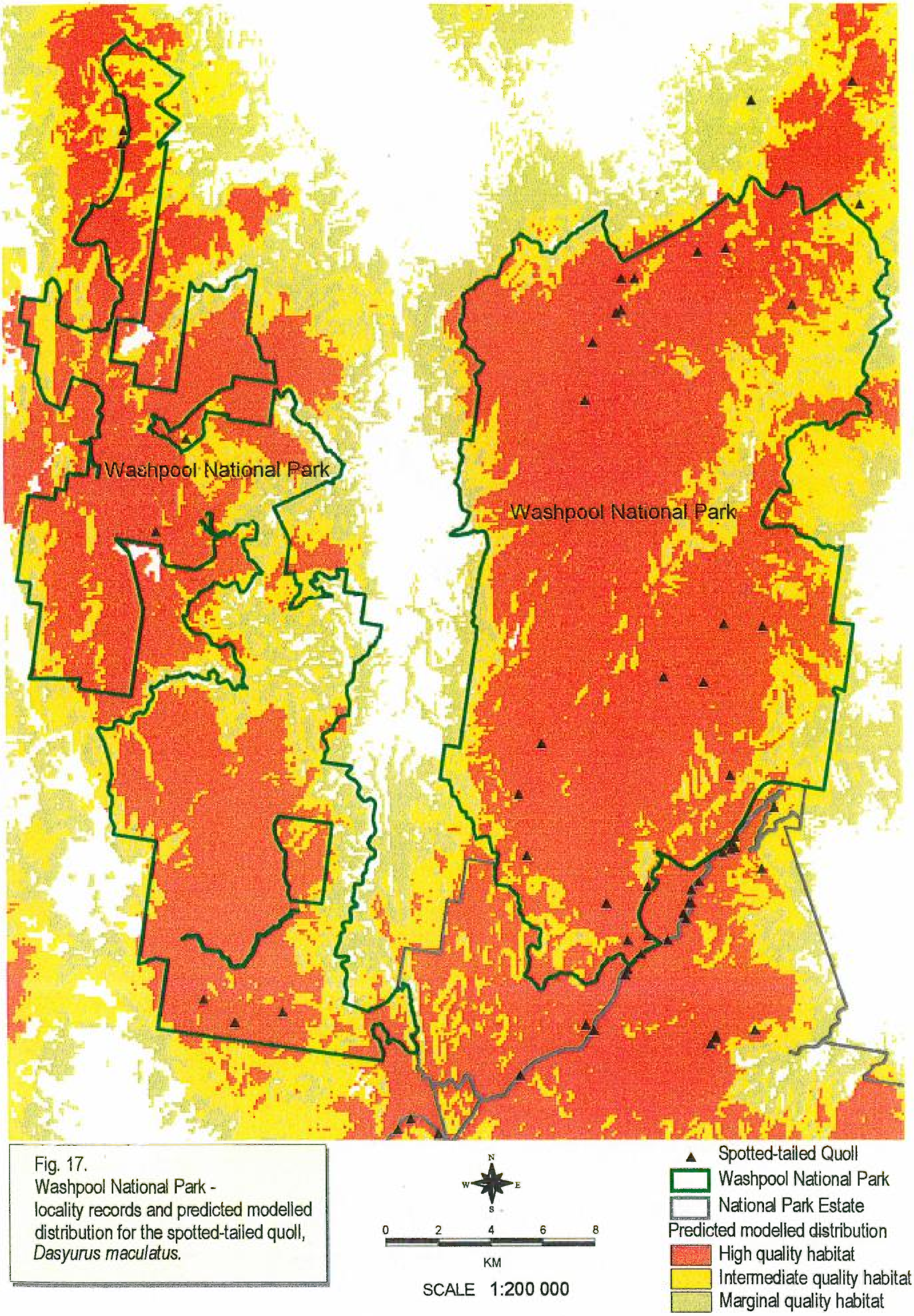

Fig. 17.
Washpool National Park -
locality records and predicted modelled distribution for the spotted-tailed quoll, *Dasyurus maculatus.*

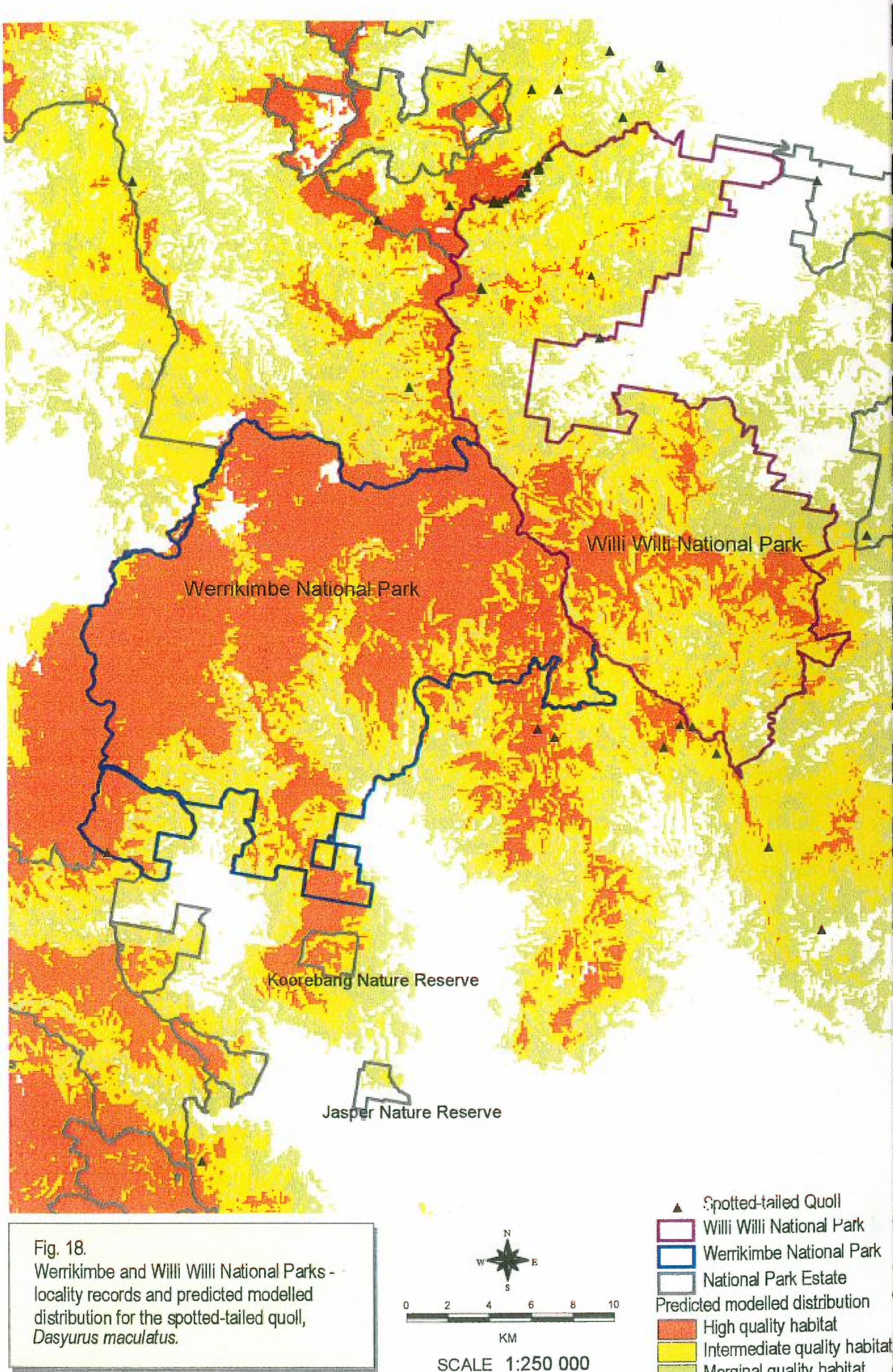

Fig. 18.
Werrikimbe and Willi Willi National Parks - locality records and predicted modelled distribution for the spotted-tailed quoll, *Dasyurus maculatus*.

Only one locality record (on the SW boundary) is shown for s-t quolls in WkNP while those in WWNP are in the northern section (Fig. 18). The only comprehensive survey of s-t quolls in the two Parks is that currently being undertaken in WWNP by A. Marshall, A. Ledden and S. Robinson (A. Marshall, NPWS, Port Macquarie, pers. comm.1999). Based on the presence of s-t quoll hairs in hair tubes and the results from trapping and spotlighting, Marshall *et. al.* have found the species is widely distributed in WWNP. S-t quolls have been recorded at sites ranging from 100-1000m in altitude, on ridges, mid slopes or in gullies, and in rainforest, tall open forest and open forest. They have found more signs of s-t quolls in forest areas with good structural development and minimal disturbance, but the species is also present in areas affected by fire and grazing. During January 1999 Marshall *et. al.* (1999) trapped 6 quolls over 110 trapnights along a 9km transect line in WWNP that was aerially baited 1.5 years ago. Three of the quolls were post-lactating females. Each was caught less than two kilometres apart. The others were a juvenile female (0.7kg) and two juvenile males (0.8kg and 0.85kg). Whether these individuals were immigrants from nearby unbaited areas or were born in the area is not known. S-t quolls have been recorded during the last 12 months on 14 (19%) of the 74 properties surveyed next to the Parks.

5.4.2 Risk to Spotted-tailed Quolls in the Proposed Baiting Area

Given the survey results of Marshall, Ledden and Robinson (See Section 5.4.1) and predicted distribution of high quality habitat (Fig. 18), it is clear that s-t quolls could be exposed to aerially distributed wild dog baits in both Parks if the baiting program proceeds. This is particularly so for the aerial baiting in the south-eastern section of WkNP even if this area represents the edge of high quality habitat for the species in the Park. The proposed baiting line in WWNP would be mainly situated in poorer quality habitat except for a thin strip of predicted high quality habitat along an access road (Figs 7 and 21). It is suggested (see later) that mound baiting could replace aerial baiting along this access road. There is one record of a s-t quoll close to the southern end of the proposed aerial baiting run in WWNP.

Although s-t quolls are reputedly widespread in both Parks and surrounding areas that have been baited in the past, future monitoring of trends in their numbers or presence would appear justified.

5.5 Conclusions

There is no doubt that individual s-t quolls face some risk of finding and eating aerially distributed wild dog baits in each of the five Parks. Although O'Brien and Cawthorn (1998) state that known s-t quoll locations will be avoided in the Byadbo Wilderness Area, the reality is that there is only a very limited knowledge of the species' distribution and abundance in the area. In OWRNP, WkNP and WWNP there is evidence that s-t quolls occur in some areas that have been aerially baited in the past and which are included in the 1999 baiting proposals. In WNP s-t quolls are known to visit and disturb mound sites (even if they rarely take free-feed baits) just to the north of the proposed aerial baiting runs (S. Boyd-Law, NPWS, Glen Innes, pers. comm. 1999). At the same time it must be recognised that the proposed aerial baiting in each Park will occur only in selected areas of s-t quoll habitat. If a "catchment area" of 500m each side of the baiting runs is calculated, it means only 1.9-8.7% of each Park would be aerially baited. (The proportion is estimated just for Byadbo Wilderness Area, not KNP, because of the lack of records of s-t quolls in KNP). Increasing the "catchment area" by 1-2km to each side to allow for the reported range of movements of s-t quolls (see Section 4.8) will considerably increase the proportion of each Park that may be a 'danger area' for s-t quolls during aerial baiting programs. Increasing the "catchment area" to 4 km each side of the baiting runs, (based on the distance the adult male poisoned in Tallaganda State Forest was found from the baiting run) would result in 15.2-69.4% of the five Parks being regarded as a 'danger area' for s-t quolls during the aerial baiting programs. Running bait lines through the middle of small Reserves such as Jasper NR (354ha) and Koorebang NR (465ha) would mean that all s-t quolls in the Reserves would likely be exposed to baits if the "catchment area" is assumed to be more than 500m to each side of the baiting run.

While it may be unfortunate if the wild dog aerial baiting programs poison some s-t quolls, what matters most of all is the extent of population mortality they experience. It is worth stressing here that all the theoretical estimates of risk to different sized s-t quolls have been based on the LD_{50} or median lethal dose for the species. This is the dose that would result in the death of *half* of all the s-t quolls that *actually ate* the baits. That point is particularly relevant! Currently, there is no information on the proportion of s-t quoll populations that do eat baits, how much each individual eats or field results to indicate the proportion that are then poisoned (See Section 7, Future Research). Also, as Choquenot and Ruscoe (1999) state "susceptibility alone provides little information on the effect that exposure to a poisoning program may have on the density of non-target species. While studies on non-target susceptibility or exposure during poisoning programs indicate the potential for reductions in non-target density, they provide no information on whether or not reductions actually occur. Estimates of non-target mortality by searches for dead animals or the rate at which radio-tagged individuals die are also incomplete because they cannot account for compensatory demographic or dispersal responses. Such responses include enhanced survival and/or reproduction (Sinclair, 1989), or higher rates of dispersal into the poisoned area". "Hence, an apparent increase in non-target mortality on poisoned sites may reflect a transient demographic response rather than a longer-term reduction in population density."

Section 2.2 of the Director General's Requirements asks for estimates of the indirect and direct impact of the proposed aerial baiting on local and regional populations of s-t quolls in terms of numbers of individuals affected and losses re regional viability. This is not possible at this stage. It has been suggested that modelled habitat maps could be used as surrogates for population densities and the proportion of high quality habitat for s-t quolls that may be aerially baited then used to obtain these estimates. Such a suggestion is not valid because the relationship between habitat quality and s-t quoll density has not been established and the actual impact of aerial baiting on their populations is still unknown. There have been only two studies of the effects of 1080-baiting programs against wild dogs on populations of non-target animals in Australia to date (McIlroy *et. al.* 1986, King 1989). Neither study showed that the baiting programs significantly affected any of the non-target species monitored (including northern quolls, *Dasyurus hallucatus*).

The status of the s-t quoll populations in each Park is fundamentally important. If their numbers are increasing or remaining basically steady, then they may be absorbing any mortality from aerial baiting programs. This may be the situation in the northern Parks? If they are rare because the habitat is only marginal, or their numbers are declining because of competition with and predation from foxes, as may be occurring in the Byadbo Wilderness Area, aerial baiting could possibly drive the population to extinction. Hence monitoring of their status is crucial for assessing the long-term security of local and regional populations.

The three core areas of predicted high quality habitat for s-t quolls in northern NSW are in and around WNP, WkNP and along the south-western border of the NPWS Northern Zone (Fig. 19). WNP is more or less in the middle of the predicted range of high quality habitat for s-t quolls in SETA 2 where 16.2% of the CRA original target area for the species has been reserved. OWRNP lies in the north-western sector of the large SETA 3 with more numerous records and predicted high quality habitat for s-t quolls to the east (Styx and Carrai State Forests), north-east and particularly to the south (Fig. 16). On the basis of the predictive habitat modelling, WkNP represents the northern end of a very large area of high quality habitat for s-t quolls (Figs 21 and 22). There appears to be few other National Parks or Reserves within this area so WkNP is important for the conservation of the species in the central section of SETA 3. Currently 50.5% of the CRA original target area for s-t quolls has been reserved in SETA 3.

It is clear from Figs 18 and 22 that s-t quolls have a much wider distribution in eastern NSW outside of the five National Parks. What is not known is the current status of the populations in different areas and regions and the extent of the habitat they occupy that is subject to aerial baiting by other organisations or to other possible threatening processes. Table 8 provides an assessment by District Pest Management Officers of the impact of introduced pest species on the habitat of s-t quolls in the five National Parks. However, without a detailed knowledge of the processes involved, and probably a comparison with other similar areas where the pests are not present (if that is possible?), the estimates can only be subjective opinions. Rabbits, feral horses, *Equus caballus*, and weeds such as lantana, *Lantana* spp, and blackberry, *Rubus fruticosus*, are estimated to have little or no impact on s-t quolls in the five Parks. Goats are possibly important in OWRNP and the Byadbo area, feral pigs in WkNP and foxes in the four southern-most Parks, especially Byadbo Wilderness Area.

In summary, aerial baiting still appears an acceptable method for wild dog control in parts of OWRNP. It is clearly the most cost-effective technique in the rugged country involved and is part of an integrated wild dog management program. This includes continued fencing that will, when completed, largely replace the need for further aerial baiting. Substituting mound baiting for aerial baiting would be a very expensive alternative but the one-off buried bait technique (see Section 6.4) may be a viable option in some areas. At present there is no evidence that aerial baiting is adversely affecting s-t quolls, with fresh signs (scats, hair and latrines) still affected any of the non-target species monitored (including northern quolls, *Dasyurus hallucatus*).

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Table 8: Impact of introduced pest species on the habitat of the spotted-tailed quoll*

Reserve	Pest species					
	Foxes	**Rabbits**	**Goats**	**Pigs**	**Horses**	**Weeds**
Washpool NP	0	0	0	0	0	0-1 (lantana)
Oxley Wild Rivers NP	1-2	0	1-2	1	0	0-1 (lantana and blackberry)
Werrikimbe NP	2	0	0	1-2	0	1 (lantana and blackberry)
Willi Willi NP	2	0	0	1	0	1 (lantana)
Kosciuszko NP (Study area only)	3 (high densities compete for prey)	0-1	2-3 (high densities compete for shelter)	0	0-1	0

*Score of estimated level of impact of key introduced pest species on the habitat of the spotted-tailed quoll as assessed by District Pest Management Officer (0 = nil; 1 = low; 2 = moderate; 3 = high level of habitat degradation).

The justification for aerial baiting in Byadbo Wilderness Area is also strong on cost-effectiveness grounds. It is clear that mound baiting in the proposed aerial baiting area would be an expensive and difficult alternative. The main difference between the proposal for Byadbo and that for OWRNP is the apparent low numbers of s-t quolls in Byadbo and the region and the lack of information on their distribution and persistence in previously baited areas. The one-off buried bait technique appears to be a safer (if more expensive) alternative to aerial baiting, either in the proposed aerial baiting area or along the Snowy River. Greater concentration of mound baiting (or buried baits) along the northern and eastern boundaries of Byadbo is also an adaptive management alternative that could be worth testing.

There are less supportive reasons for aerial baiting in the three other Parks (WNP, WkNP and WWNP). The link between the presence of wild dogs in the Parks and reserves and stock attacks on adjacent land is more tenuous than for KNP and

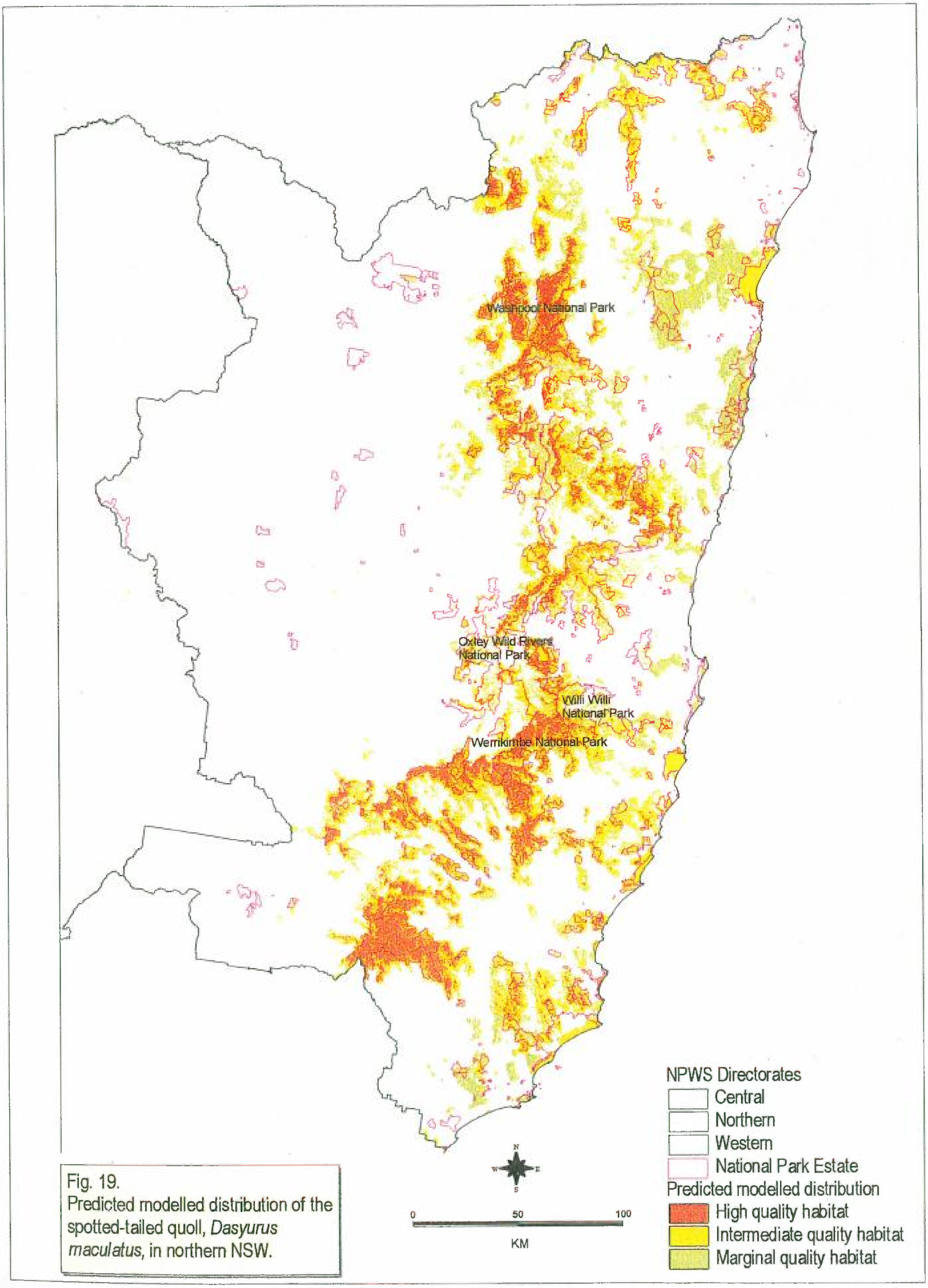

Fig. 19.
Predicted modelled distribution of the spotted-tailed quoll, *Dasyurus maculatus*, in northern NSW.

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OWRNP. Aerial baiting would be cheaper and easier to carry out than mound baiting (but not as substantially so as in Byadbo and OWRNP). One-off buried baits could be a viable alternative in WNP and WkNP that could lessen the risk of poisoning faced by s-t quolls.

6. ALTERNATIVES TO THE PROPOSED AERIAL BAITING PROGRAMS IN THE NATIONAL PARKS

6.1 Introduction

There are a number of other control techniques that could be considered as alternatives to aerial baiting in the proposed areas of the five National Parks (Table 9).

Table 9: A comparison of the suitability of alternative methods of wild dog control for the proposed aerial baiting areas in the five selected National Parks.

Method	Specificity	Effectiveness	Potential impact on:		Cost	Relative suitability for the 5 National Parks				
			Dingo	S-t quoll		KNP	OWRNP	WNP	WkNP	WWNP
Simple ground baiting	+	+	+	+++	++	+	+	+	+	+
Strategic ground baiting	+	+	+	+++	++	+	+	+	+	+
Replacement baiting	+	++	++	+++	+++	+	+	+	+	+
One-off buried baits	+++	?	+	++	++	++	++	++	++	++
Mound baiting	+++	?	++	+	+++	+	+	++	+	+
Aerial baiting	+	++	++	+++	+	+++	+++	++	++	+++
Trapping	++	++	++	+	++	+	+	+	++	+
Shooting	+++	+	+	0	+++	+	+	+	+	+
Exclusion fencing	++	++	++	0	+++	+	++	+	+	+

? = Unknown, +++ = High, ++ = Medium, + = Low, 0= Zero.

Simple ground baiting is when the baits are just thrown out of the back of a vehicle along access tracks. It is little different in reality from aerial baiting. Strategic ground baiting is when the baits are actually placed at sites along the runs to maximise the chances of dogs finding them and minimise their removal by birds and other non-target animals. Both techniques are still frequently used for wild dog control on private land. Neither are very specific for wild dogs and research results indicate they are not particularly effective (eg. 20-50% reduction in dog numbers or signs, McIlroy *et. al.* 1986a, 1986b). Given the lack of any apparent differences in the feeding behaviour between wild dogs and dingoes or their sensitivity to 1080, their impact on dingo populations is likely to be similar (as are the other control methods) to that on wild dogs. Costs depend largely on the accessibility of the baiting lines for vehicles. Both methods are not particularly suited for the proposed aerial baiting areas and, together with replacement baiting and aerial baiting, have the potential to have the greatest negative effect on s-t quoll populations.

Replacement baiting is where one or more baits are placed at bait stations along baiting runs and regularly inspected and replaced if they have been taken. Fleming (1996) recorded a 76% reduction in an index of wild dog abundance in north-eastern NSW using the technique but did not indicate whether this reduced impact on livestock or not. Aerial baiting, in comparison, has achieved reductions of 66-85% in wild dog indices of abundance (Fleming *et. al.* 1996). Obviously returning frequently to baits to inspect/replace them increases the cost involved, is less suited for rugged country where vehicle access is not possible, and from a non-target risk perspective, is a less suitable option to mound baiting.

One-off buried baits (burying baits at predetermined intervals along baiting runs without subsequent inspection or replacement) is a technique that has not yet been tested. It offers greater specificity than replacement baiting (birds, for example, are unlikely to remove buried baits) and may be as effective against dogs but less expensive than mound baiting. However, it will not give the same margin of safety re non-target animals (eg. s-t quolls) as mound baiting. It could be considerably more cost-effective in terms of wild dog control than mound baiting in KNP and OWRNP but less so than aerial baiting.

Mound baiting involves burying non-toxic baits at stations along baiting runs and covering them with sand or raked soil so the footprints of animals visiting them can be identified. Toxic baits are then substituted at those stations where non-toxic baits have been removed by wild dogs. It is the most target-specific method of baiting. Its biggest disadvantage is the cost involved in setting up and repeatedly visiting the stations, particularly in rugged steep country that is inaccessible to vehicles. Its effectiveness in reducing indices of wild dog abundance and their impact on livestock on adjacent properties has also not been scientifically assessed.

Trapping is still widely used, but generally for targeting specific 'problem' wild dogs rather than general population control. It has the disadvantage, compared to baiting, of requiring trained, experienced staff to set the traps and can frequently involve the death of non-target animals (Newsome *et. al.* 1983). McIlroy *et. al.* (1986b) caught 15 wild dogs (56% of the known population in an area of KNP) at a rate of 15.6 dogs per 1000 trap-nights. The return for trapping effort is generally lower than this (eg. 5 dogs per 1000 trap-nights, Fleming *et. al.* 1998) but, if it results in the capture of problem individuals and cessation of attacks on stock, it may be considered to be successful despite the time/labour involved.

Shooting is generally an opportunistic method of wild dog control and is not suitable for controlling populations in extensive rugged areas such as those proposed for aerial baiting in the five National Parks.

Exclusion fencing (including electric barrier fences) can be expensive to erect (eg. \$2,100 - \$8,500 per kilometre, Bird *et. al.* 1997), but can offer relatively continual protection from wild dog predation if well maintained. Obviously the practicability of their erection depends on the ruggedness of the country involved and the number of stock being attacked by wild dogs on adjacent land.

Other methods of reducing wild dog impact on livestock, such as sheep-guarding dogs, aversive conditioning of dogs, toxic collars on livestock and enterprise substitution (eg. replacing sheep by cattle or crops) are largely untested, not relevant to wild dog control inside National Parks or unlikely to be accepted by adjacent landholders. At present there is no method of biological control that could be used to target wild dogs and hybrids but safeguard dingoes. If any such agent is developed, then some means of protecting farm and other domestic dogs would also have to be developed.

6.2 Timing of 1080 Baiting

In eastern Australia aerial baiting is usually carried out during late autumn and winter (eg. May-June). There are a number of reasons for this:

- Baits are likely to last longer then than at other times of the year (McIlroy *et. al.* 1988, Fleming and Parker 1991).
- The population of wild dogs is potentially at its lowest prior to whelping in spring and so a given proportional reduction in abundance in autumn or winter equates to a smaller remnant population than the same proportional reduction in spring and summer.
- Lambing in eastern NSW mostly occurs in late winter and spring so baiting carried out before then to reduce the high predation that could occur is considered common sense (Fleming and Korn 1989).
- Movements of wild dogs are traditionally believed to be greatest in autumn and winter when young dogs are dispersing and mating is occurring (ie. April-June). This may not necessarily apply to hybrid and feral dog females that may have two oestrus cycles per year (Jones and Stevens 1988).

From the point of view of the s-t quoll, the least hazardous period to carry out wild dog baiting may be during March, April or early May. During the quoll-mating season (late May-August) male s-t quolls range over large overlapping areas and may be more likely to encounter baits. However, mortality of males during the breeding season is likely to be less important than mortality of females. The most stressful period, nutritionally, for female s-t quolls appears to be during late lactation (ie. from July onwards) when the young have left the pouch but are still clinging to their mothers. This could affect the mothers' hunting abilities and make them more prone to feed on baits if located during that period (Murray 1998).

Given the landholders' reasons for when baiting should be carried out and the biology and ecology of s-t quolls, the most appropriate period for wild dog baiting in the five National Parks would appear to be during March, April or early May.

6.3 Monitoring of Baiting Programs

All the proposals for aerial baiting of wild dogs within the five National Parks given by the NPWS Districts involved were circumspect about their monitoring of the effectiveness of the aerial baiting and the effect on non-target animals. The methods described were either inspections for signs of dogs at bait stations or sand pads, trappers' reports of signs of dogs in the baited areas or on private land adjoining the Parks or reports of livestock predation on adjoining properties before and after the baitings. None of these methods would be considered particularly reliable and accurate from a scientific perspective. The information provided by some (not all) RLPB's and WDCA's, for example, is often vague and qualitative, rather than quantitative. This is disturbing as it is this 'evidence' that often appears to be the basis for wild dog control in the National Parks concerned.

It is also disturbing that NPWS appear to simply accept this rather than evaluating whether 'their dogs' are the problem individuals or not. Instead, despite the costs involved, including the detraction from other possibly valuable conservation programs such as fox control or additional methods to enhance Threatened Species recovery, the situation often appears to be one of maintaining the 'status quo', particularly with adjacent landholders. Few successful commercial businesses would accept such a situation where they continue to spend a large amount of their money on a program that they do not know whether they need or not! Particularly when what they are spending the money on may threaten their 'company assets'!

As outlined in Section 7.1, considerable improvements are needed in the monitoring of the effect of aerial baiting (and other forms of wild dog control) on the status of wild dogs, foxes, other pests and native animals in the Parks concerned. The techniques involved (eg. sand plots, hair tubes, scat identification etc.) are well known and there are sufficient 'experts' available (eg. P Catling, CSIRO DWE; NPWS staff) to advise on how, where and when the monitoring should be done in each situation. The key point is that for many years it has simply been accepted that aerial baiting (and other methods of wild dog control) within the National Parks reduces the impact of wild dogs on livestock on adjacent land. To date that assumption has never been rigorously tested and monitoring has never been given the importance it should have. It seems absurd to continue to carry out an expensive operation year after year but never really know whether it is worth the cost or not!

According to Braysher (1993), the first step in the management of vertebrate pests is to identify whether the problem is a real one or not. NPWS have not taken that step in regard to whether the wild dogs and dingoes inside their National Parks are responsible for the attacks on livestock on adjacent land. They have also not ascertained whether the control methods they use on the dogs within their Parks are effective or not in reducing this impact to acceptable levels. Nor whether the methods involved are having a deleterious effect on the native species within the Parks. It is clear, therefore, that much more effort and financial backing needs to be focussed on these questions and adaptive management trials, rather than blindly funding the same repetitious baiting programs within the Parks year after year.

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6.4 Appropriate Control Methods for Wild Dogs in the Five Selected National Parks

Section 3.4 of the Director-General's requirements asks for a comparative assessment to be provided of the potential benefits and adverse impacts of the proposed action [aerial baiting], and detailed recommendations "concerning whether and by what means wild dog control should be undertaken in each of the subject areas"." The first task can be answered concisely. The only major potential benefit from aerial baiting in the parks is to maintain or improve relationships between NPWS and neighbouring landholders who believe there is a need for the aerial baiting. The baiting may also kill some foxes (particularly in KNP) which could enhance the survival of some native animals. The main adverse impact is that the baiting might also kill some native animals, including s-t quolls. The costs in time and money involved in the aerial baiting could also be put to other uses such as surveys or monitoring of the status of s-t quoll and other threatened species populations.

The second task is difficult to do because there is no clear, objective evidence, only local opinion (albeit often based on years of experience of dog attacks, other behaviour and a detailed knowledge of the country involved) that the first criterion of NPWS Wild Dog Management Policy 2.6.20 is met. That is "*there is adequate evidence that wild dogs coming from Service lands are involved in killing or harassing livestock*". If this evidence is judged not to be adequate then a question mark exists over *all* wild dog control *within* National Parks and not just aerial baiting. One option in such a case is to carry out wild dog control only in a buffer zone extending out from the National Park boundaries. This appears to be the situation in the Wongwibinda Wild Dog Control Association area in north-eastern NSW. Since the gazetting of Guy Fawkes River National Park (GFRNP) in 1972, the majority of the aerial baiting to control wild dogs in the area has concentrated on the perimeter of rugged gorge country situated between cleared grazing areas and forested areas, including GFRNP (Fleming *et. al.* 1996).

If, for various reasons, wild dog control has to be carried out inside National Parks, then the three key factors to consider in selecting control methods are their effectiveness in reducing wild dog numbers or preventing their possible dispersal to grazing lands, non-target animal safety and costs. Barrier fencing scores highly for the first two factors but poorly for the third (in terms of cost of construction and maintenance). It does not appear to be a practical option for at least three of the five selected National Parks concerned (WNP, WkNP and WWNP) nor probably also for KNP. Even in OWRNP, where considerable fencing has been carried out, some baiting will probably still be necessary in different areas because of the fragmented nature of the Park. 1080-baiting can be effective in providing temporary (eg. annual) reduction in wild dog numbers and, depending on the method used, a certain amount of non-target animal safety. It is also generally more cost-effective than other methods of control, such as trapping and shooting, particularly when large areas are involved. The latter methods are probably more useful for 'problem' dogs sheltering just within the boundaries of National Parks or present on grazing land.

The best methods of 1080-baiting for wild dog control within the five selected National Parks depend on the distribution and possible movement routes of the wild dogs in relation to grazing land, the environmental features involved, whether any of the proposed control areas contain Threatened Species likely to be adversely affected by the baiting method, and the cost-effectiveness of the method. Mound baiting is clearly the safest method for non-target animals but it and the other forms of ground baiting are not as cost-effective as aerial baiting in the rugged areas proposed. This is particularly so for the large areas proposed in KNP and OWRNP.

The justifications for aerial baiting provided by each NPWS District do not completely meet the criteria listed in NPWS Wild Dog Policies 2.6.20 and 2.6.46. Nevertheless, some limited, carefully proscribed aerial baiting could still be considered as a suitable control technique for wild dogs in parts of the Parks where access is difficult, particularly if the research described in Section 7 and recommendations described in Section 8 are carried out. Given the precautionary principle, no aerial baiting should occur in the vicinity of any known locations of the Threatened Species listed in 1.6.1 and 1.6.2 of the Director-General's requirements. The only exception to this for the moment is aerial baiting in areas of OWRNP that have been traditionally baited for years and where fresh signs of s-t quolls are still relatively common. Even this practice may need reviewing depending on the results of monitoring the population status of s-t quolls in the areas involved.

The whole question of wild dog control in NSW extends far beyond wild dog control in National Parks and other State Government land. It is clear from the repeated control efforts (particularly 1080-baiting) on private land each year that effective management of wild dog impact has still not been achieved, despite all the efforts by Europeans since they settled in Australia. It is probably time that its whole basis is seriously reviewed, or improved, as has occurred over recent years with the management of feral pigs, (Choquenot *et. al.* 1996). Until that occurs, wild dog impacts on livestock are likely to remain a recurring annual problem with escalating costs and increasing contention over control methods and their effect on non-target animals.

6.5 Conclusions

There are two major points about wild dog control that emerge from the SIS:

1. The NSW NPWS is carrying out control measures against dingoes and wild dogs within their Service estates, at considerable expense, without clearly knowing whether these are fully justified or not.

2. At the same time the NSW NPWS has no clear evidence that their wild dog control programs are effective in providing a sustained reduction of wild dog impact on livestock on adjacent properties (ie. "potential benefits"). Nor whether the programs may be having a deleterious effect on Threatened Species, particularly s-t quolls, within their Parks (ie. "adverse impacts"). Instead the emphasis appears to focus simply on maintaining 'relations' with the neighbouring rural community. It is quite probable that the local landholders'

opinions about wild dogs from NPWS land attacking their livestock are justified. However, the current approach to wild dog control, both within NPWS areas and elsewhere in NSW lack the principles and strategies advocated by Braysher (1993) for modern day management of vertebrate pests. These include:

- Problem definition in terms of impact;
- Determining objectives and performance indicators;
- Identifying and evaluating management options; and
- Implementing, monitoring and evaluating the management program.

Until this occurs, the problem with wild dog impacts on livestock in NSW is likely to continue, at escalating cost to NSW NPWS, whether aerial baiting within National Parks is phased out or not.

7. FUTURE RESEARCH

7.1 Determining the Role of Wild Dogs from within National Parks on Livestock Impact

The first series of basic questions to answer, if aerial baiting for wild dog control is to continue in any of the five National Parks, are ' Do any of the wild dogs living in the Parks visit or attack livestock on adjacent properties? If so, do they move back and forth from the Park or establish home ranges in the boundary area? Can these shelter areas frequented by wild dogs be easily identified? Also, what proportion of the wild dog proportion in the Parks do they represent?' Such information, together with anything obtainable on the age, sex and social status of the dogs involved could greatly help indicate whether baiting programs in the Parks (as opposed to those externally along the boundaries) are targeting problem individuals and are justified. It could also significantly help in the development of more efficient and cost-effective control programs.

The most obvious method to obtain some of this information is by trapping a sample of wild dogs, particularly in the areas in which aerial baiting is proposed and fitting radio transmitters to them. Their positions (whether inside or outside the Park) could then be located fairly quickly and simply from a fixed-wing aircraft. The frequency at which they were located would depend on the research budget involved but should focus on any periods of the year when attacks on livestock are more common. To restrict costs, the research program should concentrate only on the basic questions and not be side-tracked into more time-consuming studies of the biology and ecology of the dogs. Another reasonably simple research program that could be carried out in conjunction with the above study could be to load non-toxic baits with different markers, burying them in different parts of the Park and then collecting and examining wild dog faeces from adjacent areas where attacks on livestock have periodically occurred (see Murray 1998). The faeces of wild dogs within the Parks could also be routinely collected and quickly examined for the presence of wool or other signs of predation or scavenging on livestock. While this may not show the proportion of dogs attacking livestock (because not all individuals that do so necessarily kill or feed on the livestock) it could at least indicate that *some* wild dogs from within the Parks are responsible for attacks on livestock. That may be sufficient justification for a control program against them?

7.2 Surveys of Spotted-tailed Quolls, Wild Dogs and Foxes

Another basic question that needs to be answered is 'Do s-t quolls, wild dogs and foxes occur in the proposed aerial baiting areas?' If s-t quolls do not occur, or rarely appear to use the areas, particularly when the baiting would take place, then their safety is not an issue in deciding whether to bait the areas or not. A similar argument applies to the presence of wild dogs and foxes. If there are very few wild dogs in an area, is the baiting justifiable in terms of cost and the possible risk to s-t quolls? At present most of the decisions about where to aerially bait appear too strongly influenced by the experienced opinions of dog trappers and others on the movement patterns of dogs rather than on the relative distribution, abundance and movement patterns of all three species. While that may be an effective basis for wild dog control it may not be the best option for conservation of s-t quolls. The opinion that s-t quolls are not being detrimentally affected because "they are still there" is not based on good scientific evidence. This attitude is relevant to all five Parks but is particularly appropriate for the Byadbo Wilderness Area given the possible small population numbers of s-t quolls that may be present.

For example, Glen Innes District are considering replacing part of their current mound baiting line in the south-eastern corner of WNP by aerial baiting on the grounds of cost-effectiveness. This would involve replacing eight mound bait stations over 10km by up to 100 aerial baits. One of the first obvious questions is how often were those eight bait stations visited by wild dogs? If baits from them were regularly taken by wild dogs but rarely by s-t quolls, then there is a strong case to proceed with aerial baiting on the grounds of cost effectiveness. As a further safeguard, however, a trial could be carried out shortly before the proposed aerial baiting program. This could involve laying the anticipated number of aerial baits by hand on raked plots spaced approximately 100-250m apart along the intended baiting runs or nearby firetrail (See Section 2.3). While the trial might require some physical effort because of the ruggedness of the country involved, it could conceivably be accomplished within a week, given the rate at which ground baits have been removed by animals in general in other areas (See Section 4.8). What the trial could indicate is the number of s-t quolls that could be affected by the proposed aerial baiting of the area. It could also indicate whether it is worth proceeding with the baiting against wild dogs.

While there are difficulties in carrying out similar pre-poisoning trials in larger baiting areas, such as those in OWRNP and Byadbo Wilderness Area, the trials could still be useful in particular areas. Examples could be the Tabletop area (Winterbourne section) in OWRNP containing one of the only two patches of predicted high quality habitat for s-t quolls in the Park, along the road section of the proposed aerial baiting run in WWNP, and in the small Jasper and Koorebang Nature Reserves to the south of WkNP.

7.3 Monitoring the Effectiveness of Aerial Baiting Programs within National Parks on Wild Dog Impacts

A further basic question to answer is 'Do aerial baiting programs within the National Parks reduce wild dog impacts to acceptable levels? Also, if so, for how long?' If monitoring indicates that they do not, then they are probably a waste of money and an unnecessary risk to non-target animals. Such research, however, is complicated for NSW NPWS to undertake because the main impact (on livestock) occurs on private land outside the Parks and may involve wild dogs living in fringe areas or other non-Service land.

At present monitoring of wild dog visits to mound stations before and after aerial baiting programs provide little useful information except when and where to substitute toxic baits for free feed baits at mound stations. Monitoring of visits by foxes and s-t quolls on the other hand can be useful in estimating whether any changes are occurring in their abundance. Ground surveys of baited areas are of little use as it is rare to find any dead animals unless intensive searches are carried out. Such animals may not necessarily have died from poisoning.

Using monthly reports of stock losses from wild dog attacks is a simple, subjective, but still useful method for determining if the combined suite of wild dog control methods in and outside the Parks is reducing impact or not. However, it can not measure the effectiveness of any particular control method. What may be needed are some 'adaptive management' trials using different combinations of methods, perhaps even at different times of the year? For example, Jindabyne District hired contractors from January 1998 onwards to mound bait and trap 'off-park' areas after a REF approval to proceed with aerial baiting in the Byadbo Wilderness Area during June 1998 was refused (O'Brien and Cawthorn 1998). Judging from the Dalgety/Paupong Wild Dog Control Association stock attack records (Table 10) this seems to have been a very successful method with a rapid decrease in sheep losses from March to June 1998. This is during the period *before* aerial baiting was finally permitted under a Section 120 Licence in June 1998. It is not possible to tell from the stock attack records whether the aerial baiting in Byadbo Wilderness Area helped maintain low stock losses for the rest of the year, whether the contractors' efforts were responsible, or whether the reduction in attacks was due to stock being removed away from the affected area. Only an 'adaptive management' trial (eg. continuing with the contractors but temporarily suspending the aerial baiting in Byadbo Wilderness Area) might help differentiate the effectiveness of the different methods in reducing impact on livestock. Given the pressures faced by Jindabyne District from different parts of society to either phase out *all* aerial baiting in KNP or continue aerial baiting in Byadbo Wilderness Area, and the difficulties they would face in replacing the proposed aerial baiting program by mound baiting and trapping, there is a need to experiment with control strategies.

Table 10: Monthly reports of sheep killed and bitten during January-November 1998 by the Dalgety/Paupong Wild Dog Control Association.

Month	Number of sheep killed or bitten
January	80
February	89
March	117
April	61
May	39
June	0
July	0
August	44
September	6
October	16
November	4

7.4 Monitoring the Abundance of Spotted-tailed Quolls in National Parks

There are two important questions that need to be answered about the s-t quoll populations in each of the Parks:

1. What is the status of each of the s-t quoll populations: are they declining, remaining stationary or increasing?

2. What, if any, is the effect of wild dog aerial baiting programs on s-t quoll populations?

The first question is the standard conservation issue with any threatened species and is most easily addressed by estimating the rate of increase of the s-t quoll populations from annual estimates of abundance. The latter could be obtained as indices, using standardised sampling methods such as the number of individuals caught per 1000 trapnights along fixed trapping transects, the proportion of hair tubes at fixed sites containing s-t quoll hairs, the number of visits by s-t quolls to a reasonable fixed sample of mound bait stations or the number of fresh scats found at the same (reasonable number) of latrines per year. All four methods would be most useful if they provided similar estimates of rates of increase. If it was then found that the rates of increase in each of the Parks are mostly greater than or equal to zero over several years with a representative amount of environmental variability, then there is no conservation problem. If the rates of increase are mostly less than or equal to zero, then the populations involved are not sustainable and the problem is to sort out why.

Such an approach is probably not possible with brush-tailed phascogales and eastern quolls given their rarity in the Parks. Instead, if signs of them were found in the Parks, I would expect an instant moratorium on all wild dog control would be placed in a radius of 3-4 km around their locations.

The second question about the effect of aerial baiting on s-t quolls is analogous to harvesting animals, such as endangered whales. The best way to determine this is to compare the rates of increase of baited and unbaited populations of s-t quolls in similar habitats. Washpool and Gibraltar Range National Parks are examples of each, but more sites would be necessary to avoid pseudoreplication. If differences occurred in the rates of increase between baited and unbaited areas it would be important to determine that they are due to the baiting program.

This could be done in two different ways. The easiest way is to aerially bait a s-t quoll population with non-toxic baits containing a biomarker. A sample of the population (eg. 10-20 individuals) would then be need to be trapped shortly after the baiting and inspected in different ways for signs of the biomarker. C. Belcher (Ecosystems Environmental Consultants, Victoria), A. Murray (DNRE, Victoria), J. Darrant (State Forests, NSW) and A. Claridge (NPWS, NSW) are currently carrying out such a study, using Rhodamine B dye as a biomarker in the Badja and Tallaganda State Forests in south-eastern NSW. They intend to radio-collar about 20 individual s-t quolls before the baiting in their proposed study area to enhance trapping of all individuals after the baiting and measurement of the number that had fed on baits (A. Murray, DNRE, Victoria, pers. comm. 1999).

The main weakness with this approach is that it is likely to overestimate the potential population mortality because the method can not measure how much bait each individual consumes, only that it has eaten marked bait. It should also be replicated in a poorer habitat for s-t quolls where their population density may be much lower, such as in Byadbo Wilderness Area.

One modification of this method that could provide information on how much bait each individual s-t quoll eats is to use biomarkers such as iophenoxic acid or radio isotopes such as sodium or oxygen, but this is likely to considerably increase the costs of the research involved.

The second way, which would provide the most realistic information, is to use mortality collars on a trapped sample of s-t quolls in an area subjected to a wild dog aerial baiting campaign. This method, which should also be replicated with a low-density population, could result in the deaths of sample individuals. It is also likely to be expensive, particularly if post-mortem measurements of 1080 are required to confirm the cause of death of individuals. Depending upon the results, more field research might be necessary, such as whether aerial baiting in selected areas creates 'sink' populations of s-t quolls where the rate of increase is less than zero. If that occurred, it might necessitate measuring dispersal rates in nearby unbaited areas.

7.5 Wild Dog and Fox Control in National Parks

Considerable thought needs to be given to current and future objectives, strategies and methods for control of wild dogs and foxes in the five National Parks, including their likely effect on s-t quolls.

At present the principal techniques to control wild dogs are exclusion fencing, shooting, trapping and poisoning. Poisoning with 1080 is accepted as the most cost-effective means of reducing populations of wild dogs over large areas of remote or inaccessible country. Trapping is usually more effective for control of specific individuals, particularly those close to sheep-grazing areas where dogs may be less likely to take baits because of the abundance of easily obtained prey (ie. sheep) nearby.

Poisoning is either carried out by ground baiting (throwing the baits on the surface of the ground), mound baiting (burying the baits in the middle of prepared mounds to allow identification of the tracks of animals visiting the mounds) or aerial baiting (similar, with less precision of placement, to ground baiting). With both aerial and ground baiting, many of the baits destined for wild dogs can be removed by foxes, birds and other non-target animals (McIlroy et al 1986a,b; Fleming 1996). This can greatly reduce the effectiveness of the program in reducing dog numbers. Burying the baits below 10 cm (as in mound baiting) partly reduces this problem (although foxes can still remove substantial numbers of baits). Also prior identification of the animals that have taken baits at mounds (from the footprints they leave) can help reduce the hazard faced by s-t quolls and other non-target animals. But the cost involved is a large increase in the amount of time, effort and money necessary to carry out such programs. In addition, there have been no published studies comparing the relative effectiveness of mound baiting versus aerial baiting for wild dog control.

One suggested modification that might lessen the hazard to s-t quolls from ground baiting and reduce the cost of mound baiting is to bury the baits along a bait run, without preparation of mounds. This would be a 'one-off operation' like ground baiting, with no prior and post inspections or replacement baiting. Jindabyne District (P. O'Brien, NPWS, Jindabyne District, pers. comm. 1999) feel the method is unlikely to be as cost-effective as aerial baiting in reducing wild dog numbers in the Byadbo Wilderness Area. They maintain that to mimic the proposed aerial baiting program in Byadbo they would have to bury at least 200 baits in a single day (versus the 600 baits that could be aerially distributed in a day) and the likely results would not warrant the costs, including the logistics of organising such a large scale operation. They also feel the local community would have no faith in the method, even though in principle it seems little different (except for the more difficult access problems) than the extensive ground baiting that the Cooma and Bombala RLPB carry out in their area outside KNP.

The method deserves a better evaluation than such an untested dismissal. For example, it might be possible to use it in Byadbo in some areas where there is a higher probability of s-t quolls occurring, in combination with aerial baiting in areas where they are less likely to occur. (That is where better survey data on endangered species could help immeasurably in pest control operations). It may not be necessary to have to bury 200 or more baits per day but simply cover the area strategically/sequentially as quickly as possible? Obviously the time and costs involved would be far less than being forced to carry out only mound baiting in the area. The issue basically is one of adaptive management. Of recognising public pressure to phase out aerial baiting of wild dogs and experimenting with different combinations or modifications of methods to reduce the costs and hazards to threatened species involved.

It is possible that the one-off method might be even more appropriate in replacing particular aerial baiting runs in northern National Parks and Reserves where s-t quolls are known to occur but foxes are either absent or rare (and hence will not remove as many buried baits as in Byadbo). Possible examples (that need more pragmatic 'on-site evaluation') might be some of the more isolated 'islands' of OWRNP where s-t quolls have been reported, possibly the proposed aerial baiting runs in WNP and the proposed runs in Jasper and Koorebang Nature Reserves near WkNP?

At the same time it has to be recognised that the method gives less certainty re target specificity than mound baiting. The trade off is one of cost of baiting versus greater safeguards for non-target animals. This can only be truly answered if the status of the threatened species is known (see Section 7.4).

There are other questions that also need to be addressed over wild dog control in the National Parks. For example, is late autumn and winter the best time to aerially bait within the Parks given this coincides with the known breeding period of s-t quolls in southern Australia? During this period male s-t quolls roam much further and may more readily encounter baits than during other periods of the year.

One reason given for baiting in autumn or winter is that baits will last much longer if distributed then than during other periods of the year (Fleming and Parker 1991). But should that be the aim of 1080 baiting inside parts of a National Park that contain threatened species? Another reason given is that the populations of dingoes/wild dogs in the Parks are potentially at their lowest prior to whelping in winter or spring and so any reduction in their numbers then is likely to be more effective in reducing attacks on livestock in areas outside the Parks than during other seasons. This argument may not be valid if the wild dog segment of the population breed continuously throughout the year (as may be occurring). There is also no clear scientific evidence showing the relationship between population numbers of wild dogs inside National Parks and attacks on livestock outside the Parks. At the moment wild dog control inside National Parks is based upon the period when it is *'traditionally believed'* wild dog movements are greatest, with young dogs dispersing and mating occurring! Given the all year around reproductive capacity of wild dogs versus dingoes, such 'set patterns' may no longer occur? The most valid argument is probably to carry out control programs just prior to when records of major stock attacks occur. Based on the information provided for the Dalgety/Paupong area during 1997-98 by P. O'Brien (NPWS, Jindabyne District, pers. comm. 1999) and for the OWRNP area by Waters *et. al.* (1998) the appropriate period for control appears to be during February-March and April, respectively. Such baiting periods may slightly lessen the risk of s- t quolls encountering baits in the areas concerned?

This still leaves the question of whether only one aerial baiting per year inside the Parks is effective at significantly reducing wild dog impact outside the Parks? Fleming *et. al.* (1996) found that wild dog numbers recorded just before annual aerial baiting programs in north-eastern NSW were similar between years, indicating that the population recovered during the intervening year. While that study is interesting, the real focus should have been on identifying whether the number of wild dog attacks varied from year to year and the factors involved in that, rather than just focusing on wild dog numbers! This is particularly pertinent for dingo/wild dog numbers inside National Parks that are often distant from the scene of wild dog attacks on livestock. Perhaps more than one baiting should be tried per year in particular areas where livestock losses are high as an adaptive management practice, and its effect on stock losses evaluated? Again, this might be possible in some of the more isolated 'islands' of OWRNP that are adjacent to areas experiencing high livestock losses from dog attacks.

The objectives of NPWS in regard to fox control in National Parks containing s-t quolls also need consideration. Are they to try to obtain or maintain low population densities of foxes within the Parks incidentally through wild dog control programs or through deliberate fox poisoning programs? Are any targeted specifically for the conservation of threatened species in the Park? Are any a possible hazard for threatened species? An Action Plan is clearly needed for conservation of s-t quolls in Byadbo Wilderness Area. This will need to include strategic and sustained fox control in selected areas. It is senseless to focus just on the effect of wild dog baitings on threatened species without being aware of and 'treating' the other factors that may be causing the species' decline and threatened status.

Section 3.3 of the Director General's Requirements seeks discussion of strategies to protect areas of particular importance to s-t quolls. The problem with this Requirement is that to date no areas of "particular importance" to s-t quolls have clearly been identified. Areas containing predicted high quality habitat for s-t quolls have been mapped in northern NSW, including some close to proposed aerial baiting lines, but it is not clear how important these areas may be for local populations. Particularly whether they represent 'source' populations from which s-t quolls can disperse to other areas, including baited areas? What needs to be determined are the key factors that make any area "particularly important" for s-t quolls. Is it an absence of foxes and goats, an absence of aerial or other poisoning programs or an abundance of suitable prey throughout the year, especially during winter? It is only when these basic factors enhancing s-t quoll populations are clearly established that it will be possible to develop effective strategies to protect local populations.

Finally, should the aerial baiting procedure be modified in all possible or planned aerial baiting areas known or suspected to contain s-t quolls? This might include using wider spacing between baits (as generally occurs with mound baiting) and either larger baits (*viz* WNP) or reduced toxic loadings in the current baits used? Should there be more emphasis by the NPWS in carrying out all control measure along, but *outside* the perimeter of Service land as occurs with feral pig control in the Wet Tropics of Queensland World Heritage Area (McIlroy 1993; J Mitchell, Department of Natural Resources, Queensland, pers. comm. 1998)? Can aerial baiting for wild dog control also be used for fox control where necessary (as suggested for the Byadbo Wilderness Area)? Such questions can only be answered by adaptive management trials, increased surveys and monitoring.

8. RECOMMENDATIONS

The following recommendations are provided concerning the proposed aerial baiting programs for wild dog control in the five selected National Parks.

8.1. ***That research is undertaken to clearly establish that wild dogs from the National Parks involved are attacking livestock on adjacent rural land.***

If the research shows that wild dogs from the National Parks are responsible for attacks on livestock, then it clarifies the situation. The research may also indicate where the control efforts should be focused and enhance the effectiveness of the control programs.

8.2. ***That no aerial baiting is undertaken along the proposed aerial baiting runs in Byadbo Wilderness Area (KNP) until a much clearer idea is obtained of the distribution, abundance and movement patterns of s-t quolls, foxes and wild dogs in the area.***

Two suggested alternatives are:

- That consideration is given to continuing some or all of the additional mound baiting and trapping that was carried out outside the boundary of Byadbo Wilderness Area during January-June 1998. The objective is to determine whether this can repeat the results achieved during 1998 and maintain low numbers of stock attacks in the Dalgety/Paupong area during the rest of the year.
- To restrict all aerial baiting in the Byadbo Wilderness Area to the Snowy River, particularly the sections where Reside (1997) found abundant signs of wild dogs and foxes but no signs of s-t quolls, until the comprehensive surveys of quoll, dogs and foxes have been undertaken. If this is the 'source' of the wild dogs moving out onto private land and foxes roaming up into the last stronghold of s-t quolls in the rocky escarpments, control programs may prove more effective in mutually reducing wild dog impact on stock and enhancing s-t quoll populations if they are focused in this area. However, because of comments received by others about the presence of s-t quolls along the Snowy River, it would appear safest to either carry out a brief survey for s-t quolls in the possible baiting area or a preliminary ground surface baiting trial as described in Recommendation 8.4 before any aerial baiting was undertaken.

8.3. ***That the proposed aerial baiting program in OWRNP is allowed to proceed for the next 3-5 years given Armidale District's previously stated policy that they propose to replace all aerial baiting during that period by fencing and mound baiting.***

It is acknowledged that aerial baiting might still be used as a cost-effective control method in rugged areas in the future if research on the rates of increase of s-t quolls in the Park indicate that aerial baiting is not adversely affecting their populations.

8.4. *That aerial baiting could be undertaken in a restricted area of WNP, if necessary, but only after an assessment of the results of a preliminary ground baiting trial with non-toxic baits carried out a few weeks earlier.*

The objective of the trial (simulating the proposed aerial baiting in the area) would be to determine how many s-t quolls might take aerially distributed baits and whether there are sufficient baits taken by wild dogs to justify the cost of the aerial baiting program. Aerial baiting should not be carried out if there is evidence of s-t quolls removing baits or if dogs take only a few baits.

8.5. *That before any aerial poisoning is permitted in WkNP and WWNP stronger evidence is required that wild dogs from the proposed aerial baiting areas are having a significant impact on stock on adjacent properties. If aerial baiting is approved in WWNP it should be confined only to steeper areas distant from any roads, firetrails or access tracks unless a preliminary ground baiting trial with non-toxic baits on sand plots indicates otherwise. No aerial baiting should be permitted in the Jasper and Koorebang Nature Reserves.*

There appears no justification at present, except on cost-saving grounds, to aerially bait close to the road along the ridge between Flat Top Mountain and Double Head in WWNP (Fig. 7) when mound baiting is practically feasible and would greatly reduce any risk of poisoning to s-t quoll populations. It is accepted that aerial baiting is the only practical method for baiting the steeper country at either end of the proposed aerial baiting run, particularly in the McCoys Creek-Jacobs Ladder area. A small bait removal trial. shortly before the proposed aerial baiting (along the lines suggested for WNP) could provide the grounds for aerial baiting of the whole route. Aerial baiting in the two small Reserves could possibly expose all s-t quolls inhabiting the Reserves to the risk of being poisoned. Either mound baiting could be carried out along vehicular tracks on private land to the east and south of Koorebang Nature Reserve, or the private area to the east of the Reserve could be aerially baited. No baiting of any kind should be carried out *inside* Jasper Nature Reserve unless it is clearly demonstrated that it is the source of wild dogs attacking livestock on adjacent private land. Even if so, mound baiting along the perimeter of the Reserve would be a safer method for wild dog control.

8.6. *That all strategic wild dog baiting within the five selected National Parks is undertaken between February to early May each year.*

Given the biology and ecology of s-t quolls (especially their likely nutritional demands later in winter and movements), such a restricted baiting period may be less hazardous to the population carried out during other periods of the year.

8.7. *That surveys of spotted-tailed quolls, wild dogs and foxes are carried out in all aerially baited areas before and after aerial baiting programs.*

The objective of this is to determine whether aerial baiting in each particular area of each Park is justified as the control method in terms of the number of s-t quolls that might be poisoned compared to the number of wild dogs and foxes present. These surveys (using raked plots, non-toxic bait stations and hair tubes) should be carried out shortly before and after the aerial baiting programs in each Park. In Byadbo the surveys might best be carried out along the Snowy River while in OWRNP they should at least include the Tabletop and Budds Mare predicted high quality habitat areas for s-t quolls. In WNP and WWNP the surveys should at least cover the possible aerial baiting areas while in WkNP they should include most of the possible aerial baiting areas, including the two Reserves.

8.8. ***That the status of the spotted-tailed quoll populations in each Park is determined and field research is carried out to measure the actual effect of wild dog aerial baiting programs on spotted-tailed quoll populations.***

The priority for the first part of this recommendation is the Byadbo Wilderness Area, but the monitoring will be very difficult to undertake because of the rugged nature of the country and the possibly low population density of the s-t quolls present. Part of the research in that area should involve sustained reduction of fox and wild dog numbers along sections of the Snowy River and long-term monitoring to see if the areas are reinhabited by s-t quolls.

Studies to measure the proportion of s-t quoll populations that are killed by wild dog aerial baiting programs have been repeatedly discussed over the last 20 years. Some of the methods that could be used could provide a relatively quick, cheap answer that may overestimate actual mortality but not cause the death of individuals. More sophisticated methods will increase the accuracy of the estimates but cost more, including in some cases the likely death of individuals. If the simplest approach (adequately replicated) indicated that only a small proportion of the populations ate (non-toxic) wild dog baits in aerially baited areas, this may be sufficient for modelling the future status of their populations. If a larger proportion ate baits, then actual measurements of the number of individuals that may have subsequently died if the baits had been toxic may be necessary.

8.9. ***That all wild dog control programs in Parks where foxes occur also incorporate any extra measures necessary to enhance fox control.***

Competition with or predation by foxes is recognised as one of the major threatening processes for many threatened animal species, including s-t quolls. Consequently, any modifications or additions that may enhance fox control that can be incorporated in the wild dog control programs should be encouraged. While this may not be sufficient for effective long-term fox control (eg. more frequent baitings may be necessary) it could help reduce the predation rates of foxes. Such an integrated control program might involve additional distribution of fox baits (ie. those containing 3mg of 1080) in certain areas and the monitoring of fox numbers (as well as those of dogs and s-t quolls) before and after control programs.

8.10. ***That 'adaptive management' trials are carried out both inside the five Parks and on adjacent land to determine if strategic changes in wild dog control can reduce their impact on livestock and reduce the possible risk that non-target animals face of being poisoned.***

The objective is simple. If control efforts can largely be concentrated just outside the Parks' boundaries there will be less risk of native animals, including pure-bred dingoes inside the Parks, being poisoned. Such strategic changes will depend on surveys of wild dog distribution and movement patterns on both sides of the Parks' boundaries and require 'adaptive management' trials involving possible changes to the frequency and location of control methods.

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