Assessing the economic values of exotic invasive plants on areas of conservation significance in Queensland*

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Exotic invasive plants can threaten the integrity and biodiversity of a forest ecosystem by altering the composition and structure of native forest communities. Areas of high conservation significance are often impacted by exotic plant species as plant matter is transported from already affected habitat, often as a result of human activities. This study, a first in Queensland, assessed the economic value placed by the population on the importance of controlling exotic plants, such as Lantana and Singapore Daisy, on areas of high conservation significance. The outcome provides valuable input to informed decision making with respect to appropriate control measures and priorities.

1. Introduction

Queensland is considered as Australia's most naturally diverse state, with about 13 terrestial and 14 marine bioregions. These bioregions support more than 1000 ecosystem types and provide habitat for about 66% of Australia's known frog, reptile, bird and mammal species and 47% of vascular plant species. These ecosystems also support economic activities and provide social and environmental benefits (Environmental Protection Agency, 2003). For these reasons an increasing proportion of natural areas in Queensland have been placed under a protected area system to ensure biodiversity conservation.

However, areas of high conservation significance have been continuously threatened not only by land clearing and changed fire regimes but also by the impacts of exotic invasive species, which are also known as weeds. On a global basis, invasion by exotic invasive species in natural areas has been considered one of the major threats to biodiversity in nearly every biogeographical region (Adair and Groves, 1998). About 15 of the 20 weeds of national significance are found in Queensland and are subject to control and eradication programs.

Exotic invasive plants (or environmental weeds) are simply plants that are out of their natural habitat. These have either been accidentally or intentionally brought into Australia, causing unwanted economic, environmental and social impacts. Some plants entered the country as contaminants, others as ornamental and landscape plants, as well as those introduced as means of enhancing rural production. About 90% of environmental weeds were brought into Australia for landscaping,

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agricultural and aquarium purposes (Batianoff and Butler, 2002). When not managed properly, invasive plants pose a threat not only to agricultural production through increased management costs, productivity losses and fire risk but also to biodiversity and conservation values of native ecosystems. Wetland species are particularly vulnerable to exotic invasive plants. For example, Olive hymenachne (Hymenachne amplexicaulis) and para grass (Brachiaria mutica) are affecting many remaining natural wetlands. The State of the Environment Report 2003 suggests that invasive plants affect major areas in Queensland such as the Wet Tropics, Central Queensland Coast, and South East Queensland. Nearly 4% of Queensland is currently classified as areas of high biodiversity and with high conservation values, much of which are protected within the national parks system. In addition, almost half of the State's woody ecosystems have been cleared since European settlement to increase areas for production. Protecting areas of high conservation significance is, therefore, vital.

Losses due to the presence of weeds can be enormous. In Australia, agricultural losses due to weed impacts is estimated at $3.9 billion annually from 1997-1998 to 2001-2002. In natural environments which include National Parks, the country spent about $19.6 million in 2001-2002 for weed control. In Queensland alone expenditure on weed control in National Parks is estimated at $1.4 million annually. This figure is an underestimate since it only includes control costs, and not the loss of outputs coming from these natural areas. The extent of spread of invasive plant species in conservation areas is not known (Sinden, *et al, 2004*).

2. Lantana and Singapore Daisy as threats to conservation

This study used Lantana (*Lantana camara*) and Singapore Daisy (*Sphagneticola trilobata*) as examples of exotic invasive species. Lantana is an invasive weed and is considered as one of the worst weed species in Australia because of its potential economic and environmental impacts. In Queensland, it is ranked by the Southeast Queensland Environmental Weeds Strategy Group as the most invasive weed. Lantana has a capacity to form dense thickets that can establish in pastures as well as in natural areas containing native vegetation. These dense thickets also increase the risk of fire in areas it has invaded and poses a serious threat to biodiversity in several World-Heritage Areas such as the Wet Tropics of North Queensland and Fraser Island (see Appendix 1).

Apart from being a threat to conservation, Lantana also poses threats to the Queensland economy. The 2003 annual pest assessment conducted by Department of Natural Resources and Mines estimated that Lantana occurs in about 25.5 million hectares or about 13% of the entire State (Appendix 2). Annual pastoral losses and Lantana control costs in the primary industries are estimated at $7.7 million and $10 million, respectively. Lantana also affects the tourism industry in terms of restricted access, reduced visual amenity and quality of bushland experience (Agriculture and Resource Management Council of Australia and New Zealand, Australian and New Zealand Environment and Conservation Council and Forestry Ministers, 2001).

Singapore Daisy, on the other hand, is ranked 16th among the invasive plants affecting areas of high conservation significance. Introduced as an ornamental plant, it is now widespread along the coast of the State and along rainforest edges posing a threat to native ground cover species (Appendix 3). Both species have production and environmental impacts since they crowd out pasture species and native species.

3. Environmental values as inputs in policy decisions

Natural areas generate both private and public benefits. It is well-known that ecosystem services provided by natural areas have wide ranging impacts on agricultural production, on recreational opportunities and water quality among others. The values generated by natural areas are often classified as direct and indirect use values as well as non-use values. Direct-use values refer to those associated with the use of the natural areas for production or consumption such as visits to national parks for recreation purposes. Indirect use values refer to the contribution of natural areas to support human life such as carbon fixation and improvement of water quality while non-use values include values such as biodiversity and existence values (Wills, 1997).

Invasive plants could affect these values. Grice *et al.*. (2004) reviewed studies on the environmental impacts of invasive plants on Australian ecosystems and concluded that studies quantifying these environmental impacts are scarce. However, there had been increasing interest in estimating changes to outputs coming from these systems. For example, the benefit transfer method has been developed to provide proxies for both tangible and intangible outputs (Walsh, *et al*., 1990; Brouwer, R., 2000). Using the values generated by Walsh *et al.* (1990) AECgroup (2002) estimated that the forest protection value for Southeast Queensland is about $87 per household. This includes values such as recreation use, bequest value and existence value. However, this estimate did not take into account that endemic species could be lost, nor considered the presence of other ecosystem outputs such as improvement of water quality. The use of benefit transfer to determine proxy values is still a moot issue that needs further exploration.

Most of the known outputs of ecosystems such as scenic amenity are considered public benefits which are characterised mainly by their attributes such as non-rivalry and non-excludability. Non-rivalry means that the marginal cost of providing benefits to another consumer is zero. Services are non-excludable if benefits accrue to everyone regardless of their contribution to its maintenance or protection. Since these goods and services are not traded in a market system, there is insufficient incentive for consumers or landholders to maintain or protect such environmental values.

Currently, policies addressing the management of invasive exotic species are directed towards eradication of new incursions and the control of species that are extensively established and which are costly to eradicate. The choice of priorities is often *ad hoc* and based on economic evaluations which are mostly undertaken on an *ex post* basis. Economic evaluations also focus on production impacts only as these are more readily quantifiable. At best, the inclusion of environmental values has been in the form of qualitative descriptions in policy and management decisions. This study addresses such gap and is a pioneering study in Queensland.

4. Queensland Study

This study is a first attempt in Queensland to estimate the value of environmental weeds. It aims to provide some information on such values which could be used in policy decisions.

4.1 Objective

This study aimed to capture the average willingness to pay (WTP) per household in Queensland for two types of programs. One program pertains to stopping the spread of environmental weeds, such as Lantana and Singapore Daisy, within areas of high conservation significance such as national parks. Lantana and Singapore Daisy were used for the study as they represent both major and lesser known environmental weeds in Queensland and since data on these species were readily available. The other program examined a reduction in the area of infestation by environmental weeds. The study also investigated variables which could influence the value of the WTP estimates and explored the development of a process that could incorporate environmental values in policy and management decisions.

4.2 Valuation of natural areas

There have been attempts to estimate the values of natural areas in the past using established valuation methodologies (Andersen, *et al.*. 2004). These include Contingent Valuation (CV), Hedonic Pricing, Choice Modelling and the Travel Cost Method. These methodologies rely on inferred values based on the choices of individuals with respect to areas of residence and places to pursue recreation activities or simply to have the opportunity to enjoy similar benefits not only for themselves but also for future generations.

In the case of the exotic invasive species which is the subject of this study, values will be inferred from what the respondents are willing to pay in order to support two types of management program – stopping weed spread and reducing the area of infestation by these exotic invasive species. Managing exotic invasive species incur costs but could generate benefits in terms of maintenance of biodiversity or protecting the integrity of high conservation areas such as national parks. The benefits could also be in terms of private benefits that accrue to neighbouring agricultural land which would otherwise incur productivity losses and weed management costs when exotic invasive species spread from neighbouring public lands. These changes in benefits could be collectively given values by respondents who indicate their WTP for such programs.

More recently, there had been attempts at undertaking bio-economic modelling to estimate changes to the values of natural areas. Bio-economic modelling involves modelling the physical changes to these areas and estimating the community values associated with the changes. For example, Hester *et al.* (2004) developed a dynamic bioeconomic modelling which can be used to value the cost of weed incursion in natural environments. The work of Whitten and Bennett (2002) also used bio-economic modelling in determining the values of changing management strategies in the Murrambidgee River Flood Plain. Higgins *et al.* (1997) applied ecological-economic model when analysing conflicts with respect to the biological control of environmental weeds that has invaded the fynbos ecosystem of South Africa.

4.3 Contingent Valuation (CV)

This study used CV to assess the Queensland population's consensus about the values of environmental weeds in Queensland. CV was selected for its capacity to gather primary data rather than relying on benefit transfer methods of valuation. The data collected also has a tendency to be statistically significant. In addition, a value of non-market goods and services can be derived from the data gathered, and there is relative ease of comparing between different types of environmental weeds. A CV method has the advantage of conforming to given time and budget constraints.

CV is one of the more established methodologies for goods that have non-market values. It is a survey-based technique used to elicit preferences for non-market goods (Carson, 1998; Mitchell and Carson, 1989; Bishop and Romano, 1998) based on a particular or defined outcome (Sinden and Thampapillai, 1995). It involves directly asking an individual's WTP for a good or service, or how much they are willing to accept to give it up. By creating a pseudo-market, researchers are able to estimate individual preferences when it comes to non-market goods and services. CV is based on the assumption that the aggregation of individual WTP represents WTP for society.

Various studies used CV method to estimate WTP for a number of non-market values such as value of recreation at Bryce Canyon National Park, New South Wales (Johnson and Haspel, 1983), economic value of Centennial Park in Sydney (Lockwood and Tracy, 1995) and restoration of ecosystem services on a river basis (Loomis, *et al.*, 2000). Other estimates of non-market values include value of forest quality protection (Walsh, *et al.*, 1990), beach and dune maintenance (Pitt, 1997), establishment of new forest reserves (Scarpa, *et al.*, 2000) and increasing budgets on weed control (Odom *et al.*, 2003).

Although used extensively in valuation of natural resource values, CV has its shortcomings such as its inability to identify and value actual impacts with certainty. The shortcomings of the CV method were discussed extensively in Carson (1998), Clark, *et al*. (2000), Diamond and Hausman (1994), EPA (2003), Hanemann (1994), Hoehn and Randall (1987) and Mitchell and Carson (1989).

4.4 Survey design

In this survey, several key factors were considered such as ensuring that adequate and accurate information were provided to respondents. Since there is a wide range of understanding about the issue being evaluated, it was deemed important that respondents have a common basis of knowledge in order to elicit comparable estimates of WTP. Realistic and identifiable scenarios were also chosen to elicit realistic answers. Counterfactual information was avoided, that is, the questions pertained to relevant future conditions for which a decision is required. In order to avoid biased responses, questions were framed to give a general perception of big business or the Government (Hanneman, 1994) which would give the concept of balance and impartiality.

Questions were also constructed so that respondents could choose from a specified range of high and low prices and not feel pressured to identify either a high or low estimate, which may provide a biased answer (Loomis, *et al*., 2000). A realistic and suitable payment vehicle was also chosen to allow respondents to provide realistic trade-off of utilities against monetary gain. Carson (1998) suggests that respondents should bid realistic values which could be enforced and collected, and to avoid protest bids from respondents. Protest bids occur when the respondents bid so low or with zero bids in order to avoid paying additional taxes. This study used household levy ranging from \$5 to \$150 as payment vehicle. These values are close to environmental levies currently charged in Queensland.

Questions asked in typical CV surveys can either be open-ended questions, a sequential bid or close-ended question. Open-ended questions require the individual to identify their maximum WTP for a given situation. In sequential bidding respondents are asked to accept or reject a single specified sum with the question repeated using higher or lower bid values. On the other hand, closed-ended questions are used to accept or reject a single specified sum or bid amount which can be varied across respondents. Closed-ended questions or "single-bounded dichotomous choice models" are favoured by many since the respondent is only required to provide a yes/no answer. A smaller cognitive effort is used relative to open-ended questions (Scarpa, *et al.*, 2000). Close-ended questions have the added benefit of simulating the behaviour of the purchaser in an actual market place, such as whether or not to buy a particular good for a specified dollar amount. Close-ended questions were used in this study.

Due to resource and time constraints, the telephone survey method was used in the study. Telephone surveys ensure timeliness of response, increase response rate, and to ensure data consistency and were used to avoid the pitfalls of mail-out and other self-administered surveys (Arrow, *et al.*, 1993). Telephone surveys, however, are limited since visual aids cannot be used.

4.5 Analysis

The responses to WTP questions were analysed using Logit Analysis (which is a parametric technique) and two non-parametric techniques (Turnbull Lower Bound Mean and Median and Kristrom Non-Parametric Mean and Median). An estimate of WTP was derived using each technique. Parametric analysis, as outlined in Gujarati (1995) involved specification and estimation of one or more probability models of individual choice.

Logit analysis was used as some of the questions in the survey were of a discrete nature. The logit analysis deals specifically with discrete binary responses and a set of explanatory variables to identify the probability of a "yes" response for a specific contribution (Gujarati, 1995). Turnbull and Kriström (Vaughan, *et al.*, 1999) methods, both widely accepted non-parametric methods, were conducted to test the accuracy of the logit analysis.

The analysis fits linear regression models for binary response data by the method of maximum likelihood which is carried out with the Fisher-scoring algorithm (f-test) (Gujarati, 1995). Logistic regression, in this instance, is ordinary regression using the logit as the response variable (see Appendix 4).

5. Survey results

The data collected in the survey include WTP for the proposed weed management program, validation data for household demographics and respondent's personal information such as level of knowledge about the impact of environmental weeds and ranking of the importance of environmental weeds relative to other natural resource management.

Two management scenarios were examined for two environmental weeds, Lantana and Singapore Daisy. One management scenario was stopping and preventing the current expansion of the environmental weed; the other was stopping weed expansion and reducing the area of infestation. The survey questions focussed on knowledge of the different types of environmental weeds and on perception of the importance of environmental weeds relative to other weeds and to other environmental issues. The survey also focussed on respondents' WTP support for control and maintenance programs to control environmental weeds.

5.1 Sample Size and Sampling Confidence

A total of 806 telephone surveys were conducted throughout Queensland with an almost equal distribution for South East Queensland (SEQ) and Rest of Queensland (ROQ) (Table 1). The sampling confidence indicates an estimate of the number of the total population that would have given the same answer if asked the same question.

Table 1. Sampling confidence

Group	Sample Size	95% Confidence Interval
South East Queensland	**410**	**+/- 4.8%**
Rest of Queensland	**396**	**+/- 4.8%**
Total Queensland	**806**	**+/- 3.4%**

5.2 Demographic Characteristics

The age distribution of respondents to the survey generally matched the State age distributions, indicating the sample was reasonably representative (Figure 1). About 78% of respondents have children (Figure 2). With respect to income, about 16% of respondents earn about $800 to $999 per week with the least number of respondents coming from the lowest income category (Figure 3). About 29% of respondents did not specify their income details. Most of the respondents live in town and cities (78%), with the rest living in rural blocks (Figure 4).

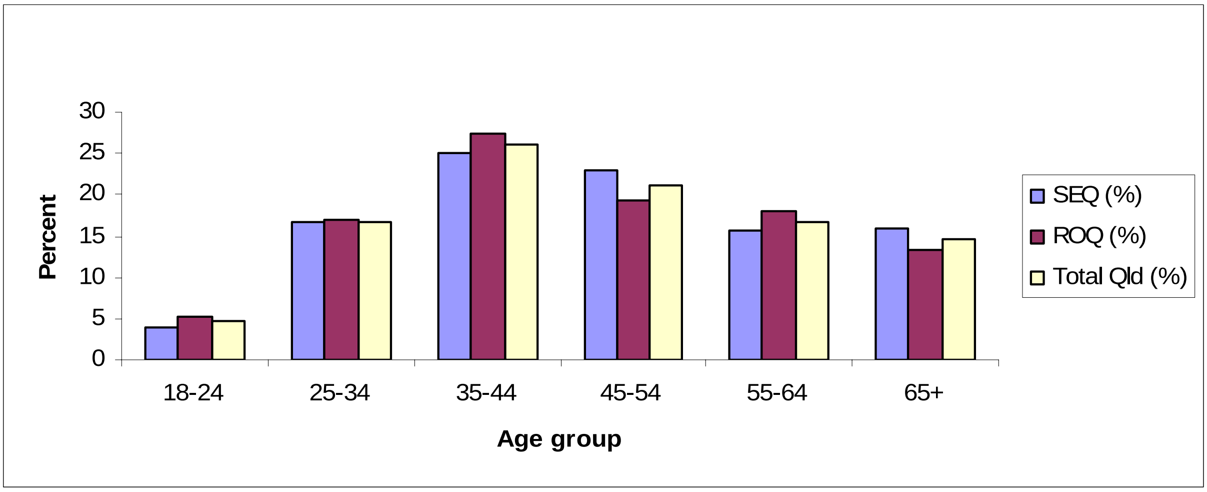

Figure 1. Age distribution by respondents

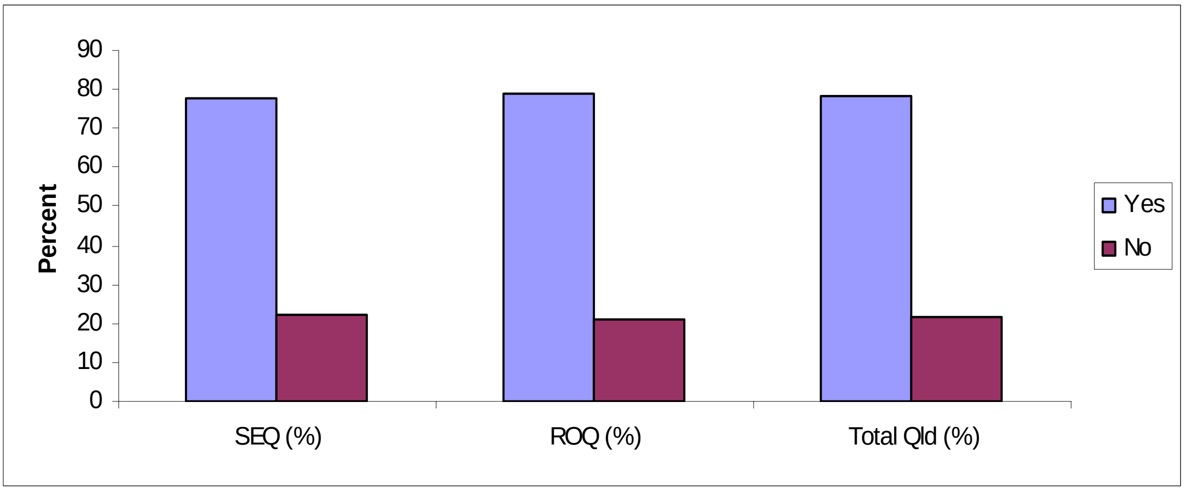

Figure 2. Respondents with or without children

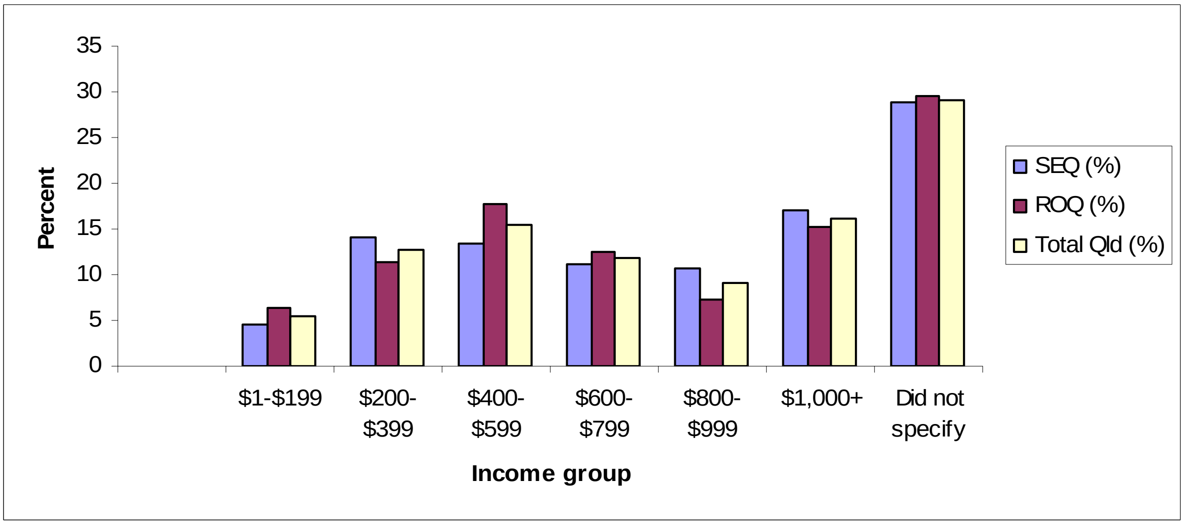

Figure 3. Income distribution

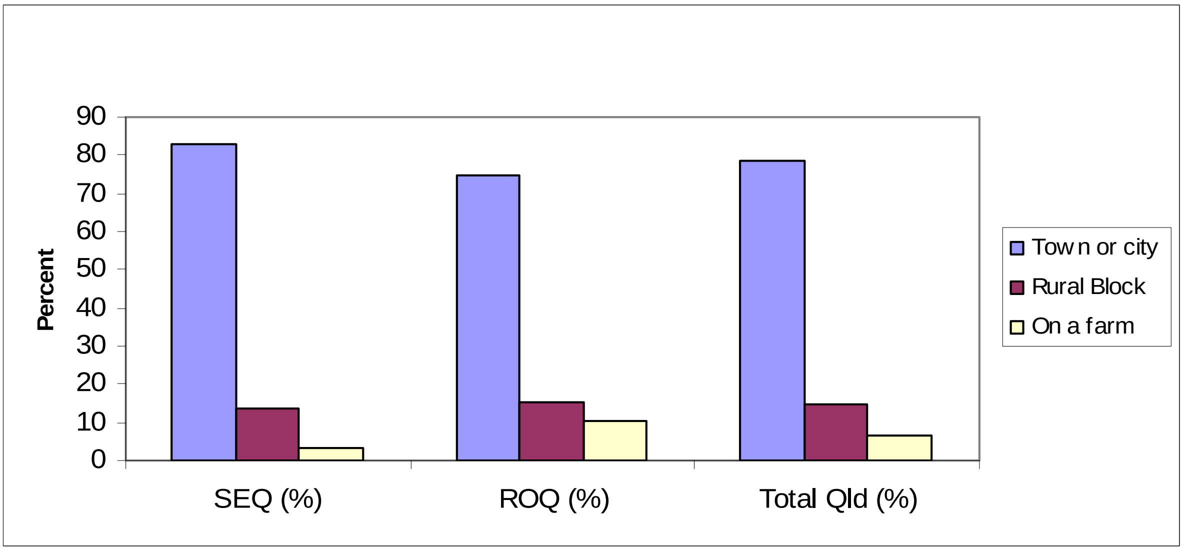

Figure 4. Type of residence

About 59% of all survey respondents have previously heard of the term “environmental weeds,” with a slightly higher ratio in the ROQ (60.1% than in SEQ (57.3%) (Figure 5). Most of the respondents (75%) consider environmental weeds to be a serious problem in Queensland. A great majority considered environmental weeds problem at par with other environmental problems such as damage to the Great Barrier Reef, salinity, water quality and loss of production from weeds that affect agriculture (Table 2).

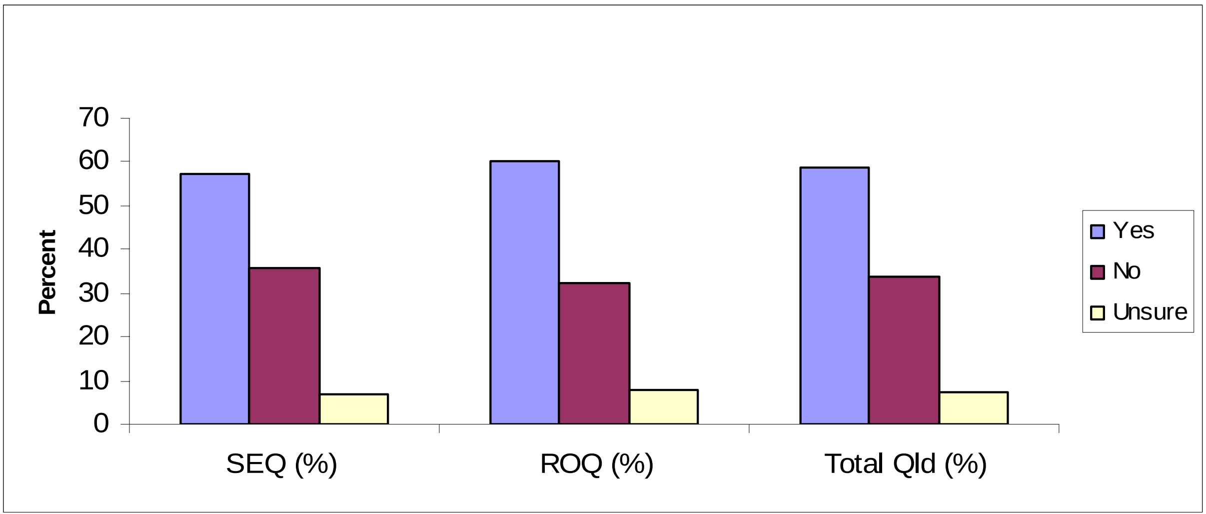

Figure 5. Pre-survey knowledge of environmental weeds

Table 2. Respondents’ relative ranking of environmental weeds to other environmental issues

Comparison	Higher (%)	Equal (%)	Lower (%)	No Response (%)	Total (%)
Damage to the Great Barrier Reef	22.3	47.6	29.2	0.9	**100.0**
Damage from salinity	17.4	44.3	37.2	1.1	**100.0**
Damage from water quality	22.5	46.3	29.5	1.7	**100.0**
Damage from global warming	24.4	30.6	43.1	1.9	**100.0**
Loss of production from weeds that impact on agriculture	25.4	45.3	27.0	2.2	**100.0**

6. Results and Discussions

This study was an attempt to estimate the WTP of the Queensland population to support a program to control environmental weeds within areas of high conservation significance in the State. The WTP derived from the respondents’ willingness to pay for a given attribute or scenario can be used as minimum estimates of the impact of environmental weeds within Queensland.

Two well-known environmental weeds, Lantana and Singapore Daisy, were used as a basis for testing respondents’ knowledge about these weeds. About 95% of the respondents have heard about Lantana and about half have heard about Singapore Daisy. Approximately 92.6% of the respondents indicated that they would support a program that would stop Lantana or woody weeds from spreading in areas of high conservation value (Table 3). Knowledge about environmental weeds could be a big factor in supporting programs directed at stopping the spread of these weeds.

Table 3. Support for program that would stop *Lantana* or woody weeds from spreading in areas of high conservation value such as National Parks

Response	South East Qld (%)	Rest of Qld (%)	Total Qld (%)
Yes	91.7	93.4	92.6
No	8.3	6.6	7.4
Total	**100.0**	**100.0**	**100.0**

6.1 Willingness to pay

As expected, WTP estimates have an inverse relationship with the amount of bid asked to support a program to stop Lantana, except for an unusually higher proportion of respondents from SEQ who are willing to pay $50 per year to stop or reduce the spread of Lantana relative to a $20 bid. A similar trend occurs when the question asked related to another type of program, that is, reducing the area of spread (Figures 6 and 7).

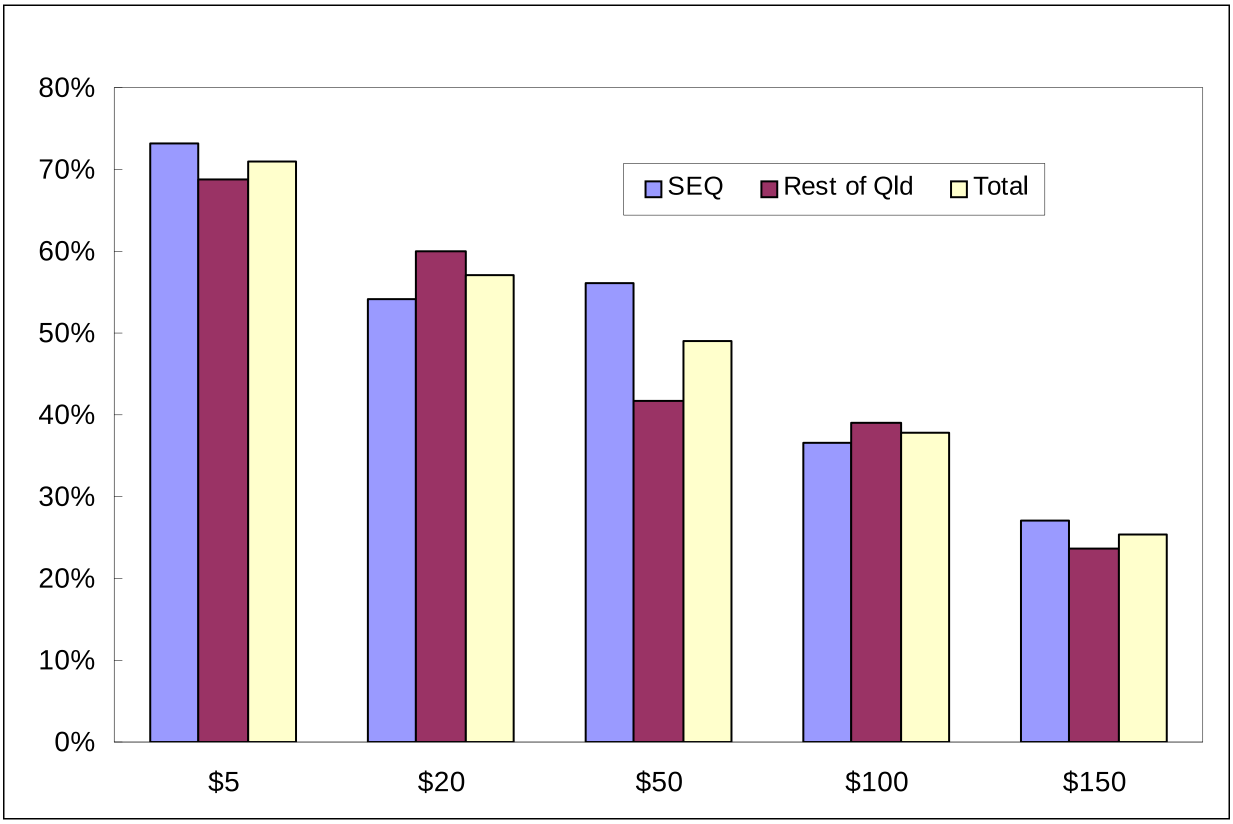

Figure 6. WTP to Stop Lantana by bid amount

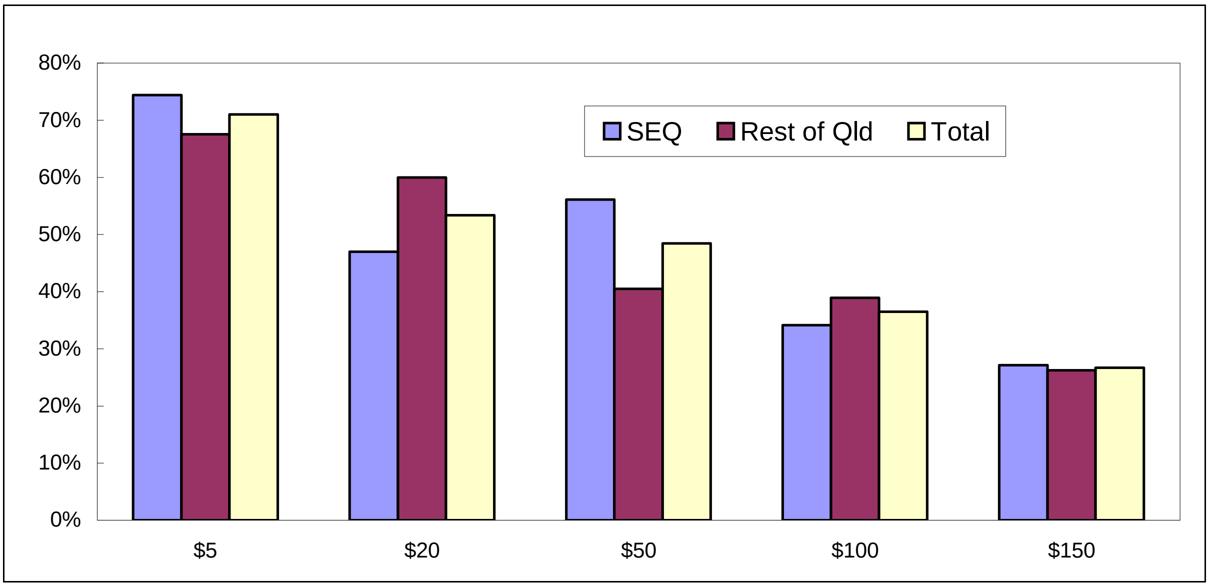

Figure 7. WTP to reduce Lantana by bid

WTP to stop the spread of Lantana is estimated at $56.88 with WTP estimated to be slightly higher in South-East Queensland ($61.64) when compared with the Rest of Queensland ($52.08) (Table 4). The Logit analysis was used as it is the more conservative technique and as such, the results discussed in this section focus on the outcomes of the Logit technique. The outcomes for Singapore Daisy were not statistically different from the outcomes for Lantana.

Table 4. WTP for Management of Environmental Weeds

Technique	Lantana		Singapore Daisy	
	Mean	Median	Mean	Median
Stop the Spread				
Turnbull	$58.43	$46.50	$55.61	$37.28
Kristrom	$73.66	$46.50	$70.50	$37.28
Logit	$56.88		$52.69	
Reduce Area Infested				
Turnbull	$57.68	$40.55	$55.29	$33.10
Kristrom	$72.58	$40.55	$69.96	$33.10
Logit	$53.08		$50.56	

There are approximately 1.2 million households in Queensland. Therefore, the WTP of Queensland households is approximately $68 million to reduce the spread of Lantana and approximately $73 million to stop the spread of Lantana. On the other hand, WTP to stop the spread of Singapore Daisy is estimated at $52.69 and WTP to reduce its spread s estimated at $50.56. WTP for the whole of Queensland households is approximately $66 million to reduce the spread of Singapore Daisy and $68 million to stop its spread. Therefore, the value of environmental weeds in Queensland, as inferred from the WTP for control programs to stop the spread or reduce the area affected by weeds such as Lantana and Singapore Daisy, is at least $67 million per year. This is almost 3 times the current expenditure by State and Local Government of $24 million on declared invasive plants and animals in 2002-2003

(AECgroup, 2002). This could give an indication to policy makers that the current government expenditure is less than the socially optimal level or what the community is willing to pay for the control of exotic invasive species. This is interesting as AECgroup (2002) found that private landholders do not have sufficient financial or production incentive to invest in weed and pest animal management initiatives to the level required to provide the maximum benefit to society.

6.2 Statistical tests

A paired t-test showed that there is no statistical difference between the values identified for the different management techniques, that is, whether the program is for stopping the spread of lantana or for reducing the affected area. This may be due to the perceived higher costs associated with reducing the areas impacted by the weed. The community probably considers that there are sufficient areas of native vegetation remaining that will be protected by stopping the expansion. In addition, the community may perceive that management programs added to these areas would be surplus to requirement. Additional targeted surveying work would be required to identify the actual reasons for this outcome.

The study also analysed whether the WTP responses were influenced by demographic factors such as age, income, having children, place of residence (whether urban or rural) and previous knowledge about the weed in question. In SEQ the only two factors, location and previous knowledge of Lantana have significant influences on WTP. The odds-ratio analysis also showed a higher probability of saying ‘yes’ to supporting a program to stop the spread of Lantana in younger age groups (18-54 year olds), respondents with children, urban residents, and income brackets of $600-799 and over $1000 per week.

With respect to reducing the spread of Lantana, age and location are the only significant factors. There is a higher probability of saying “yes’ to supporting such program among younger age groups (18 to 54 year olds), respondents with children, residents in urban locations, and those who earn $800-$999 per week.

On the other hand, age is the only factor influencing the decision to support programs that would stop the spread of or to reduce the area affected by Singapore Daisy. The same demographic factors that affect decisions to say ‘yes’ to Lantana control programs also affect decisions for Singapore Daisy.

Statistical analysis also showed that there was no significant difference in the value of the environmental weeds between the two regions examined – South East Queensland and the Rest of Queensland. The community also displayed no preference between stopping the spread of these weeds and that of reducing infested areas.

7. Conclusions/Policy Implications

It is widely accepted that environmental weeds have economic impacts on agricultural production as well as wide-ranging environmental impacts such as posing threats to biodiversity and integrity of ecosystems which support human life. However, the type and extent of impacts of environmental weeds in areas of high conservation significance in Queensland is not known. The values of outputs coming from natural areas such as National Parks have not been estimated either due to the complexity of their attributes, and mainly because most of the known outputs have no market-based prices. More importantly, the extent to which weeds affect outputs from areas of high conservation significance is not known and the least that can be done is to infer values of these weeds by eliciting WTP responses for supporting weed management programs.

WTP estimates give strong indications of the value placed by households with respect to supporting control programs such as stopping the spread of environmental weeds and reducing the area of infestation. In this study WTP estimates indicate that Queensland households would support control programs that would cost about $56 a year. The value of environmental weeds in Queensland has been estimated to be at least $66 million.

Given production and environmental benefits of management and control it is plausible that landholders could invest in the management of pest plants and animals to the point where marginal benefits (maintained or increased production) outweigh the marginal costs of control. The Government may have to invest further to cover the difference between total control cost and private landholder benefits. This is an application of the beneficiary-pays principle to underpin policy analysis and development.

The majority of the respondents did not change responses between weed species such as Lantana, which is more widespread, and the lesser-known Singapore Daisy. This indicates that the community values the outcome of weed management programs (saving high conservation areas such as national parks), rather than cause of the problem such as specific environmental weed.

There are several weaknesses of the study. Respondents were only given information on the extent of spread and existence of weeds. Had information on socio-economic and environmental impacts of environmental weeds been assessed and presented to respondents, it is quite possible that WTP levels would have been different. Information on various values (amenity, recreation and existence values) provided by natural areas such as National Parks and the impacts of weeds on these values could also have an impact on the WTP responses. Instead of simply correlating knowledge of existence of such environmental weeds, the respondents can be informed beforehand about projected scenarios, and then asked of their willingness to mitigate the impacts of such problem on retaining conservation values. There is also a problem relating to additivity issues, that is, households have a decreasing propensity to spend per weed or environmental concern when constrained by income.

CV as a method also has its own limitations, especially in its ability to identify and value actual impacts with certainty. The WTP estimates generated in this study are merely indications of economic values placed by the community in supporting programs that could stop the spread or reduce the areas affected. It is well-known that WTP estimates are likely underestimates of the actual or true impact of environmental weeds.

Despite such weaknesses, this study shows that the values of exotic invasive species can be estimated using established environmental valuation methodologies such as CV. A process to undertake systematic valuation of these types of species is worth further exploration. The inclusion of estimates of values of invasive species should be seriously considered when making policy decisions about priorities, and in evaluating the impacts of these species. Estimates of values of invasive species can give an indication of the likely support of the community for weed management programs in natural and production areas in Queensland.

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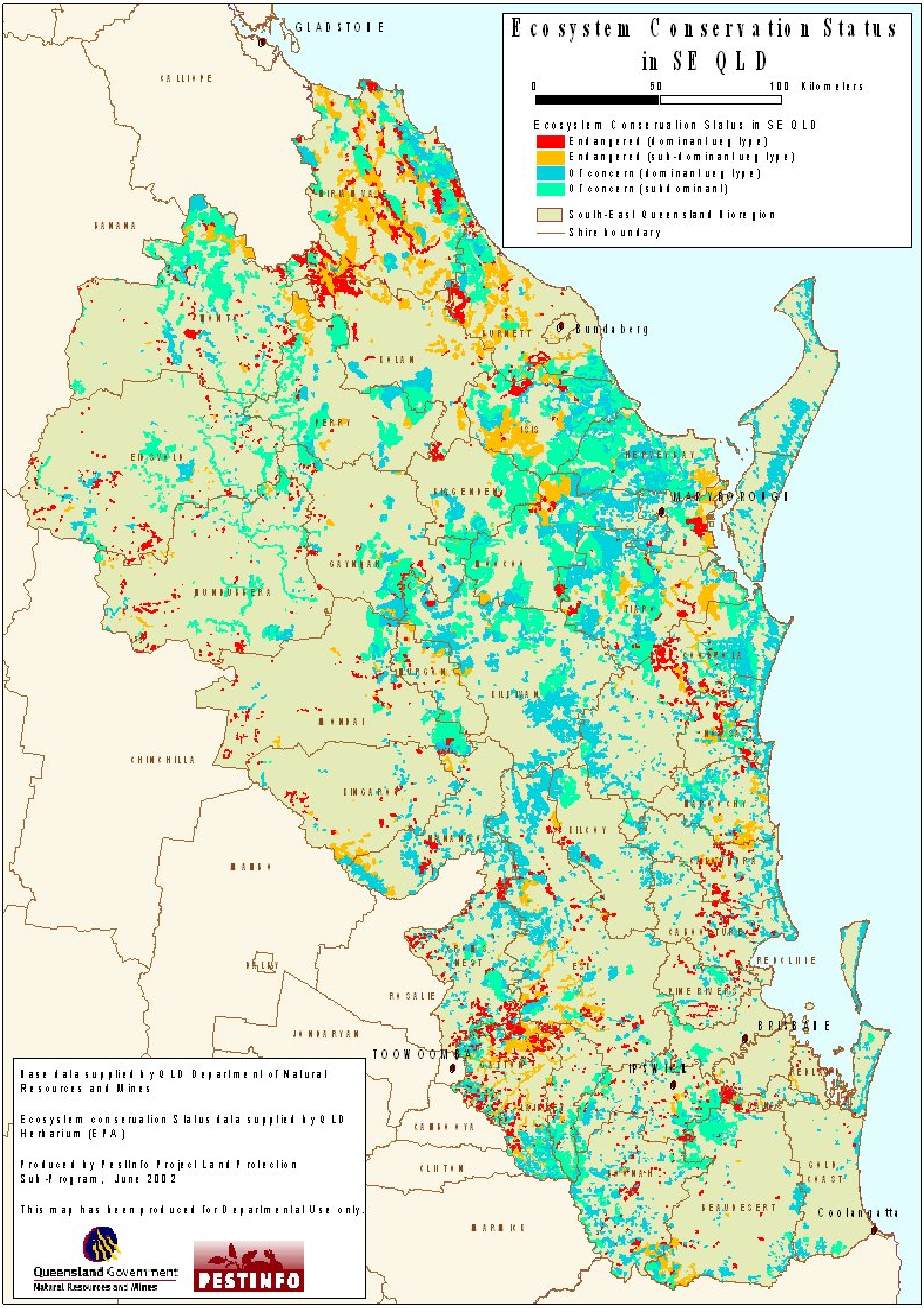
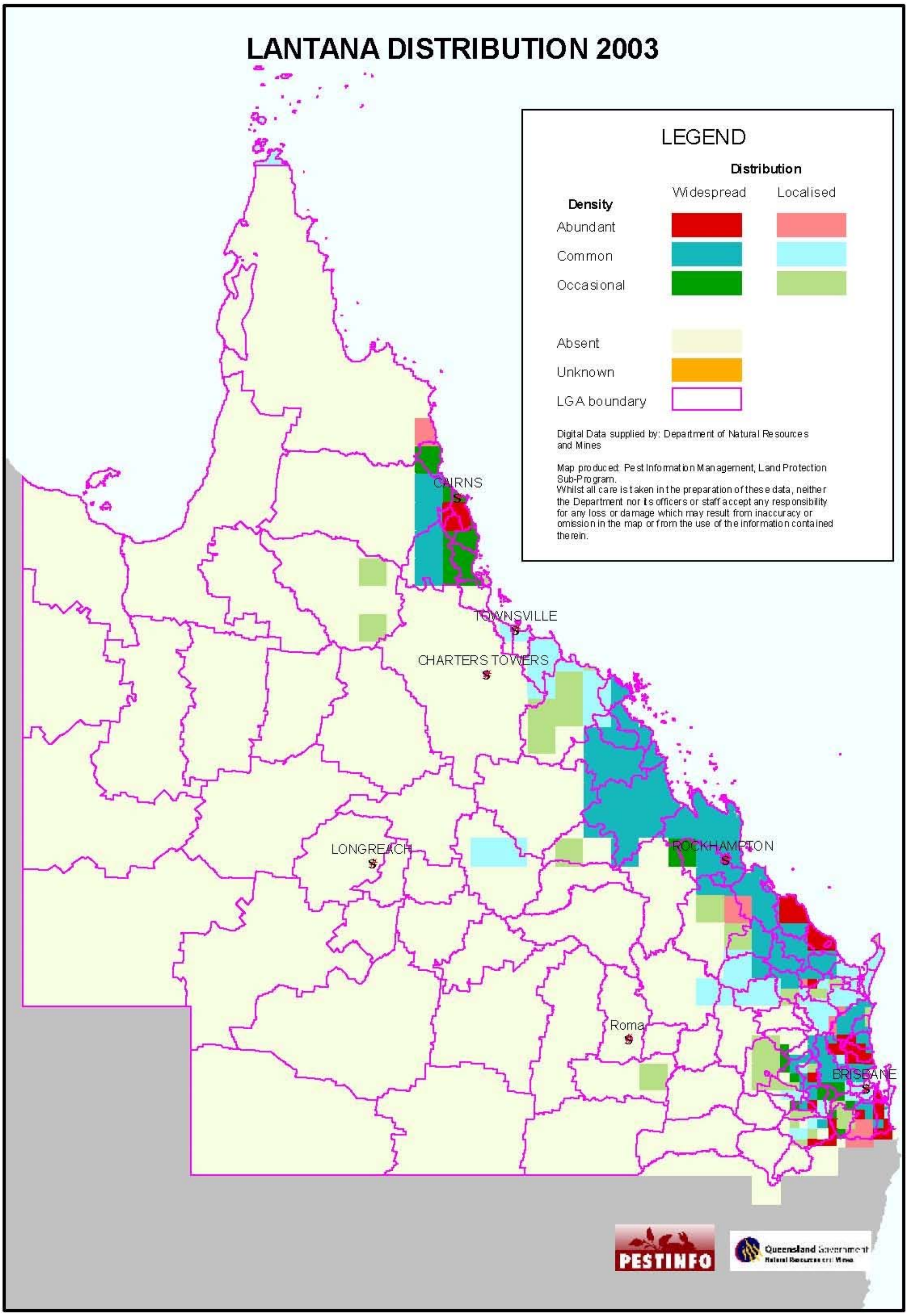
Figure 1. Ecosystem conservation status in Southeast Queensland



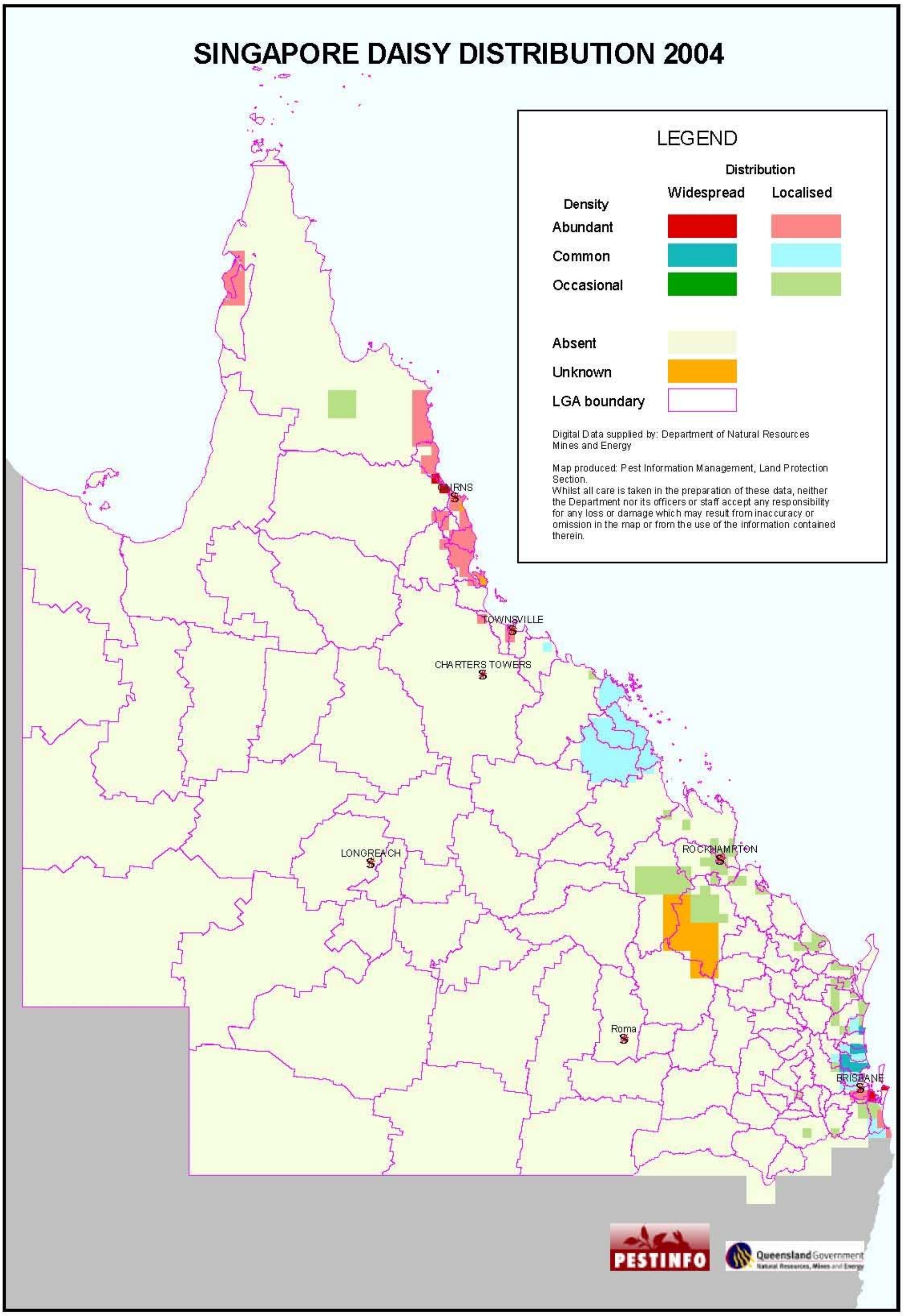
Source: PestInfo, Department of Natural Resources and Mines, Queensland

Appendix 2. Lantana distribution in Queensland



Source: PestInfo, Department of Natural Resources and Mines, Queensland

Appendix 3. Singapore Daisy distribution in Queensland



Source: PestInfo, Department of Natural Resources and Mines, Queensland

Appendix 4. The Logit Model (Gujarati (1995).

1. Let P_i be the probability of the program being accepted at a certain bid or the probability of saying "yes." From a total of N_i total respondents there will n_i respondents saying "yes" to a bid amount X_i. P_i is calculated as the n_i/N_i or the estimate of the true Pi to each corresponding *Xi*. The probability of respondents saying "no" to a bid is therefore $(1- P_i)$.

2. $P_i/(1- P_i)$ is the odds ratio in favour of saying "yes" to those who respond with a "no."

3. Finding the natural log *Li* of the odds ratio $P_i/(1- P_i)$ is obtaining $L_i = \ln (P_i/(1- P_i)) = \beta_1 + \beta_2 X_i$. L is called the logit.

4. To resolve the problem of heteroscedasticity, the analysis used a weighted least squares (WLS) approach as opposed to ordinary least squares (OLS) approach. WLS is OLS on the transformed data. The logit equation is transformed to:

$L_i^* = \beta_1 \mathrm{isqrt}(w_i) + \beta_2 X_i^* + v_i$

Where:
L_i^* is the transformed or weighted L_i
X_i^* is the transformed or weighted Xi and
v_i is the transformed error term.

5. For a certain income level, X*, the probability of saying "yes" is derived from:

$P_i = 1/(1 + \exp -(\beta_1 + \beta_2 X_i))$.

The mean value X_M, which coincides with the median, is equal to $-\beta_1/\beta_2$ where β_1 and β_2 are the results of the regression in (4).