Report Cover Page

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Title
A decision framework for estimating consequence impacts under operational conditions Case study: Review of the Emergency Plant Pest Categorisation Questionnaire
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Summary

The Emergency Plant Pest Response Deed is a legally binding agreement between plant industries and government that specifies cost-sharing arrangements in the event of a pest incursion. The core principle underpinning cost-sharing is that beneficiaries of the eradication of an emergency plant pest pay an appropriate and equitable proportion of the costs of mounting a response. Stakeholders hold different views on what might be considered 'appropriate and equitable'. The Pest Categorisation Questionnaire is a decision-support protocol that informs cost-sharing arrangements. This report critiques the Pest Categorisation Questionnaire, highlighting weaknesses and potential remedies.

There are three main problems embedded in the current protocol:

1. The protocol is ambiguous in its interpretation of the cost-sharing principle of the EPPRD. Some elements imply a cost-sharing arrangement whereby government pays according to the magnitude of impact on public values, irrespective of the magnitude of impact on private values.
2. The point scoring procedure underpinning the protocol can lead to clearly erroneous categorisation.
3. The verbal descriptors of impact ('major', 'moderate' and 'minor') are poorly defined, leading to assessments that confound predictions of impact with value judgments of the importance of those impacts.

Collectively, these problems lead to inconsistent categorisations.

We propose four improvements to the Pest Categorisation Questionnaire to remedy these problems:

1. Amend the decision tree for pest categorisation.
2. Clearly align each question to either public impacts or private impacts.
3. Clarify the IF-THEN rules that define cost-sharing categories.
4. Clarify what is meant by verbal descriptors of impact, and assign points accordingly.

Negotiation among key stakeholders is required to calibrate what is meant by ‘major’, ‘moderate’ and ‘minor’ impacts for public and private interests. Calibration will provide clarity on the extent to which public and private beneficiaries of eradication are required to pay.		
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A decision framework for estimating consequence impacts under operational conditions

Case study: Review of the Emergency Plant Pest Categorisation Questionnaire

ACERA 1002

Improved biosecurity decision-making through better characterization of consequences.

Victoria Hemming, Australian Centre of Excellence for Risk Analysis

Terry Walshe, Australian Centre of Excellence for Risk Analysis

November 2011

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Executive Summary

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1.0 Context: The Emergency Plant Pest Response Deed (EPPRD)

The EPPRD is a legally binding agreement between plant industries and government. The EPPRD is administered by Plant Health Australia (PHA), which is a non-profit national coordinating body representing the Australian Federal Government, State and Territory Governments and 26 national plant industry signatories.

Among the motivations for initiating the EPPRD were:

- the desirability of defining responsibilities for funding response plans in the event of an incursion of an emergency plant pest, and
- provision of a framework whereby the beneficiaries of the eradication of an EPP pay an appropriate and equitable proportion of the costs of mounting a response.

The Pest Categorisation Questionnaire is the key means by which these elements are achieved. It seeks to characterise the expected impacts of a potential plant pest on (a) industry and (b) public values, so that a cost-sharing arrangement can be agreed between the private and public sectors according to proportional benefits associated with successful eradication (PHA 2011).

This document critiques the Pest Categorisation Questionnaire, highlighting weaknesses and potential remedies.

1.1 Cost-sharing under the EPPRD

Plant pests vary in the extent to which they impact industry and public values. *Wheat Spindle Streak Mosaic* Virus, for example, can cause stunting, smaller flowering heads and lower seed yields in wheat (DPI 2005). Although there is no cure for the virus, it only affects wheat and rye crops, and is not thought to have an effect on other plant species, or any serious public health implications. Incursion by this pest would be expected to largely affect industry, and have minimal impact on public interests. In contrast, establishment and spread of Red Imported Fire Ants may have serious implications for the natural environment, human health and lifestyle, as well as public amenity, but its direct impacts on industry are limited.

Under the EPPRD, a pest can be categorised into one of four cost-sharing categories depending on the estimated public and private benefits associated with successful eradication. These four categories are shown in Table 1.

Table 1. Categorisation of plant pests and relevant cost-sharing between the private and public sectors (PHA 2010 a).

Category	Cost Share
Category 1	100% public funding
Category 2	80% public funding 20% private funding
Category 3	50% public funding 50% private funding
Category 4	20% public funding 80% private funding

The costs associated with eradication of a pest can be extensive. The four categories define who is responsible for meeting these costs (see Appendix 1 for details). The longevity of goodwill and a co-operative approach to pest management rests in part on the logic and coherence of the questionnaire that informs categorisation.

1.2 Outcomes of categorisation in the past

The current version of the EPPRD (PHA 2011) reports the outcomes of categorisation of 80 pests in the past (Table 2). More than half (54%) have been categorised as Category 3, whereby the costs of a response plan are shared equally between government and industry. Approximately one third (34 %) of pests have been categorised into Categories 1 or 2, where response plans are exclusively or majority government funded. Only 10 of the 80 pests have been categorised as Category 4, where industry is the majority funder.

Table 2. Current categorisation of 80 pests under the EPPRD (Source: PHA 2011)

Category	Cost-sharing (government : industry)	number of pests
1	100:0	3
2	80:20	24
3	50:50	43
4	20:80	10

2.0 A brief outline of the Pest Categorisation Questionnaire

The Pest Categorisation Process is divided into two stages. The initial categorisation is completion of the Pest Categorisation Questionnaire (PCQ) by nominated specialists from government and industry. This is then followed by a review of outcomes and formal categorisation by the Categorisation Group, the membership of which is defined under the EPPRD (see Appendix 2). Both stages are based on the Pest Categorisation Decision Tree (Figure 1).

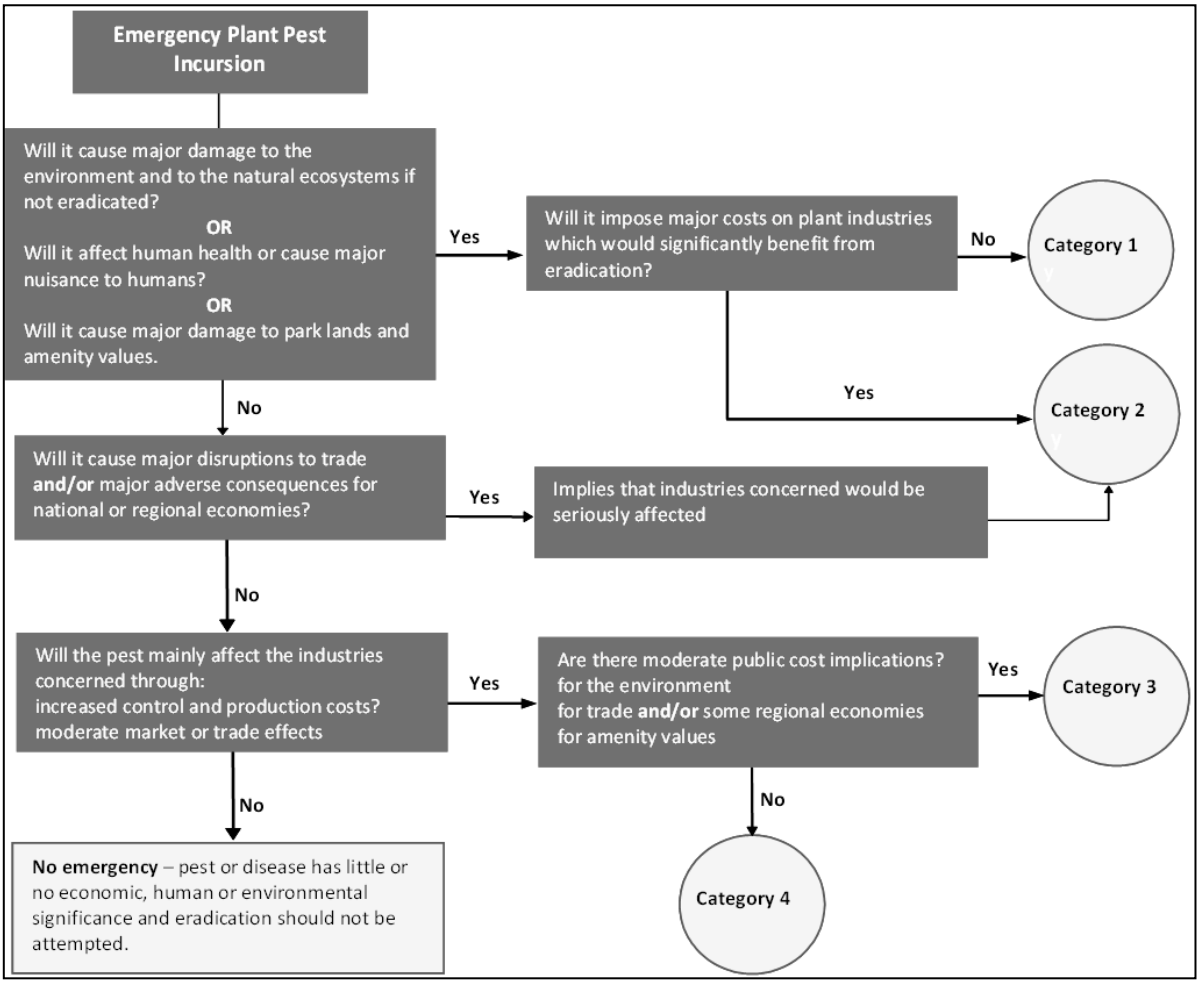


Figure 1. The Pest Categorisation Decision Tree (PHA 2010).

The PCQ comprises seven questions (Table 3). The seven questions capture key impacts considered important for public or private interests. Specifically:

- The public interest in the environment (Q1)
- The public interest in human health and lifestyle (Q2)
- The public interest in amenity (Q3)
- The public interest in regional communities (Q7)
- The private interest in net returns to industry (Q4 and Q6)
- The public ***and*** private interest in trade (Q5)

A government or industry specialist assessor is asked to rate the impact a pest will have on each of these interests. For most questions, this means defining an impact according to one of three ordinal descriptors, *Major*, *Moderate* or *Minor*. Some questions have sub-questions which are considered useful predictors or proxies for the corresponding public or private interest. For example, Question 7 relates to regional communities and is broken down into series of sub-questions that concentrate on employment. Answering each of these sub-questions determines whether or not there will be a substantial effect on regional communities.

Table 3. The Pest Categorisation Questionnaire and responses (Source: PHA 2010).

Question	**Candidate responses**
1. The impact of the pest on the environment and natural ecosystems would be:	• Major • Moderate • Minor or no impact
2. The impact of the pest on human health and lifestyle would be:	• Major • Moderate • Minor or no impact
3. The impact of the pest on public amenities and/or parklands would be:	• Major • Moderate • Minor or no impact
4. The direct impact on industry net returns would be: The answer to this question is derived through supplementary questions exploring • availability of resistant varieties or germplasm • availability of chemical control • registration status of chemicals • future prospects for chemical control availability • whether the pest kills the plant • whether presence of the pest reduces or causes production to cease • additional costs incurred to make the product marketable	• Major • Moderate • Minor or no impact
5. The presence of the pest in Australia would result in market/trade restrictions with:	• The majority of trading partners • Some trading partners • No trading partners
6. Would the presence of the pest cause indirect (flow-on) effects to other industries or other sectors be: The answer to this question is derived through supplementary questions exploring • whether importation of the commodity into Australia is restricted • geographically isolation of commodity production	• Larger than direct impacts • Equivalent • Smaller
7. Will the presence of the pest impose significant social adjustment costs to regional communities? The answer to this question is derived through supplementary questions exploring • geographic concentration of the industry • significance of the direct industry as a regional employer • significance of any value-adding industry as a regional employer • mobility of affected employees • flow-on effects of relocating employees on regional services	• Yes • No

Responses to each of the seven questions are assigned points, the number of which varies from question to question (Table 4). The sum of responses to the seven questions determines the categorisation outcome (Table 5).

The PCQ also allows a series of 'exception rules' (Table 6) which override categorisation based on the sum of points shown in Table 5. Fourteen of the 15 exceptions alter the point scoring outcome from Category 1 to Category 2 in circumstances where large industry impacts are anticipated as well as major impacts on public values. The last exception rule alters a point scoring outcome of Category 2 or 3 to Category 4, for the curious circumstance where impacts on trade are large despite only 'minor' impacts on public values and minor direct and indirect impacts on industry.

The point scoring procedure and exceptions collectively imply a set of IF-THEN rules about how a pest is categorised under the current protocol. These rules are graphed as logic trees for Categories 1, 2 and 4 in Figure 2.

Table 4. Points assigned to each responses in the Pest Categorisation Questionnaire.

Question	Major	Moderate	Minor
Q1 Environment	1400	30	0
Q2 Health and lifestyle	1400	30	0
Q3 Amenity	1400	30	0
Q4 Direct industry returns	100	10	0
Q5 Trade	400 (majority)	30 (some)	0 (none)
Q6 Indirect industry returns	100 (larger)	30 (equal)	0 (smaller)
Q7 Regional communities	400 (yes)	na	0 (no)

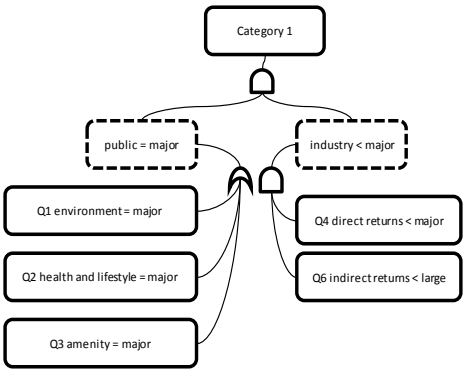
Table 5. Categorisation based on the sum of points associated with responses to each of the seven questions.

Category	Points
1	≥ 1400
2	400 - 1399
3	30 - 399
4	<30

Table 6. The exception rules of the Pest Categorisation Questionnaire.

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Category
Response	Major	Major	Major	Major	Any	Any	Any	2
	Major	Any	Any	Major	Any	Any	Any	2
	Any	Major	Any	Major	Any	Any	Any	2
	Any	Any	Major	Major	Any	Any	Any	2
	Major	Major	Any	Major	Any	Any	Any	2
	Any	Major	Major	Major	Any	Any	Any	2
	Major	Any	Major	Major	Any	Any	Any	2
	Major	Major	Major	Any	Any	Large	Any	2
	Major	Any	Any	Any	Any	Large	Any	2
	Any	Major	Any	Any	Any	Large	Any	2
	Any	Any	Major	Any	Any	Large	Any	2
	Major	Major	Any	Any	Any	Large	Any	2
	Any	Major	Major	Any	Any	Large	Any	2
	Major	Any	Major	Any	Any	Large	Any	2
	Minor	Minor	Minor	Minor	Any	Small	no	4

(a)



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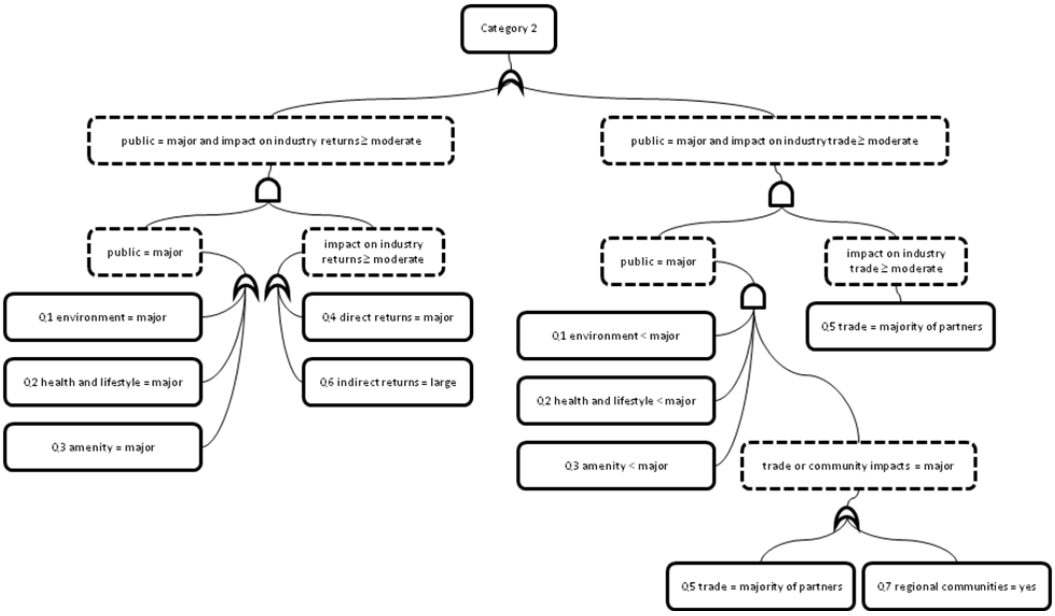

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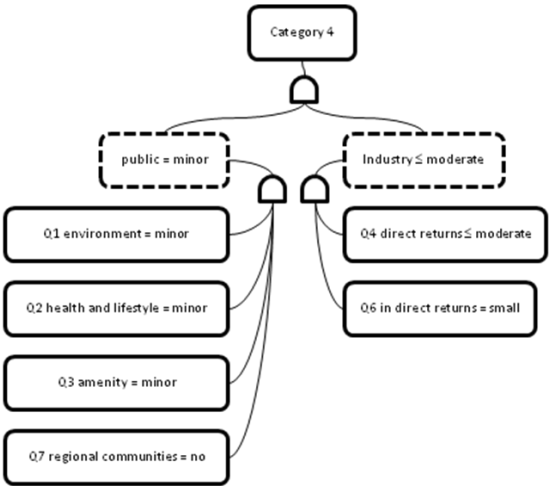


Figure 2. Logic trees summarising IF-THEN rules for categorisation of a pest using the PCQ. (a) Category 1, (b) Category 2, and (c) Category 4. Category 3 is used in all other circumstances. AND gates use the symbol  . OR gates use the symbol  . Dashed boxes are implied in the current protocol but not explicitly stated.

3.0 What's wrong with the Pest Categorisation Questionnaire?

There are three main problems embedded in the current protocol.

1. The protocol is ambiguous in its interpretation of the cost-sharing principle of the EPPRD
2. The point scoring procedure can lead to clearly erroneous categorisation.
3. The verbal descriptors of impact are poorly defined.

3.1 Ambiguity of cost-sharing principle

The EPPRD defines the basis of cost-sharing: *beneficiaries of the eradication of an EPP pay an appropriate and equitable proportion of the costs of mounting a response.*

A plain reading implies that costs be borne proportional to expected impacts of a pest. So that if impacts on industry and public values are both 'major' then Category 3 (50/50 split in costs) seems appropriate. If anticipated impacts will be felt mainly by industry then Category 4 is appropriate. Pests whose impacts fall overwhelmingly or substantially on the side of public values should be Category 1 or 2.

This understanding of cost-sharing is not strongly evident in the current protocol. Contrary elements include:

- If impacts on public values (environment, health or amenity) are considered 'major', the highest proportion of response plan costs borne by industry is 20% under Category 2, even when impacts on industry are also considered to be 'major'(see Figure 3).
- If impacts on public values (environment, health or amenity) are considered 'major' and industry impacts are 'moderate' then costs are borne exclusively by government under Category 1.
- Where there is a 'major' direct impact on industry, it is impossible to get a Category 4 outcome, no matter how benign the impacts on public values or trade (see Figure 2c).

Collectively these elements mean that the current protocol emphasises a cost-sharing arrangement whereby government pays according to the magnitude of impact on public values, *irrespective of the magnitude of impact on private values*. This emphasis essentially translates to a government subsidy. The inclusion of a *de-facto* subsidy may have been intentional in the initiation of the EPPRD to encourage industry participation. Stakeholders vary in their perception of the level of subsidy that is appropriate today. This theme is explored further in Section 5.

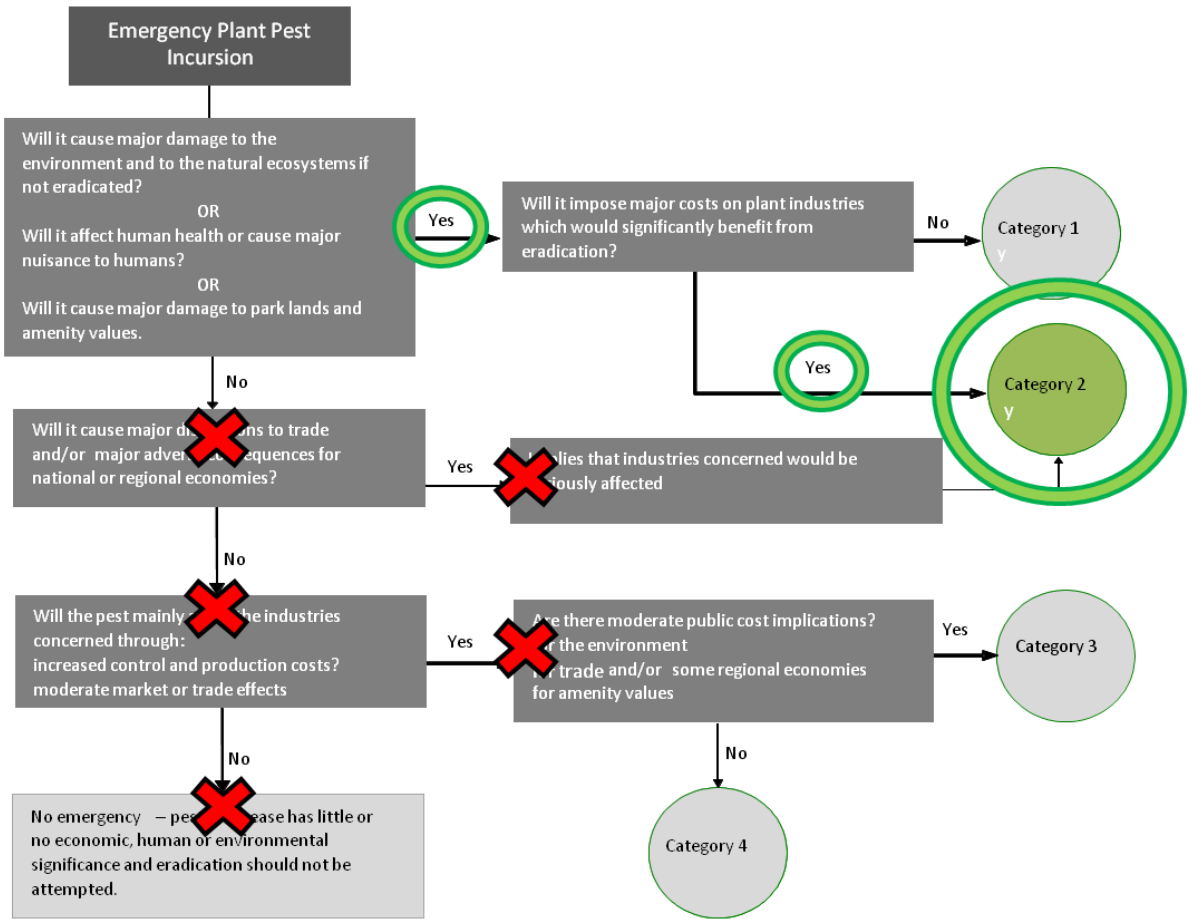


Figure 3. The categorisation of a pest that has a 'major' impact on both public and private values using the decision tree. The Category 2 outcome results in government contributing 80% towards the costs of a Response Plan even though the impacts on industry are also considered 'major'.

3.2 Summing points

The simple summation of points can lead to plainly unintended outcomes. Examples are shown in Table 7. Government may well question why it should fund 80% of the response plan under Case 1. Industry would be similarly perplexed to learn that it is obliged to pay 50% under Case 2, or 20% under Case 3. A summary of an actual categorisation that was compromised by the point scoring procedure of the PCQ is shown in Box 1.

The most striking failure of the point scoring procedure embedded in the current PCQ is that major impact to industry will *never* lead to a Category 4 pest, even if there are no impacts to public values. Category 4 outcomes comprise those circumstances where the sum of points over all seven questions is less than 30 (Table 5). A 'major' direct or indirect impact on industry attracts 100 points alone. The naivety of the current point scoring procedure means that if a major impact on industry is anticipated, the most it will be asked to contribute is 50% under Category 3, even when public impacts are negligible.

A lesser but non-trivial problem is the way points are assigned for indirect industry impacts under Question 6. The responses are *relative* to those provided in Question 4 regarding direct impacts.

That is assessors are required to judge whether indirect impacts are 'greater ', 'equal' or 'smaller' than direct impacts. The problem is that the number of points assigned to 'greater ', 'equal' and 'smaller' are fixed at 100, 30 and zero, respectively. Imagine a scenario where direct impacts are 'minor' and indirect impacts are 'equal'. Now imagine another scenario where direct impacts are 'major' and indirect impacts are again 'equal'. The magnitude of indirect impact on industry is plainly different under the two scenarios, but under the current protocol 30 points are assigned to the response to Question 6 in both cases.

Table 7. Counterintuitive outcomes of the current Pest categorisation Questionnaire that arise from simple summation of points. Points are shown in brackets.

	Public values	**Industry**	**Trade**	**Outcome**
Case 1	Q1 Environment = minor (0) Q2 Health = minor (0) Q3 Amenity = moderate (30) Q7 Regional communities = no (0)	Q4 Direct = major (100) Q6 Indirect = larger (100)	Q5 Trade = majority (400)	630 points = Category 2
Case 2	Q1 Environment = minor (0) Q2 Health = moderate (30) Q3 Amenity = minor (0) Q7 Regional communities = no (0)	Q4 Direct = minor (0) Q6 Indirect = smaller (0)	Q5 Trade = none (0)	30 points = Category 3
Case 3	Q1 Environment = moderate (30) Q2 Health = minor (0) Q3 Amenity = minor (0) Q7 Regional communities = yes (400)	Q4 Direct = minor (0) Q6 Indirect = smaller (0)	Q5 Trade = none (0)	430 points = Category 2

3.3 The verbal descriptors of impact are poorly defined

Just what constitutes a 'major', 'moderate' or 'minor' impact is open to variable interpretation. In making judgments the most common strategy recognised by cognitive scientists is *'anchoring and adjustment'.* In ambiguous circumstances we tend to set an 'anchor' as a starting point for our estimates and then 'adjust' (often inadequately) from that point (Hastie and Dawes 2010). In pest categorisation exercises several pests are typically assessed in a single meeting. Anchoring and adjustment suggests pests will be more or less consistently assessed *within* meetings, but that the different anchors implicit in initial judgments made at different meetings will lead to inconsistent assessments *between* meetings.

Ambiguity confounds the task of prediction with value judgments. The PCQ requires respondents to characterise perceived impacts of a pest as 'major', 'moderate' or 'minor' with no specification of the magnitude of these effects. The lack of any explicit guidance on the magnitude of impact associated with verbal descriptors inevitably leads to inconsistent assessments. Assessors completing the questionnaire will tend to conflate their predictions of impact with value judgments of the importance of those impacts. It is possible that two or more assessors agree on the magnitude of impact on say amenity but enter entirely different responses because they hold different value judgments concerning the importance of public amenity and parkland.

Box 1: Categorisation of *Botrytis squamosa* (Onion Botrytis Leaf Blight).

In February 2011, a pest categorisation meeting was held to categorise *Botrytis squamosa* (Onion Botrytis Leaf Blight). The seven questions of the Pest Categorisation Questionnaire were answered as follows:

Question 1: c) No impacts to environment (0 points).
Question 2: c) No impacts to human health (0 points).
Question 3: c) No impacts to amenities (0 points).
Question 4: b) Moderate Impacts on Industry (10 points).
Question 5: b) Affect some trade partners (30 points).
Question 6: c) Expected to have small to no flow on effects to other industries (0 points).
Question 7: c) Pose no significant social adjustment costs to regional communities (0 points).

Responses imply no impact on public interests as it does not affect environment, health, amenity, or regional communities. The only impacts the pest is expected to have is a moderate direct impact on industry returns and a limited impact on trade. The impacts of the pest appear to more or less exclusively affect industry. The pest might therefore be expected to be categorised as a Category 4 pest.

The PCQ's simple summation of the points associated with responses to the seven questions leads to a total of 40 points, placing it as a Category 3 outcome. That is, it was deemed that there was a 50/50 split of public and private benefits for eradication of the pest, such that industry and government are expected to share the cost of eradication equally.

Figure 4 shows the categorisation of *Botrytis squamosa* using the decision tree. According to the decision tree the pest is not a Category 1 pest, because it has no major impacts on environment, health, or amenities. It is not a Category 2 pest because it will not cause major disruptions to trade, or major consequences for regional economies. It will however affect industries through increased control and production costs (direct industry impacts) and through moderate trade and market restrictions. Using the decision tree the pest is, therefore, either a Category 3 or Category 4 pest.

The final decision node in Figure 4 determines which of these Categories (3 or 4) will be the outcome. Although the pest was judged to have negligible impacts on public values (Questions 1, 2, 3 and 7), the meeting did recognise a non-trivial impact on trade. The protocol assumes this impact translates to substantial harm to regional communities, resulting in a Category 3 outcome.
Note that in the decision tree a 'moderate' impact on trade is included in the final two nodes. In one of these nodes it reflects an impact to industry, consistent with the judgment of the categorisation meeting. In the other, a moderate impact on trade implies an impact on public values - an assessment which was *inconsistent* with the judgment of the categorisation meeting. Ambiguity in the decision tree's treatment of trade impacts lead to *Botrytis squamosa* being categorised as a Category 3 pest (equal impacts to industry and public values) rather than a Category 4 pest (impacts more or less borne exclusively by industry).

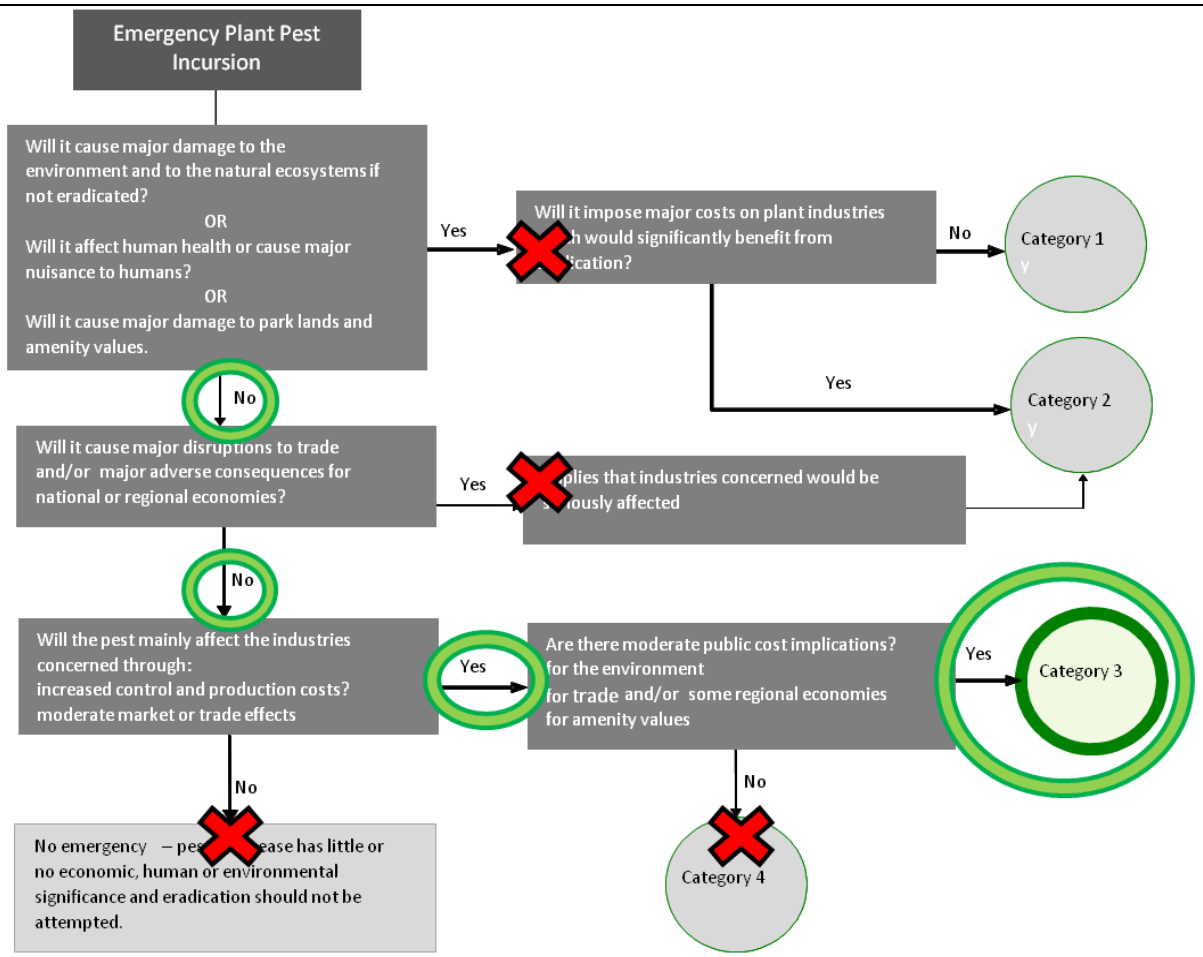


Figure 4. Categorisation of *Botrytis squamosa* using the PCQ decision tree.

For example, Assessor A may estimate a pest will lead to the loss of 250 km^2 of mature River Red Gum (*Eucalyptus camaldulensis*) woodland. Assessor A may characterise this as a 'major' impact on the environment because these trees are likely to be over 400 years old, they contain hollows for birds and other fauna, they mitigate soil salinity, stabilise rivers banks, provide food for numerous insects through abundant flowering and seed production, and provide habitat for ground dwelling fauna through production of litter and coarse woody debris. Assessor B may agree that 250 km^2 of mature woodland will be lost. However, they may rate the same impact as 'moderate' because River Red Gums are common and not threatened.

Keeney (2002) gives an example involving ranking the importance of impacts to the environment, health and the economy. In the absence of any contextual information specifying the magnitude of consequences, participants tended to rank health as the most important, followed by environment and then economic impacts. When told the consequences were equivalent to an impact on health resulting in a two day illness, an environmental impact equivalent to destroying 10 square miles of native vegetation, and economic impacts equivalent to $3 billion, respondents' rankings were reversed. Judgments of impact are seriously compromised if there is no explicit attempt to specify the magnitude of those impacts.

Given the structural problems with the current protocol, the points assigned to 'major', 'moderate' and 'minor' (Table 4) are somewhat arbitrary. However, if the structural problems were to be remedied, the allocation of say 1400 points to 'major' and 30 points to 'moderate' for environmental impact implies that major impacts are some 40-50 times greater than 'moderate' impacts. However, points assigned to each response in the PCQ are not visible to those charged with the responsibility of completing the questionnaire. They are left to make their own judgments concerning the difference in impact magnitude between 'major' and 'moderate', and 'moderate' and 'minor'.

Box 2. Should industry impacts be interpreted as relative or absolute costs under Question 4?

Any attempt to address the ambiguity in what is meant by 'minor', 'moderate' and 'major' needs to decide whether to use relative or absolute interpretations. Illustrative examples of the two interpretations are shown in the table below.

Impact descriptor	Relative interpretation	Absolute interpretation
Minor	<5% of industry value	<$5 million
Moderate	5 -25% of industry value	$5 - $50 million
Major	> 25% of industry value	> $50 million

Our view is that the characterisation of direct impacts on industry should use absolute estimates. Here we explain why.

Imagine two industries, one large and one relatively small. The large industry has a value of $200M and the other is valued at $50M. The large industry is threatened by Pest A. Should Pest A establish and spread it is expected to lead to a 10% decline in value (i.e. a ***moderate*** impact using the relative interpretation in the table above). The small industry is threatened by Pest B. It's also expected to lead to a (***moderate***) 10% decline in value.

For public values, Pests A and B are expected to have ***moderate*** impacts on the natural environment. A monetary value for environmental degradation is difficult to assign, but for the purposes of illustration let's say a coarse estimate of $20M has been made for both pests. Where both public and industry impacts are considered equal (in this case both are estimated to be 'moderate') then Category 3 is the appropriate outcome under a plain interpretation of the cost-sharing principle of the EPPRD. The relative interpretation works fine for Pest A. That is:

- public benefits = $20M, the same as
- private benefits = 10% of $200M = $20M.

But for Pest B relative interpretation suggests a different outcome. That is:

- Public benefits = $20M
- Private benefits = 10% of $50M = $5M.

Here, the *absolute* impact on industry leads to a ratio of public benefits to private benefits (4:1) consistent with Category 2, where industry meets only 20% of the costs. But if we interpret industry impact in a *relative* sense then the outcome is Category 3, where the small industry is asked to meet 50% of costs. Interpreting industry impacts in a relative sense rather than an absolute sense effectively discriminates against smaller industries.

4.0 Improving the Pest Categorisation Questionnaire

We propose four improvements to the PCQ:

1. Amend the decision tree.
2. Clearly align each question to either public impacts or private impacts.
3. Clarify the IF-THEN rules that define categories.
4. Clarify what is meant by verbal descriptors of impact, and assign points accordingly.

4.1 Decision tree

The decision tree underpinning the current protocol (Figure 1) conveys the impression that categorisation is largely about the relative impacts on public values, and less concerned with the ratio of public and private outcomes. In particular, the tree shows that even where industry impacts are estimated to be 'major' the private sector will be asked to pay no more than 20% of costs in circumstances where public impacts are also 'major'. A tree that better captures a plain interpretation of cost-sharing built on the idea that beneficiaries of the eradication of an emergency plant pest pay an appropriate and equitable proportion of the costs of mounting a response is shown in Figure 5.

We note that the decision tree in Figure 5 does *not* include an outcome of 'no emergency' for the circumstance where both public and private impacts are characterised as 'minor'. If impacts on the private sector are framed in absolute terms rather than relative terms, as advocated in Box 2, then the appropriate categorisation is Category 3 (50/50 cost-sharing), because 'minor' impacts can still be very substantial for smaller industries.

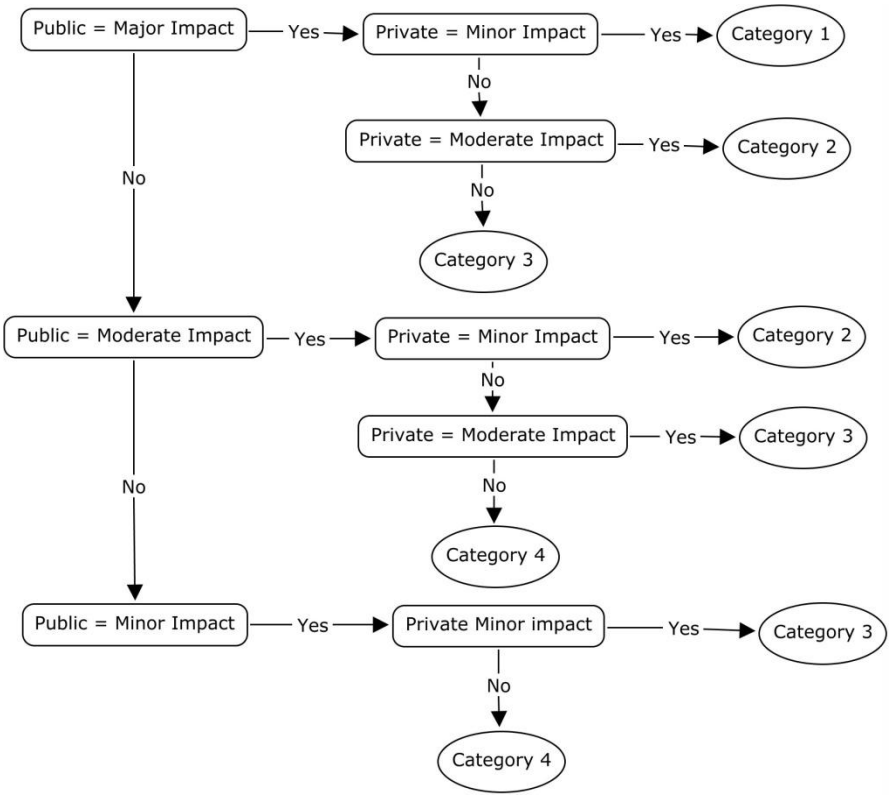


Figure 5. An improved decision tree that captures an understanding that cost-sharing is guided by the proportional predicted impacts on public and private sector values.

4.2 Alignment of questions

To avoid the problems associated with simple summation of points described in Section 3.2, we suggest points be tallied into two 'bins' corresponding to impacts on public values and impacts on industry. Questions (and their associated responses and points) should be clearly aligned with either public interests or private interests.

The current protocol is vague on the alignment of questions. Thirteen EPPRD stakeholders (see Appendix 3) were asked to specify whether each of the seven PCQ questions were relevant to public values, private values, or both. The results are shown in Figure 6. Note that considerable variation in responses is evident for Questions 4, 5, 6 and 7. Confusion surrounding the relevance of questions to public and private values encourages arbitrary uncertainty and error in categorisation.

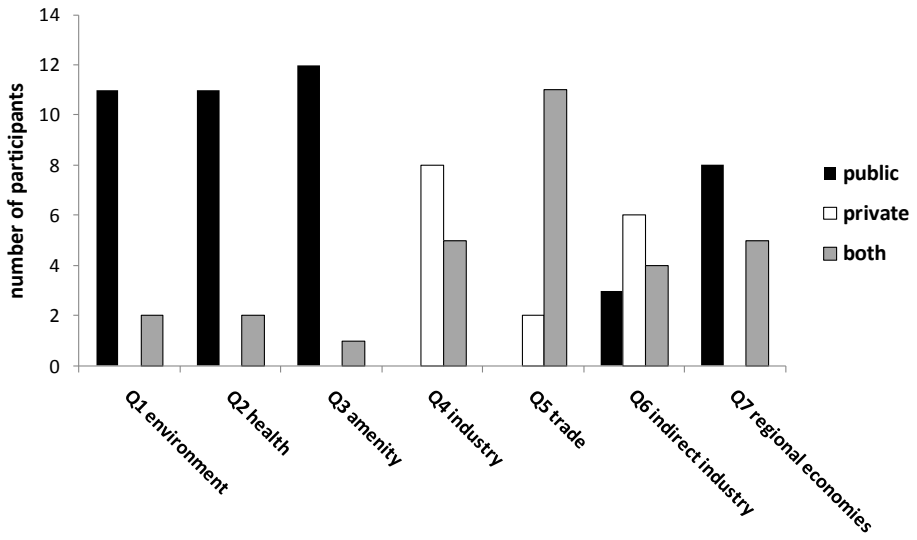


Figure 6. The perceptions of thirteen workshop participants regarding whether each of the seven questions currently included in the Pest Categorisation Questionnaire refer to impacts on public values, private interests, or both.

The inclusion of points for Question 5 is problematic because trade has implications for both public and private outcomes, and because it will result in double counting. Part of the confusion inherent in the question is a failure to distinguish means and ends. It is important to identify fundamental ends, especially when impacts are summed (Keeney 2002).

Figure 7 shows a cognitive map based on the Pest Categorisation Questionnaire. Questions 4, 5 and 6 essentially relate to means - we care about them because they influence an end of fundamental importance. There is no fundamental concern with trade restrictions in themselves, however, trade restrictions often lead to reduced capacity to export a commodity, which would lead to a loss of revenue for an industry or industry collapse. It may also lead to social costs through impacts on employment. Trade is a *means* for achieving the *fundamental* ends of maintaining industry

profitability and the viability of regional communities. Including means objectives in protocols that sum impacts generally leads to double counting or violation of the assumption of mutual preference independence (Keeney and von Winterfeldt 2007). We note that direct and indirect industry impacts are not a problem because they are additive means contributing to the fundamental end of overall industry impacts.

We suggest Question 5 be treated as a sub-question for both Questions 6 and 7. In doing so, we clarify the alignment of questions to private and public concerns:

Public	***Private***
Impacts on the environment (Q1)	Direct impacts on net returns to industry (Q4)
Impacts on human health and lifestyle (Q2)	Indirect impacts on net returns to industry (Q6)
Impacts on amenity (Q3)	
Impacts on regional communities (Q7)	

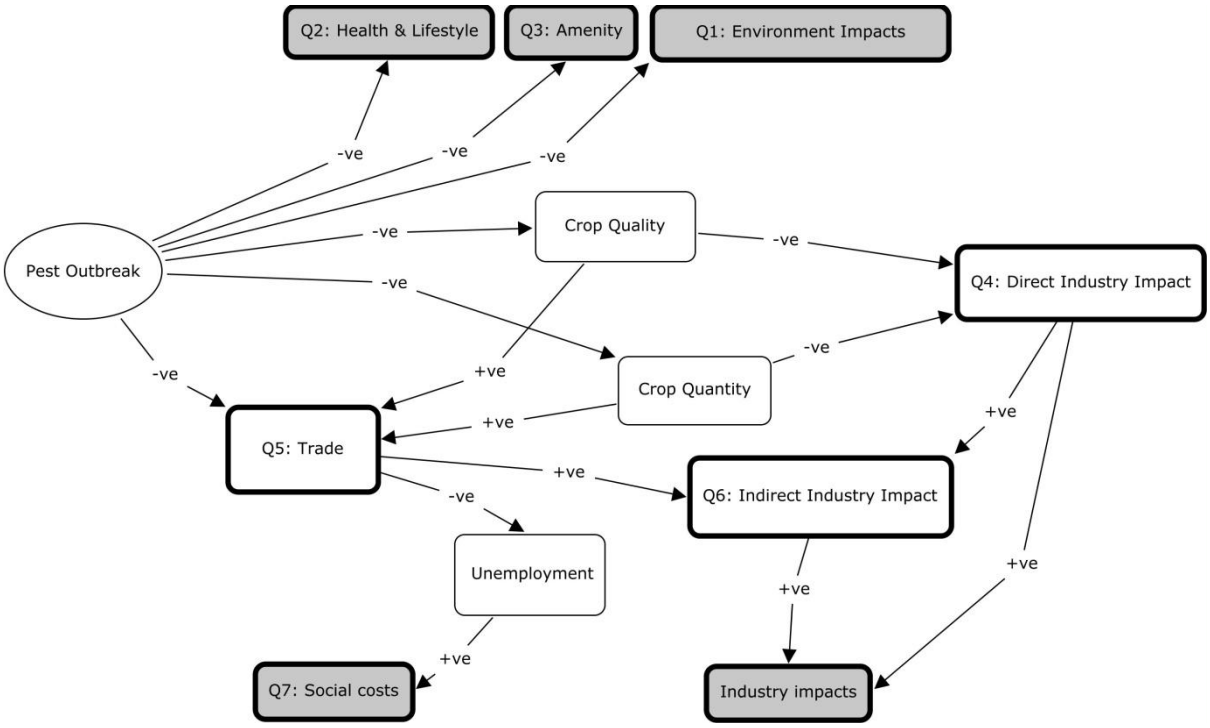


Figure 7. Cognitive map showing links between the seven questions (bold outlines) and fundamental public and private concerns (shaded grey). The map emphasises trade as a pathway for both public and private adverse outcomes. Question 5 is important for informing the response to Questions 6 and 7, but allocation of points to Question 5 will result in double-counting. Positive links indicate a direct relationship between parent and child nodes (as the parent's influence increases, so too does the child). Negative links indicate inverse relationships (as the parent increases the child decreases).

4.3 Clarify the IF-THEN rules that define categories

A more intuitive set of IF-THEN rules consistent with an understanding that cost-sharing arrangements should be proportional to the beneficiaries of successful eradication is suggested below (Table 8). Note that Table 8a restates the decision tree shown in Figure 5.

Table 8. IF-THEN rules consistent with an understanding that cost-sharing arrangements should be proportional to the beneficiaries of successful eradication.

Table 8a. Categorisation of public and private impacts

IF Public	AND Private	THEN Category
= minor	=minor	= 3
= minor	= moderate	= 4
= minor	= major	= 4
= moderate	= minor	= 1
= moderate	= moderate	= 3
= moderate	= major	= 4
= major	= minor	= 1
= major	= moderate	= 2
= major	= major	= 3

Table 8b. Characterisation of public impacts

IF	THEN Public
ANY of Q1, Q2, Q3 OR Q7 = major	= major
ANY two OR MORE of Q1, Q2, Q3 AND Q7 = moderate	= major
ALL of Q1, Q2, Q3 AND Q7 = minor	= minor
OTHERWISE	= moderate

Table 8c. Characterisation of private impacts

IF Direct impacts (Q4)	AND Indirect impacts (Q6)	THEN Private
= minor	= minor	= minor
= minor	= moderate	= moderate
= minor	= major	= major
= moderate	= minor	= moderate
= moderate	= moderate	= moderate
= moderate	= major	= major
= major	= minor	= major
= major	= moderate	= major
= major	= major	= major

4.4 Verbal descriptors

Currently Question 7 (regional communities) accommodates only a binary response – 'yes' or 'no'. We recommend that responses to Question 7 include 'major', moderate' and 'minor' so that its resolution is the same as all other questions.

There are no internal inconsistencies in the IF-THEN rules described in Table 8 if the following points are assigned to responses (Table 9).

Table 9. Suggested points assigned to revised PCQ responses.

Question	Major	Moderate	Minor
Q1 Environment	80	20	1
Q2 Health and lifestyle	80	20	1
Q3 Amenity	80	20	1
Q4 Direct industry returns	80	20	1
Q6 Indirect industry returns	80	20	1
Q7 Regional communities	80	20	1

As a coarse guideline verbal descriptors can be interpreted as

- Minor <$5M
- Moderate $5M - $100M
- Major >$100M

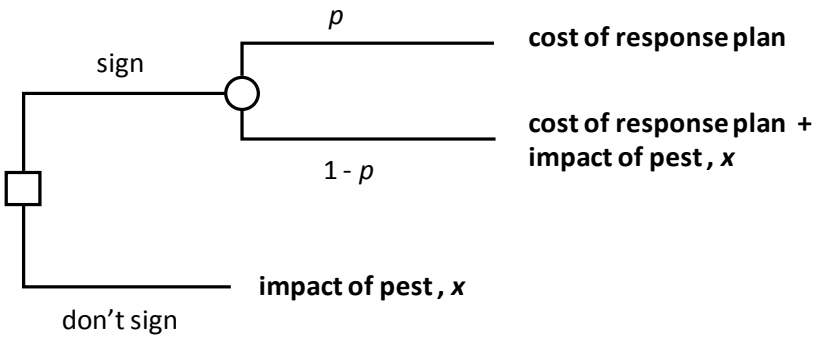
Although coarse, we recommend this guideline for interpretation be visible to participants as they complete the questionnaire.

These monetary guidelines are of limited use for non-market values. Appendix 4 outlines examples of monetary estimates for impacts on the environment, public health, amenity and regional communities.

Box 3. What is the monetary equivalent of a 'major' impact?

One approach to answering this question is to pose another: What magnitude of impact would motivate a plant industry to sign the EPPRD? Benefits of signing include (i) the (uncertain) prospect of successful eradication of pests, (ii) compensation for specific owner reimbursement costs associated with reporting an incident, and (iii) a formal role in decision-making about the nature and magnitude of a Response Plan. For the sake of simplicity, here we countenance only the prospect of successful eradication.

A decision to sign the Deed implies a belief the industry is better off than had it not signed (or at least no worse off). The decision can be formalised according to the logic tree below. On the left is a choice point, indicated by a square, where a decision-maker chooses a course of action (sign or don't sign). The lines trace outcomes arising from each choice. The uncertain event of whether or not a Response Plan will lead to successful eradication is indicated by a circle. While the outcomes are uncertain, we can ascribe a subjective estimate to the chance of things spilling one way or another. Plausible bounds for successful eradication might be p = 0.05 (one in twenty) to 0.10 (one in ten). At the end of each branch of the tree is a summary of consequences.



The *expected* consequences for signing the deed are
[p × cost of Response Plan] + [(1 – p) × (cost of Response Plan + impact of the pest, x)].
And the expected consequences for not signing the EPPRD equate simply to the expected impact of the pest, x.

The cost of a Response Plan is not fixed. However the EPPRD does define an 'Agreed Limit', beyond which agreement in writing is required (Appendix 1). The Agreed Limit is the lesser of 2% of the value of crops or $20 million. Assuming a cost of $20 million and a 50% contribution from industry (i.e. a $10M contribution under Category 3), we can determine a value for x under plausible values for p that makes the expected consequences of signing the EPPRD equivalent to the consequences of *not* signing the EPPRD.

When p = 0.10 the point of equivalence is x = $100M. When p = 0.05 it's $200M. That is, if an industry believes that the impact of higher risk pests will be less than $100M, they may be better off not signing the EPPRD, depending on their view of the prospects for successful eradication (and other benefits of signing).

We can roughly say that an impact of $100M is around the mark of when an impact can begin to be considered a 'major' impact for industry.

5.0 Towards consistent categorisation

5.1 A formal description of inconsistency

The weaknesses in the current protocol described in section 3 lead inevitably to inconsistent assessments. Table 10 provides an example of inconsistent categorisation. The assessment is inconsistent because Pest D is assigned a higher ranked category than Pest C, even though Pest C has a lesser private impact (and the same public impact). The categorisation makes the nonsensical assertion that government contribute more to the costs of a Response Plan for Pest D than for Pest C even though industry benefits more from the eradication of Pest D than Pest C.

Table 10. Hypothetical categorisation outcomes for five hypothetical pests.

	Public impact	Private impact	Category
Pest A	major	minor	C1
Pest B	major	moderate	C2
Pest C	moderate	moderate	C3
Pest D	moderate	major	C2
Pest E	minor	major	C4

One interpretation would be to say that Pest D is correctly categorised, implying that Pest C (and Pests A and B) can only be assigned Category 1 or Category 2. Another interpretation is that Pest C is correctly categorised. It logically follows that Pest D can be no higher than Category 3.

Alternative interpretations arising from inconsistent assessments can be formally described using dominance-based rough sets (Greco et al. 2002). The task of categorisation is a multi-attribute ordinal classification problem. That is, an ordinal classification (Category 1, 2, 3 or 4) is assigned on the basis of preference-ordered assessments of public and private impacts. The ordering of preferences depends on whether you are a government or industry stakeholder. Here we formulate the problem from the perspective of industry. The preference order of industry stakeholders for industry impacts is minor $\succ$ moderate $\succ$ major, where *x* $\succ$ *y* reads '*x* is preferred to *y*'. For public impacts it is major $\succ$ moderate $\succ$ minor. Government stakeholder preferences are the exact opposite.

Table 10 describes a universe *U* of five pests classified according to a decision attribute *d* (category) using a set *F* of two condition attributes (public and private impacts). The decision attribute *d* partitions $x \in U$ into $\boldsymbol{Cl} = \{Cl_1, \ldots, Cl_m\}$, such that each x belongs to one and only one preference-ordered class $Cl_t, t = 1, \ldots m.$ That is pests can only be categorised into one of m = 4 categories. For all $r, s = 1, \ldots, m$, $r > s$, so that Cl_r is preferred to Cl_s. For industry, the preference order is Category 1 $\succ$ Category 2 $\succ$ Category 3 $\succ$ Category 4.

Rough sets approximate the 'upward' union and 'downward' union of decision classes, respectively:

$$Cl_t^{\geq} = \bigcup_{s \geq t} Cl_s, \quad Cl_t^{\leq} = \bigcup_{s \leq t} Cl_s, \quad t = 1, \ldots m.$$

For example, the class $Cl_2^{\geq}$ contains all the pests that belong to at least Category 2 (i.e. Category 2 or Category 3 or Category 4). The class $Cl_2^{\leq}$ contains all the pests that belong at most to Category 2 (i.e. Category 1 or Category 2). Note that $Cl_1^{\geq} = Cl_m^{\leq} = U, Cl_m^{\geq} = Cl_m$ and $Cl_1^{\leq} = Cl_1$.

The structure of rough sets is defined by a dominance principle whereby x dominates y with respect to a set of attributes $P \subseteq F$ if x has evaluations at least as good as y on all P attributes. It follows that x should be assigned a decision class at least as good as y. Pest categorisations satisfying the dominance principle are *consistent*, and those violating it are *inconsistent*.

Inconsistent assessments lead to uncertainty in the set of objects that belong to class $Cl_t^{\geq}$. The *P*-lower approximation of $Cl_t^{\geq}$, denoted $\underline{P}Cl_t^{\geq}$, is the set of objects that *certainly* belong to $Cl_t^{\geq}$. Object (pest) x is *certain* to belong to $Cl_t^{\geq}$ in the sense that no other object in *U* contradicts this claim. That is, every other object that *P*-dominates x also belongs to the class union $Cl_t^{\geq}$. The *P*-upper approximation of $Cl_t^{\geq}$, denoted $\overline{P}Cl_t^{\geq}$, is the set of pests that *possibly* belong to $Cl_t^{\geq}$. Object x belongs to the upper approximation if there exists another object *P*-dominated by x from class union $Cl_t^{\geq}$. The same logic applies to the downward union of classes $Cl_t^{\leq}$. Lower and upper approximations for the categorisation example are shown in Table 11.

Table 11. Lower and upper approximations of unions of decision classes for the five pests categorised according to Table 10. (a) Downward union of classes; (b) upward union of classes.

(a)

Class	**Description**	**Certain** $\underline{P}Cl_t^{\leq}$	**Possible** $\overline{P}Cl_t^{\leq}$
$Cl_1^{\leq}$	The set of pests that belong to C1	A	A
$Cl_2^{\leq}$	The set of pests that belong to C1 or C2	A B	A B C D
$Cl_3^{\leq}$	The set of pests that belong to C1 or C2 or C3	A B C D	A B C D

(b)

Class	**Description**	**Certain** $\underline{P}Cl_t^{\geq}$	**Possible** $\overline{P}Cl_t^{\geq}$
$Cl_4^{\geq}$	The set of pests that belong to C4	E	E
$Cl_3^{\geq}$	The set of pests that belong to C3 or C4	E	C D E
$Cl_2^{\geq}$	The set of pests that belong to C2 or C3 or C4	B C D E	B C D E

The *P-boundaries* of $Cl_t^{\geq}$ and $Cl_t^{\leq}$, denoted $Bn_P(Cl_t^{\geq})$ and $Bn_P(Cl_t^{\leq})$, respectively, are defined as,

$$Bn_P(Cl_t^{\geq}) = \overline{P}Cl_t^{\geq} - \underline{P}Cl_t^{\geq}, \qquad t = 2, \dots m,$$

$$Bn_P(Cl_t^{\leq}) = \overline{P}Cl_t^{\leq} - \underline{P}Cl_t^{\leq}, \qquad t = 1, \dots m-1.$$

Note that $Bn_P(Cl_t^{\geq}) = Bn_P(Cl_{t-1}^{\leq}), for\ t = 2, \dots, m$

The *quality of approximation* of the entire classification $\boldsymbol{Cl}$ by a set of attributes *P* is defined as the ratio of the number of objects *P*-consistent with the dominance principle and the number of all the objects in *U*. *P*-consistent objects do not belong to any *P*-boundary $Bn_P(Cl_t^{\geq})$, *t* = 2, ...,*m*, or $Bn_P(Cl_t^{\leq})$, *t* = 1,..., *m* - 1. So the quality of approximation is,

$$\gamma_P(Cl) = \frac{|U - (\cup_{t=2\dots,m} Bn_P(Cl_t^{\geq}))|}{|U|} = \frac{|U - (\cup_{t=1\dots,m-1} Bn_P(Cl_t^{\leq}))|}{|U|}$$

For the classification example (Tables 10 and 11) the quality of approximation = 0.60. *U* comprises five pests. Using the downward union of classes, there are two pests (C and D) in $Bn_P(Cl_2^{\leq})$. For the upward union of classes, Pests C and D occur in $Bn_P(Cl_3^{\geq})$. In either case, the quality of approximation is simply (5-2)/5 = 0.60. Note that the quality of approximation is insensitive to whether we formulate the preference structure from the perspective of industry or government. We also note that when using the IF-THEN rules described in Table 8, the quality of approximation = 1.00.

5.2 Inconsistency among EPPRD stakeholders

Under ideal circumstances, the only source of disagreement among those charged with the responsibility of categorising pests would be epistemic uncertainty concerning predictions of the magnitude of impacts on clearly defined public and private values. The weaknesses in the PCQ protocol described in Section 3 introduce other sources of disagreement, including:

1. Language-based ambiguity associated with impact descriptors, 'major', 'moderate' and 'minor'.
2. Different value judgments concerning the relative importance of impacts on industry, environment, health, amenity and regional communities.
3. Different views on what is 'appropriate and equitable' cost-sharing (i.e. to what extent a *de-facto* subsidy should be maintained in the PCQ).

We explored the influence of these three elements in a workshop involving EPPRD stakeholders, held 7 – 8 April 2011 (see Appendix 3 for the list of participants). Two exercises were conducted, both involving five categorisation tasks per participant. A single categorisation task is shown in Table 12. Numerical descriptors of impact were provided for each of four public values (environment, health, amenity and regional economies) and two private interests (direct and indirect industry

impacts). After designating public and private impacts as 'major', 'moderate' or 'minor', participants then assigned a pest category. An example of the full questionnaire is shown in Appendix 5.

Table 12. Example of a categorisation task for a hypothetical pest.

Public Values	Impact	Magnitude (Please circle)
Q1. Environment (Hectares impacted)	**6,589**	Major / Moderate / Minor
Q2. Health (Patient Days)	**2,926**	Major / Moderate / Minor
Q3. Amenity (Park visits lost)	**217,394**	Major / Moderate / Minor
Q7. Regional Economies (Number of households relocated)	**22**	Major / Moderate / Minor
Overall Public Impact (please circle)	Major / Moderate / Minor	
Private Values	**Impact ($ million)**	**Magnitude (Please circle)**
Q4. Direct industry impacts	**57.36**	Major / Moderate / Minor
Q6. Indirect Industry Impacts	**82.08**	Major / Moderate / Minor
Overall Private Impact (please circle)	Major / Moderate / Minor	
Category (Please Circle)	**1 / 2 / 3 / 4**	

The impacts described in each categorisation task represent a hypothetical pest. To generate hypothetical pests, we sampled randomly from three strata for each attribute, corresponding to arbitrary demarcation of thresholds for 'minor', 'moderate' and 'major' (Table 13). For six attributes each having three levels there are $3^6 = 729$ possible combinations, or 729 potential hypothetical pests each having a unique impact profile. We combined random samples to create 13 participants × 5 tasks = 65 hypothetical pests, such that each of the four pest categories were represented in approximately equal numbers according to categorisation using the IF-THEN rules described in Table 8.

All participants were briefed on the weaknesses of the current PCQ protocol described above in section 3. We also provided contextual information for the numerical descriptors of impact associated with each of the six attributes (Appendix 6). Participants were unaware of the sampling scheme used to generate hypothetical pests and its arbitrary thresholds (Table 13).

Table 13. Stratification of the range of sampled impacts for the generation of hypothetical pests.

Attribute	Stratum 1	Stratum 2	Stratum 3
Environment (hectares)	<833	833 - 6,666	6,666 - 147,000,000
Health (sick days)	<4975	4,975 - 39,801	39,801 - 100,000
Amenity (picnic days)	< 263,158	2,105,263 – 263,518	2,105,263 - 10,000,000
Regional economies (households relocated)	<250	250 - 2,000	2,000 – 10,000
Industry ($ million)	<5	5 - 40	40 – 5,000
Indirect Industry ($ million)	<5	5 - 40	40 – 5,000

In Exercise 1, participants were free to use whatever thresholds and whatever informal IF-THEN reasoning rules for aggregating impacts they deemed appropriate. When the 13 × 5 = 65 categorisations were pooled the quality of approximation was 0.508. Inconsistency may have arisen from (a) variable value judgments concerning what constitutes a 'major', 'moderate' or 'minor' impact for each of the six questions (Figure 8), or through (b) variable value judgments around what constitutes an appropriate and equitable cost-sharing arrangement, or both. We emphasise that this striking inconsistency comes from value judgments alone. The uncertainty associated with technical predictions was completely removed by specifying the magnitude of impact for each of the six questions.

In Exercise 2, we tested for the specific contribution to inconsistency of value judgments around what constitutes an appropriate and equitable cost-sharing arrangement. Categorisation tasks were randomised among participants to avoid repetition of Exercise 1 hypothetical pests. We controlled for value judgments concerning what constitutes a 'major', 'moderate' or 'minor' impact for each of the six questions by insisting on use of the IF-THEN rules shown in Table 8. We provided three alternative scenarios for thresholds demarcating 'minor', 'moderate' and 'major' impacts (Appendix 7). The three scenarios varied in the extent to which they provided a *de-facto* subsidy to industry. Scenario 1 applied the same monetary thresholds to attributes describing public values and private interests. Participants that used Scenario 1 thresholds were essentially indicating a preference for no subsidy. Scenario 2 contained thresholds for public values that were 25% less than those for private interests, implying a relatively small subsidy. Scenario 3 contained thresholds for public values that were 50% less than those for private interests – a relatively large subsidy.

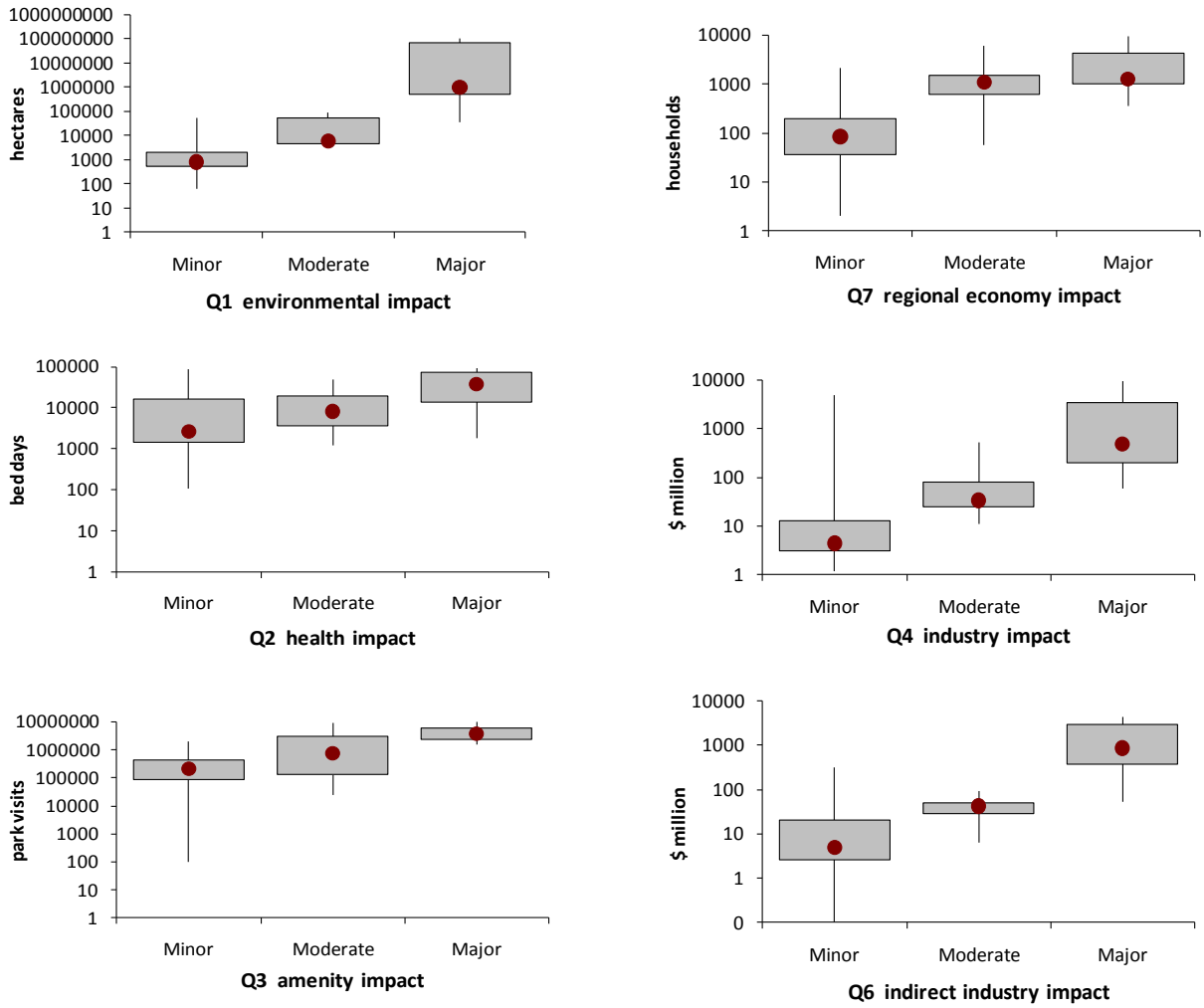


Figure 8. Ordinal classification of impacts by workshop participants in Exercise 1. Median judgments are indicated by a dot, the box shows the inter-quartile range, and whiskers indicate the full range of responses of the 13 participants.

The task for participants in Exercise 2 was less demanding than in Exercise 1. Each participant needed only to select a preferred subsidy scenario, assign ordinal classifications of impact ('major', 'moderate' or 'minor') on the basis of that selection, and then mechanically arrive at a pest category through use of the specified IF-THEN rules. In analyses, we retained respondents' ordinal classification impacts and discarded outcomes for pest category (note that results would be uninformative had we retained participants' categorisations because use of the IF-THEN rules shown in Table 8 provides a quality of approximation of 1.00, irrespective of which subsidy strategy, or mix of strategies is used). We identified the category of each of the 65 hypothetical pests under each of the three scenarios. Three calculations of the quality of approximation were computed, corresponding to categorisation outcomes for the three subsidy scenarios. In each case participants' ordinal descriptors of impact for the six attributes were held constant. Results for the quality of approximation were:

Scenario 1 0.815
Scenario 2 0.785
Scenario 3 0.738

All three results are a marked improvement on the quality of approximation of 0.508 obtained in Exercise 1. But substantial inconsistency remains. This suggests value judgments concerning (a) the importance of different attributes, and (b) what constitutes fair and appropriate cost-sharing, both contribute to inconsistent categorisation outcomes.

The higher value for Scenario 2 (relatively small subsidy) indicates it was the most commonly used by participants, although only marginally so. Detailed inspection of the responses of individuals was equivocal. Of four participants representing government, two used Scenario 1 (no subsidy) and two were indeterminate. Of the five participants from industry, three used Scenario 3 (relatively large subsidy), one used Scenario 2 (small subsidy) and one was indeterminate. There were an additional four participants representing Plant Health Australia. Two used Scenario 2, one used Scenario 3, and one used either (or both) Scenario 1 or 2.

6.0 Discussion

ACERA (2010) identified six common mistakes in current biosecurity decision support protocols:

1. Vague use of language;
2. Vague formulation of the decision problem;
3. Confusing means and ends objectives;
4. Assigning arbitrary value judgements (or avoiding value judgements altogether);
5. Failure to include uncertainty; and
6. Poor estimation of likelihood in the prediction of expected consequences.

Mistakes 1 – 5 are clearly evident in the current PCQ. Mistake 6 is irrelevant because the characterisation of expected consequences for the purposes of categorisation assumes a pest's successful entry, establishment and spread.

Vague use of language

Language-based ambiguity is an arbitrary source of uncertainty (Regan et al. 2002). You cannot make value trade-offs without being aware of the consequences that are being considered, and without having some kind of measure for the consequences (Keeney 2002). The pest categorisation asks people to define perceived impacts of a pest as 'major', 'moderate' or 'minor' with no specification of the magnitude of these effects. The ambiguous nature of these descriptors invites confusion between technical predictions of impact and personal value judgments of the importance of those impacts.

To more effectively support categorisation the separate tasks of making predictions and articulating preferences need to be disentangled. The PCQ could be substantially improved by simply defining

the magnitude of impact meant by the terms 'major', 'moderate' and 'minor' in the various contexts in which they are used in the decision tree designed to guide cost-sharing arrangements. Wherever possible, direct, measurable and understandable attributes should be used to describe expected consequences against each objective or criterion (Keeney and Gregory 2005).

Vague formulation of the decision problem

The basis of cost-sharing under the EPPRD is that *beneficiaries of the eradication of an EPP pay an appropriate and equitable proportion of the costs of mounting a response* (PHA 2011). The supposed aim of the PCQ is to characterise the relative public and private impacts of a plant pest, so that the pest can be categorised into one of the four cost-sharing arrangements. However, elements of the decision tree and point scoring procedure encourage a contrary interpretation of cost-sharing, whereby government pays according to the magnitude of impacts on public values, irrespective of impact on private interests. The broad structure of the protocol and the way in which points are aggregated need to faithfully and consistently apply the cost-sharing principle articulated in the EPPRD.

Confusing means and ends objectives

Reduced trade has important implications for both public and private interests. Adverse impacts on trade leads to reduced profitability for the private sector, which translates to lesser investment in labour and capital, which then erodes the viability of regional economies and communities. We implicitly seek to maintain healthy trade because it is a means to the fundamental ends of industry profitability and community vitality. However, respondents to the PCQ might legitimately be confused by the inclusion of Question 5 concerning trade impacts. It is unclear how their assessment informs the characterisation of impacts on public and private interests. In any case means objectives should not be included in any decision-support protocol that sums impacts. To do so invites double-counting and violation of the assumption of mutual preference independence (Keeney and von Winterfeldt 2007).

Assigning arbitrary value judgements (or avoiding value judgements altogether)

The weights or points assigned to questions should reflect the value-judgments of decision-makers. These judgments should be sensitive to the range of consequences specific to the particular decision context, not just the importance of objectives, free of context. Where consequences are not explicitly described (such as in the PCQ's ambiguous descriptors of 'major', 'moderate' and minor') the weights are essentially arbitrary.

Failure to include uncertainty.

Detailed treatment of uncertainty in the PCQ is beyond the scope of this report. However, we note that all the questions in the PCQ require crisp ordinal or categorical responses (e.g. major/moderate/minor responses in Questions 1, 2, and 3, and the yes/no response required by Question 7). As highlighted above, the categories suffer from language-based ambiguities, but even if these were to be resolved there will be borderline cases. People will hold degrees of belief (rather than absolute beliefs) in the extent to which a species falls into one or more categories of response. For example, an assessor may believe a pest will have a major health effect with 60% confidence, or

it may be a moderate impact with 40% confidence. Because the PCQ fails to incorporate this uncertainty, the assessor is likely to state that the impact of the pest on health will be 'major', with no place to report their belief that there is a 40% chance that the effect may be 'moderate'.

These weaknesses can be substantially remedied through implementation of the recommendations in Section 4 of this report. The recommendations do not resolve the critical question of the extent to which a de-facto subsidy should be maintained in the PCQ, explored in Section 5. Negotiation is required to calibrate value judgments among key stakeholders regarding what is meant by 'major', 'moderate' and 'minor' impacts for public and private interests. Calibration will provide clarity on the extent to which public and private beneficiaries of eradication are required to pay.

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Appendix 1
Cost-sharing arrangements under the EPPRD

Cost-sharing among governments

Regardless of which of the four categories a pest is placed, a minimum of 20 percent of the costs of pest control is met by government. The government share is split between the Commonwealth government and the affected State and Territory governments. Part 1 of Schedule 6 of the EPPRD stipulates the Commonwealth government will always contribute 50 percent of the government share, whilst the remaining 50 percent is split among the affected state and territory governments. For Category 1 pests (where the impacts are more or less exclusively on public values) the cost borne by an individual State or Territory is proportional to its human population size. For pests in Categories from 2 - 4, costs are split proportional to the three year average of Local Value of Production for affected crops.

Cost-sharing among industries

Part 2, of Schedule 6 of the EPPRD shows the agreed cost-sharing arrangements for industry where a pest is expected to affect more than one crop or more than one industry. It is typically dependent on the proportional impact that pest is expected to have on the industry, adjusted for the size of the industry.

Cost-sharing for an uncategorised pest

Many of the pests listed under the EPPRD have not yet established in Australia, and are categorised to ensure that if and there is an incursion it has already been agreed as to who will pay the costs of the management of the pest. In some instances a new pest which has not yet been categorised may enter. In this case the EPPRD sets out that it is to be classified as a Category 3 pest (50:50 cost-sharing between affected industry and government) until it can be formally categorised. If the categorisation process declares it to be re-categorised into one of the other three categories, then the cost-sharing arrangements will change effective of that date.

Industries which are not signatories

The EPPRD cost-sharing program covers all signatories. Currently, in the case that a cropping sector has a gross LVP less than $20 million dollars and is not represented by a signatory industry party, Commonwealth and State / Territory governments may eradicate the pest if it is economically feasible (PHA 2011). Cropping sectors with a LVP more than $20 million dollars not represented by an industry party signatory to the EPPRD, are not covered under the cost-sharing agreement.

Funding requirements

As part of the EPPRD there is an agreed limit to how much will be eligible for cost-sharing under a Response Plan. Where there is only one affected industry party, the Agreed Limit which will apply to that Response Plan will be the lesser of (PHA 2011):

- 2% of the LVP of the Crop(s) represented by the Affected Industry Party; or
- 2% of the LVP of the Affected sub-group(s) of Crops; or
- $20 million; or
- The amount set out in Schedule 14 by the Operative Date or the amount:
    - Nominated to Plant Health Australia in writing by the Affected Party in respect of the relevant Crop(s); and
    - Approved by the general meeting of members of Plant Health Australia.

For Cost-sharing in respect of a Response Plan where there is more than one Industry Party which is an Affected Party, the Agreed Limit which applies to the Response Plan will be (PHA 2011):

- 1% of the sum of the LVPs of the Crops represented by the Affected Industry Parties; or
- 1% of the sum of the LVP of the Crops represented by the Affected Industry Parties, but only using the LVP of the relevant sub-group(s) where applicable.

The Agreed Limit cannot be exceeded unless agreed in writing by all Affected Parties. If a response plan reaches 90% of the Agreed Limit then the National Management Group (NMG) must meet to consider whether the Agreed Limit should be revised.

Each industry nominated under a cost-sharing arrangement must initially meet its own costs for implementing a Response Plan. Where an industry is not able to meet its cost-sharing obligations, the Commonwealth will initially meet its cost-sharing obligations. Each industry party is then expected to meet its cost-sharing obligations with the Commonwealth (Clause 10, Schedule 7, APH 2011 b).

The EPPRD also clearly defines what can and cannot be claimed as part of the cost-sharing agreement, this includes salaries and wages, operating costs, capital costs, owner reimbursement costs, and estimated consequential losses (see PHA(2011), Part 4 of Schedule 6 for more information).

Cost-sharing continues until the NMG make the decision for it to cease. Cessation of the response program usually occurs when eradication has been achieved, or when it is no longer technically or economically feasible (PHA 2010 b). If eradication has not been achieved additional costs from that point forward for long term management of the pest are not subject to the cost-sharing agreement.

Appendix 2
Membership of the Categorisation Group

As a minimum the Categorisation Group will comprise:

a) An independent chair from Plant Health Australia;

b) one standing member representing Industry Parties nominated by the Board of Plant Health Australia;-

c) technical experts (people with specific expertise in the relevant areas of plant pathology or entomology), 1 nominated by the Commonwealth, 1 nominated by the States and Territories, and 1 nominated by the Industry Party(s);

d) a person with relevant economic expertise, including in social, trade and regional and national impact assessment nominated by the Chairman of Plant Health Australia; and

e) a nominee from each Industry Party Affected by the EPP being categorised.

Appendix 3

Participants at a workshop held 7 – 8 April 2011

Amy Forbes, Plant Health Australia
Andrew Bishop, Tasmanian Department of Primary Industries, Parks, Water and Environment
Nicole Bresolin, Plant Health Australia
Pat Barkley, Citrus Australia
Tony Battaglene, Wine Makers Federation of Australia
John McDonald, Nursery and Garden Industry
Rod Turner (Friday only), Plant Health Australia
John Hannay, South Australian Department of Primary Industries and Resources
Mike Cole, Commonwealth Department of Agriculture Fisheries and Forestry
Greg Kauter, Cotton Australia
Sharyn Taylor, Plant Health Australia
Joanne Thomas-Ward, Onions Australia
Kristopher Morey , Australian Bureau of Agricultural and Resource Economics and Sciences
Monica Staines (Thursday only), Commonwealth Department of Agriculture Fisheries and Forestry

As a coarse guideline Section 4.4 suggested verbal descriptors be interpreted as

- Minor <$5M
- Moderate $5M - $100M
- Major >$100M

Here we (a) briefly outline alternative methods for valuation of non-market impacts on the natural environment, health, amenity and regional communities, and (b) summarise their implications for the description of 'minor', 'moderate' and 'major' impacts.

Environment

Among other things, impact on the environment may be characterised in terms of native vegetation loss or species extinction risk.

Vegetation

Option 1 - Quality adjusted hectares

For degraded native vegetation in Victoria, a 'habitat hectare' seeks to estimate the areal equivalent of 1 ha of high quality habitat (DNRE 2002). The median price of a single Habitat Hectare between May 2006, and December 2010 was approximately $138,000 (FigureA2.1). Most native vegetation in Victoria is deemed to be of 70% quality (DSE 2007). A benchmark value per hectare would be $138,000 × 0.7 ≈ **$96,000 per hectare.**

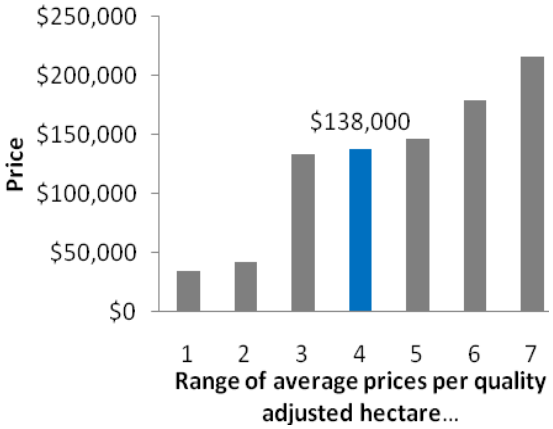

Figure A2.1 Median price of a quality adjusted hectare based on average prices obtained from market transactions (DSE 2010).

Option 2 - Cost to restore the land

Restoration of native vegetation is estimated to cost between $2,000 and $10,000 per hectare. Median cost of restoration is **$6,000 per hectare** (Schimer and Field, 2000).

Option 3 - The cost to buy land under the reserve system

The median price to acquire land for conservation reserves by four conservation agencies (Trust for Nature, Australian Wildlife Conservancy, Bush Heritage Australia, Tasmanian Land Conservancy) over 28 properties across Australia was approximately **$126 per hectare** (DSEWPaC 2011 a,b,c and d)**.**

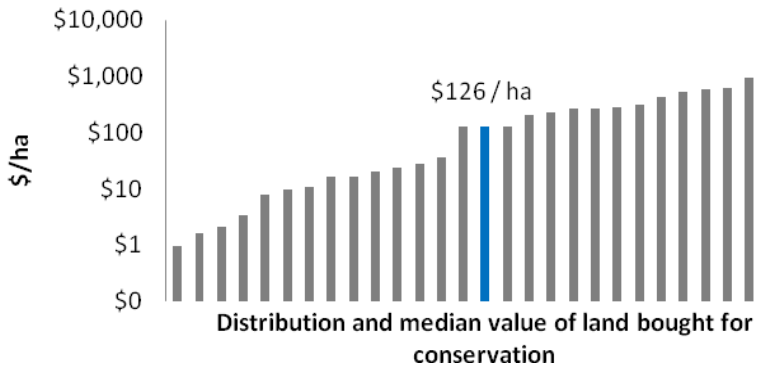

Figure A2.2 Median price of land bought for conservation purposes by four conservation agencies displayed on a logarithmic scale (DSEWPaC 2011a, b, c and d).

Table A2.1 Defining a magnitude of impact using different valuations of native vegetation.

	Option 1 ($96,000 / ha)	**Option 2** ($6,000 / ha)	**Option 3** ($126 / ha)
Major	> 1,042 ha	> 16,667 ha	> 793,651 ha
Moderate	52 – 1,042 ha	833 – 16,667 ha	39,682 – 793,651 ha
Minor	< 52 ha	< 833 ha	< 39,682 ha

Table A2.2 Examples of how different impacts might be categorised given different valuations for native vegetation.

Permanent loss	**Option 1** ($96,000 / ha)	**Option 2** ($6,000 / ha)	**Option 3** ($126 / ha)
Kakadu National Park (2 million ha)	$192,000 million	$ 12,000 million	$252 million
260,000 hectares across Australia[1]	$24,960 million	$1,560 million	$ 32.76 million
Wilson's Promontory (50,000 ha)	$4,800 million	$300 million	$6.3 million
50% defoliation			
Kakadu National Park (2 million ha)	$96,000 million	$ 6,000 million	$ 126 million
260,000 hectares across Australia	$12,480 million	$780 million	$16.38 million
Wilson's Promontory (50,000 ha)	$ 2,400 million	$ 150 million	$ 3.15 million
5% defoliation			
Kakadu National Park (2 million ha)	$9,600 million	$600 million	$12.6 million
260,000 hectares across Australia	$1,248 million	$78 million	$1.64 million
Wilson's Promontory (50,000 ha)	$240 million	$15 million	$ 0.315 million

[1] Estimated amount of native vegetation removed annually in Australia (ABS 2010)

Threatened species

Option 1: Money spent on species recovery plans.
Table A2.3 shows the money spent on recovery plans for 30 randomly selected species listed under the Commonwealth *Environment Protection and Biodiversity Conservation* Act 1999 (15 fauna and 15 flora species)(DSEWPaC 2011e). Each recovery plan seeks to reverse the decline of a species. The median value spent on a recovery plan of a species was $530,000 over a five year period.

For flora species the median value was $353,000 and ranged from $160,000 for the Wyalkatchem Foxglove to $1,300,000 for the Wollemi Pine. For fauna the median value was higher at $1,200,000 per species, with a lower bound of $40,000 for the Blue Mountains Water Skink and an upper bound of $31,000,000 for the Murray Cod.

Table A2.3 Money spent on five year recovery plans for 30 EPBC listed Flora and Fauna species.

	Median	**Lowest**	**Highest**
Flora	$353,000	$160,000	$1,300,000
Fauna	$1,200,000	$40,000	$31,000,000
Flora and fauna	$530,000	$40,000	$31,000,000

Option 2: Contingent Valuation
Jakobsson and Dragun (2001) used contingent valuation to elicit from households in Victoria how much should be paid for the conservation of the 'charismatic' species, Leadbeater's possum, as well as how much should be paid for the conservation of 700 other state threatened species.

The study indicated the conservation value of Leadbeater's possum was in the order of $40-$84 million dollars per year. Participants indicated a median value of approximately $250 million should be spent per year on the 700 species, equivalent to about $355,000 per year per threatened species, or approximately $1.75 million per species over 5 years (Table A2.4).

Table A2.4 Estimated value of a threatened species (Source: Jakobsson and Dragun 2001).

	$ million / year	$ million / 5 years
1 threatened species	$0.355	$1.75
1 charismatic threatened species	$60	$300

Table A2.5 The number of threatened species equating to 'major', moderate' and 'minor' impacts using three alternative valuations.

	Option A	Option B		Option C	
	Any ($530k/sp)	Flora ($353k/sp)	Fauna ($1.2m/sp)	Plain ($1.75m/sp)	Charismatic ($300m/sp)
Major	≥ 189	> 283	> 83	> 57	1
Moderate	10 – 189	15 – 283	5 - 83	> 3 - 57	na
Minor	0 - 9	0 - 14	0 -4	0 - 3	0

Table A2.6 Examples of how extinction threat for different types and groups of species might be categorised using different valuation techniques. Amounts are AU$ millions.

	Option A	Option B	Option C
Murray Cod (Charismatic Fauna species)	$0.53	$1.2	$300
Blue Mountains Water Skink (Non-charismatic fauna species)	$0.53	$1.2	$1.75
Wollemi Pine (Charismatic Flora species)	$0.53	$0.353	$300
Swamp Wallaby Grass (Non-charismatic Flora species)	$0.53	$0.353	$1.75
All four of the above species	$2.12	$3.106	$603.5
5 plain plant species and 5 plain fauna species	$5.3	$7.765	$17.5

Health

The willingness of people to pay for their health is coarsely revealed by the cost of hospitalisation and insurance payouts.

Sick days

The daily cost of a bed is estimated to be $1005 per day (Graves *et al* 2009),

Hospital visits

The average length of hospital visits in 2005 was seven days (AIHW 2007). Assuming the daily cost of a bed is $1005 per day (Graves *et al* 2009), the cost of the average visit **$7035.**

Permanent disability and death

Serious disability is costed at per person of **$266,376** per person based on the median maximum compensation amount payable for an injury at work under work cover (Figure A2.3).

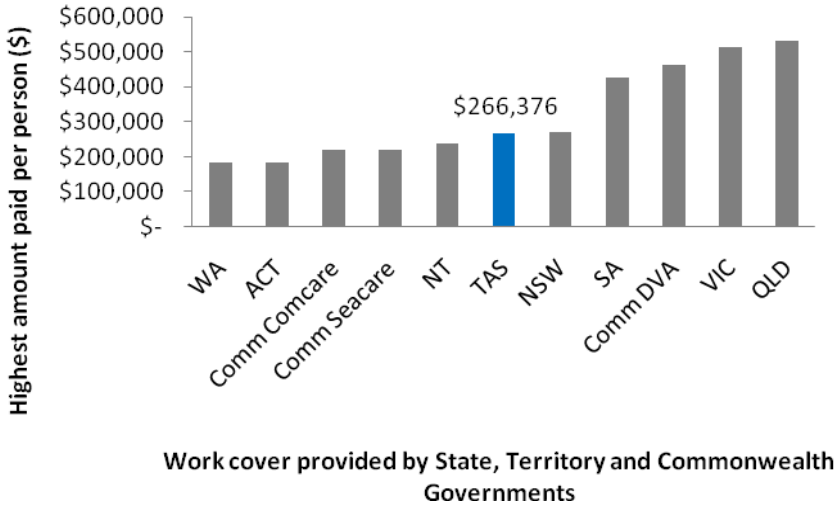

Figure A2.3 Value of payout for permanent disability or injury provided under WorkCover agreements across different State, Territory, and Commonwealth Governments. (Note DVA refers to the Commonwealth Department of Veteran Affairs). Source: SWA (2011).

Based on work cover compensation for death across various State, Territory, and Commonwealth governments across Australia, an estimate of the cost of a death is **$447,692** (Figure A2.4).

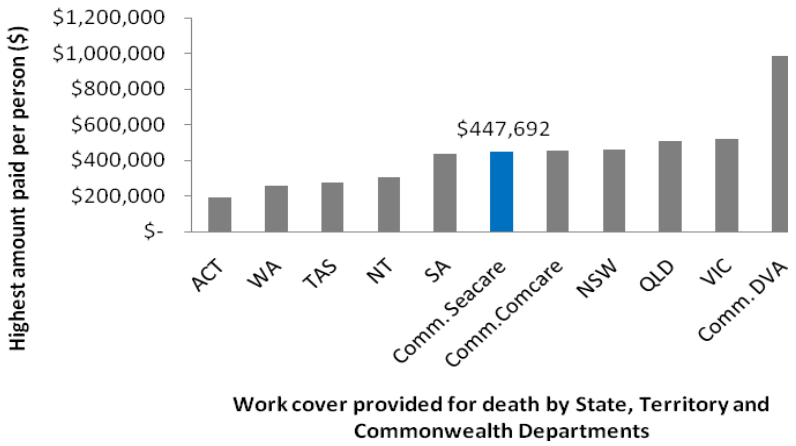

Figure A2.4 The median value provided for a death by WorkCover, across Australia.

Table A2.7 The cost of being sick as reported for hospital bed days, average length of stay in a hospital, the amount awarded for permanent disability or death under work place cover.

	Sick days ($1,005 per hospital bed day)	Hospital visits ($7, 035 per average visit)	Permanent disabilities ($266,376 per person)	Deaths ($447,692 per person)
Major	>99,502	>14,215	>375	> 223
Moderate	4,975 – 99,502	711 - 14,215	19 - 375	11 - 223
Minor	< 4,975	< 711	< 19	< 11

Example: Bee stings cause two deaths per year in Australia. This impact would be considered minor. However people may have non-fatal health impacts from bees such as sick days, and hospitalisations.

Amenity

Amenity encompasses an enormous range of considerations. Here we briefly look at two elements – street trees and park-based recreation.

Street trees

The value placed on street trees varies substantially. The City of Glen Eira in metropolitan Melbourne estimates a tree costs **$4,000** to replace (City of Glen Eira 2007).

Table A2.8 The number of street trees equating to 'major', moderate' and 'minor' impacts assuming a single tree is valued at $4,000

Major	> 25,000
Moderate	1,250 – 25,000
Minor	< 1,250

Example: Melbourne has approximately 6,000 elm trees. If these had to be replaced then this would be a moderate impact (6,000 × $4,000 = $24 million).

Park-based recreation

Sturgess (2003) used the travel cost contingent valuation method to arrive at an estimate of **$19 per person per day** for the recreational value of non-metropolitan parks in Victoria. Blackwell (2007) estimated a similar value of $17.74 for beach visits.

Table A2.9 The number of recreation days equating to 'major', moderate' and 'minor' impacts based on a valuation of $19 for the average price paid per person per visit to Victoria's parks.

Major	> 5,263,158 days
Moderate	263, 158 - 5,263,158 days
Minor	<263,158 days

Example: Canberra has approximately 330,000 residents. Let's say that each resident visits a park 6 times a year, on average. If a pest meant that all residents could not access parks for an entire year, the impact would be moderate (330,000 × 6 × $19 = $37.62 million). If access was restricted beyond a year, the impact would be 'major'.

Regional communities

Government assistance packages provide a coarse estimate of the value placed on the viability of regional communities. Examples include packages available to farmers for adaptation to climate change and structural adjustment of the forest industry following withdrawal of resource access.

Retraining

The Commonwealth Government makes $10,000 available for retraining to farmers that leave the farm because of economic hardship brought about by exceptional circumstances (Centrelink 2010). The New South Wales government also made $10,000 available to forest workers for retraining through the NSW River Red Gum Structural Adjustment Package (DII NSW 2010).

Relocation

Under the NSW River Red Gum Structural Adjustment Package, workers forced to relocate may receive $20,000 (DII NSW 2010).

Redundancy payout

Under the NSW River Red Gum Structural Adjustment Package, forest workers forced to change career received $91,360 (DII NSW 2010).

Table A2.10 The estimated cost of various impacts on employment.

	Retraining ($10,000 per person)	Relocate ($20,000 per worker)	Redundancy payouts ($91,360 per person)
Major	> 10000 people	> 5,000 households	> 1,095 people
Moderate	500 – 10,000 people	250 - 5,000 households	54 – 1,095 people
Minor	< 500 people	< 250 households	< 54 people

Table A2.11 Examples of the cost of various impacts on employment.

Impact type	Quantification of impact	Potential cost	Magnitude of impact
Retraining of workers	100 workers require assistance to be retrained	$1.0 million	Minor
Relocating households	100 households forced to relocate	$2.0 million	Minor
Retrenchment of workers (no potential for relocation or training)	100 workers made redundant and limited prospects of finding employment through retraining or relocating	$9.1 million	Moderate

Source material for Appendix 4

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Appendix 5

Example questionnaire for Exercises 1 and 2

'Code' Name: _____

Example Pest A:

Public Values	Impact	Magnitude (Please circle)
Q1. Environment (Hectares impacted)	**None**	Major / Moderate / Minor
Q2. Health (Patient Days)	**None**	Major / Moderate / Minor
Q3. Amenity (Park visits lost)	**None**	Major / Moderate / Minor
Q7. Regional Economies (Number of households relocated)	**None**	Major / Moderate / Minor
Overall Public Impact (please circle)	Major / Moderate / Minor	
Private Values	**Impact**	**Magnitude (Please circle)**
Q4. Direct industry impacts ($ AUD)	**$ 10 Billion**	Major / Moderate / Minor
Q6. Indirect Industry Impacts ($ AUD)	**$10 Billion**	Major / Moderate / Minor
Overall Private Impact (please circle)	Major / Moderate / Minor	
Category (Please Circle)	**1 / 2 / 3 / 4**	

Example Pest B:

Public Values	Impact	Magnitude (Please circle)
Q1. Environment (Hectares impacted)	**670 million**	Major / Moderate / Minor
Q2. Health (Patient Days)	**5.6 million**	Major / Moderate / Minor
Q3. Amenity (Park visits lost)	**74 million**	Major / Moderate / Minor
Q7. Regional Economies (Number of households relocated)	**780,000**	Major / Moderate / Minor
Overall Public Impact (please circle)	Major / Moderate / Minor	
Private Values	**Impact**	**Magnitude (Please circle)**
Q4. Direct industry impacts ($ AUD)	**$10,000**	Major / Moderate / Minor
Q6. Indirect Industry Impacts ($ AUD)	**$0**	Major / Moderate / Minor
Overall Private Impact (please circle)	Major / Moderate / Minor	
Category (Please Circle)	**1 / 2 / 3 / 4**	

Using the examples above to gauge the range of possible impacts, please assign a cost-sharing arrangement to the following five hypothetical pests.

Pest 1:

Public Values	Impact	Magnitude (Please circle)
Q1. Environment (Hectares impacted)	**6,589**	Major / Moderate / Minor
Q2. Health (Patient Days)	**2,926**	Major / Moderate / Minor
Q3. Amenity (Park visits lost)	**217,394**	Major / Moderate / Minor
Q7. Regional Economies (Number of households relocated)	**22**	Major / Moderate / Minor
Overall Public Impact (please circle)	Major / Moderate / Minor	
Private Values	**Impact ($ million)**	**Magnitude (Please circle)**
Q4. Direct industry impacts	**57.36**	Major / Moderate / Minor
Q6. Indirect Industry Impacts	**82.08**	Major / Moderate / Minor
Overall Private Impact (please circle)	Major / Moderate / Minor	
Category (Please Circle)	**1 / 2 / 3 / 4**	

Pest 2:

Public Values	Impact	Magnitude (Please circle)
Q1. Environment (Hectares impacted)	**846**	Major / Moderate / Minor
Q2. Health (Patient Days)	**1,997**	Major / Moderate / Minor
Q3. Amenity (Park visits lost)	**208,292**	Major / Moderate / Minor
Q7. Regional Economies (Number of households relocated)	**443**	Major / Moderate / Minor
Overall Public Impact (please circle)	Major / Moderate / Minor	
Private Values	**Impact ($ million)**	**Magnitude (Please circle)**
Q4. Direct industry impacts	**78.81**	Major / Moderate / Minor
Q6. Indirect Industry Impacts	**17.32**	Major / Moderate / Minor
Overall Private Impact (please circle)	Major / Moderate / Minor	
Category (Please Circle)	**1 / 2 / 3 / 4**	

Pest 3:

Public Values	Impact	Magnitude (Please circle)
Q1. Environment (Hectares impacted)	**470**	Major / Moderate / Minor
Q2. Health (Patient Days)	**2,131**	Major / Moderate / Minor
Q3. Amenity (Park visits lost)	**104,406**	Major / Moderate / Minor
Q7. Regional Economies (Number of households relocated)	**634**	Major / Moderate / Minor
Overall Public Impact (please circle)	Major / Moderate / Minor	
Private Values	**Impact ($ million)**	**Magnitude (Please circle)**
Q4. Direct industry impacts	**26.74**	Major / Moderate / Minor
Q6. Indirect Industry Impacts	**51.13**	Major / Moderate / Minor
Overall Private Impact (please circle)	Major / Moderate / Minor	
Category (Please Circle)	**1 / 2 / 3 / 4**	

Pest 4:

Public Values	Impact	Magnitude (Please circle)
Q1. Environment (Hectares impacted)	**3,697**	Major / Moderate / Minor
Q2. Health (Patient Days)	**96,470**	Major / Moderate / Minor
Q3. Amenity (Park visits lost)	**1,658,478**	Major / Moderate / Minor
Q7. Regional Economies (Number of households relocated)	**7,012**	Major / Moderate / Minor
Overall Public Impact (please circle)	Major / Moderate / Minor	
Private Values	**Impact ($ million)**	**Magnitude (Please circle)**
Q4. Direct industry impacts	**515.08**	Major / Moderate / Minor
Q6. Indirect Industry Impacts	**96.46**	Major / Moderate / Minor
Overall Private Impact (please circle)	Major / Moderate / Minor	
Category (Please Circle)	**1 / 2 / 3 / 4**	

Pest 5:

Public Values	Impact	Magnitude (Please circle)
Q1. Environment (Hectares impacted)	**820**	Major / Moderate / Minor
Q2. Health (Patient Days)	**19,873**	Major / Moderate / Minor
Q3. Amenity (Park visits lost)	**8,719,289**	Major / Moderate / Minor
Q7. Regional Economies (Number of households relocated)	**179**	Major / Moderate / Minor
Overall Public Impact (please circle)	Major / Moderate / Minor	
Private Values	**Impact ($ million)**	**Magnitude (Please circle)**
Q4. Direct industry impacts	**25.38**	Major / Moderate / Minor
Q6. Indirect Industry Impacts	**38.41**	Major / Moderate / Minor
Overall Private Impact (please circle)	Major / Moderate / Minor	
Category (Please Circle)	**1 / 2 / 3 / 4**	

Environment: measured as an impact to vegetation in adjusted hectares (i.e. Area impacted X Intensity of impact) e.g. 200 ha x 0.4 defoliation = Impact equivalent to 80 Ha.

- Approximately, 670 million hectares of native vegetation currently exist in Australia (ABS 2003).
- Approximately, 88.4 million hectares are part of the National Reserve System (National Parks) in Australia (Figure 1, HREOC 2008).
- Kakadu National park Northern Territory is approximately 2 million hectares (DAFF 2007).
- Wilsons Promontory National Park in Victoria is approximately 50,000 hectares (Tourism Victoria 2011).
- It's estimated that in Australia approximately 260,000 hectares of native vegetation are cleared annually (ABS 2010).

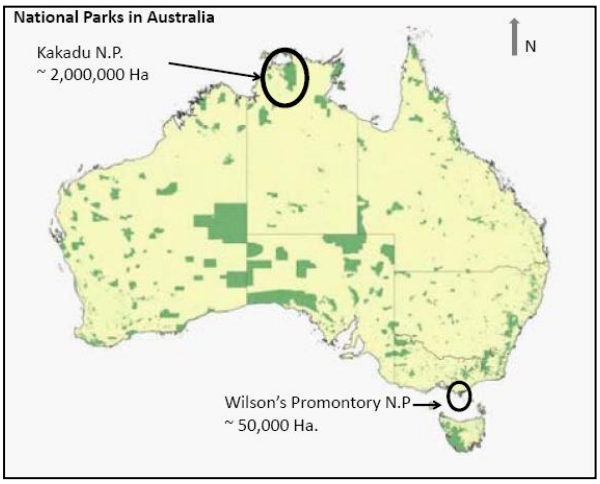

Figure1: Location of National Parks in Australia. Source: HREOC (2008).

Health (measured in patient days):

- In 2004-2005 there were approximately 5.63 million patient days recorded across public and private hospitals in Australia (AIHW 2007).
- "Complication of medical and surgery care" was the highest contributor to the number of patient days (2.93 million patient days) (AIHW 2007).
- "Road accidents" were attributed to 340,991 patient days (AIHW 2007).
- "Exposure to venomous plants, animals, or forces of nature" was attributed to 18,158 patient days (AIHW 2007).

Amenity Values (measured in park visits):

- In 1998, it was estimated that 74 million visits annually were made to metropolitan parks in Sydney by local residents (Veal 2001).
- Each resident makes on average 20 visits to their local park per year (Veal 2001).

Regional Economies (measured in the number of households required to relocate to find work):

- Under the NSW Red Gum restructure package the cost paid to workers to relocate to other areas to continue working in the same industry was $20,000 per household (DII NSW 2010).

Industry (measured in dollars):

Estimates of the Local Value of Production of the following crops in the 2008/09 financial year (ABS 2010) were approximately:

- Wheat $ 5,522 million
- Grapes $ 1,154 million
- Cotton $ 636 million
- Bananas $ 313 million
- Onions $ 199 million
- Lemons and Limes $ 45 million

Scenario 1

	Public impacts (Q1, Q2, Q3 and Q7)	Industry impacts (Q4 and Q6)
Major	>$100M	>$100M
Moderate	$10M - $100M	$10M - $100M
Minor	<$10M	<$10M

Scenario 2

	Public impacts (Q1, Q2, Q3 and Q7)	Industry impacts (Q4 and Q6)
Major	>$75M	>$100M
Moderate	$7.5M - $75M	$10M - $100M
Minor	<$7.5M	<$10M

Scenario 3

	Public impacts (Q1, Q2, Q3 and Q7)	Industry impacts (Q4 and Q6)
Major	>$50M	>$100M
Moderate	$5M - $50M	$10M - $100M
Minor	<$5M	<$10M

Environment

	Option 2 ($6,000 / ha)		
	Scenario 1	Scenario 2	Scenario 3
Major	>16,667 ha	>12,500 ha	>8,333 ha
Moderate	1,667 – 16,667 ha	1,250 – 12,500 ha	833 – 8,333 ha
Minor	<1,667 ha	<1,250 ha	<833 ha

Health

	Sick days ($1,005 per hospital bed day)		
	Scenario 1	Scenario 2	Scenario 3
Major	>99,502 days	>74,627 days	>49,751 days
Moderate	9,950 – 99,502 days	7,463 – 74,627 days	4,975 – 49,751 days
Minor	<9,950 days	<7,463 days	<4,975 days

Amenity

	Recreation ($19 per person per visit)		
	Scenario 1	Scenario 2	Scenario 3
Major	>5,263,158 visits	>3,947,368 visits	>2,631,579 visits
Moderate	526,316 – 5,263,158 visits	394,737 – 3,947,368 visits	263,158 – 2,631,579 visits
Minor	<526,316 visits	<394,737 visits	<263,158 visits

Regional communities

	Relocate ($20,000 per household)		
	Scenario 1	Scenario 2	Scenario 3
Major	>5,000 households	>3,750 households	>2,500 households
Moderate	500 – 5,000 households	375 – 3,750households	250 – 2,500 households
Minor	<500 households	<375 households	<250 households