Report on Methodological Issues
pertaining to

Revised Draft Import Risk Analysis Report for the Importation of Cavendish Bananas from the Philippines

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1 Introduction

This report has been prepared upon request by the Australian Banana Growers Council, as part of its response to the “Revised Draft Import Risk Analysis Report for the Importation of Cavendish Bananas from the Philippines” (BA February 2007). In this document we examine the draft IRA report from a methodological perspective. In particular, we examine whether the draft IRA report correctly implements the methodology it describes, and furthermore point out the inadequacies of the methodology adopted. We find that there are a number of errors in the implementation of the methodology, ranging from calculation errors, to errors in interpretation and use of evidence, whose net effect is to underestimate the probability of entry establishment and spread of the various diseases assessed. In addition we point out a number of methodological flaws with the risk assessment process that provide no confidence that the measures recommended will adequately protect Australia from the risk of disease introduction. Overall, we conclude that the draft IRA Report, as presented, can not confidently be used to assess and appropriately manage the risk associated with the importation of bananas from the Philippines.

2 Pests Treated Individually

The pest risk assessment process treats each pest individually and separately, deciding under what conditions Australia’s ALOP is met. According to the draft IRA Report (part B, page 2), “Section 70 of the Quarantine Proclamation 1998 sets out the matters to be considered when deciding whether to grant a permit to import.

> *In deciding whether to grant a permit to import a thing into Australia or the Cocos Islands, or for the removal of a thing from the Protected Zone or the Torres Strait Special Quarantine Zone to the rest of Australia, a Director of Quarantine:*
> *(a) must consider the level of quarantine risk if the permit were granted; and*
> *(b) must consider whether, if the permit were granted, the imposition of conditions on it would be necessary to limit the level of quarantine risk to one that is acceptably low;…”*

This indicates that a director of quarantine should consider the level of quarantine risk if the importation was to be permitted, and allows for the imposition of conditions to limit the level of quarantine risk that is acceptably low.

The overall level of quarantine risk represented by an import is not adequately represented by a piecemeal assessment of each pest in isolation, even if in isolation, each individual pest can be considered (with conditions as appropriate) to fall below the benchmark defined in the draft IRA report as the ALOP. This does not guarantee that the risk associated with the importation will be below the ALOP. There is no mechanism in the IRA process for estimating the total risk associated with importation, and a director of quarantine would not be fulfilling (a) and (b) above if they relied solely on the draft IRA report in making the import decision.

To see how this may work, consider the hypothetical example below. There are five pests of significance to be evaluated. Each pest is determined to have a probability of entry establishment and spread p_i, and a consequence once established of c_i. The risk associated with establishment of pest *i* is then $p_i c_i$. The total risk accumulates, and if consequences were disjoint, the total risk would add to $p_1 c_1 + p_2 c_2 + ... + p_5 c_5$. If all the risks $p_i c_i$ are below the ALOP, the total risk may still exceed the ALOP.

This factor should be considered in the draft IRA report. Risks are very often judged to be below the ALOP by a small margin. When taken together, the overall risk accumulates, and consequently may be above the ALOP.

3 Qualitative assessment of Consequences and Calculation of Risk

3.1 Variability and Uncertainty

The quantitative modelling of the probability of entry establishment and spread results in a distribution that expresses both variability and uncertainty of knowledge of the probability of entry establishment and spread. This is important information relevant to the calculation of risk. However the framework adopted in the draft IRA Report does not further consider this distribution, expressing uncertainty in precise knowledge of the probability of entry, establishment and spread. Instead, the median of this distribution is used to represent the probability of entry establishment and spread in the calculation of risk. However this use of the median, regardless of the distribution it comes from, means that the methodology adopted by the Draft IRA Report considers that a probability of entry establishment and spread that is precisely known represents the same risk as a comparable probability (with the same median) that is very imprecisely known. In the second case, a prudent course is to make additional allowance for a risk that may be considerably greater than expected. A consideration of the risk implied by the 95th (or some appropriately high) percentile can provide the basis for such allowances. While the 95th percentile is referred to occasionally in the draft IRA report, it is not systematically examined in the crucial determination of risk management strategies required for each pest to bring it below the ALOP. Thus no confidence can be placed in the conclusion that the risk management strategies, in general, reduce risk below the ALOP. This is particularly so as many of the pest risk management options result in probabilities of entry establishment and spread that are only marginally below a category that would place the risk over the ALOP. These are discussed in the sections devoted to each specific pest.

3.1.1 Inconsistent Assessments of risk

The assessment of risk is inconsistent from pest to pest, and between commodities because of the use of the fiftieth percentile to calculate the risk. In reality, the PEES is not precisely known, and the distribution derived from modelling the importation and distribution scenarios expresses uncertainty about the expected value of the PEES. The criterion used in the draft IRA Report for judging that ALOP is met is simply that the median PEES is below a given threshold for each consequence category. However this can represent a wide variety of situations, from a great degree of certainty that the ALOP will be met, up to a 50% chance of meeting ALOP. There are at least two important considerations to the estimation of risk. The first is an estimate of the probability of occurrence, and the second is a consideration of how precisely this estimate has been made. The risk associated with an imprecise estimate is much greater than the risk associated with a precise estimate, however the draft IRA Report, by relying on the median, considers only the first aspect of risk, and ignores the second aspect of risk.

A more consistent way of making this decision is to look at the percentile point of the distribution at which the ALOP is exceeded. For example in the figure below three different PEES distributions are shown, compared to the ALOP threshold for a particular consequence level, as defined in Table 6.2. For example, the threshold for moderate consequences is a PEES of 0.05. According to the methodology of the draft IRA report, all three PEES distributions would result in a median below 0.05, and a decision that the ALOP is being met. Yet in each case there is a starkly different chance of ALOP being exceeded. In the top curve, a chance of 49% of exceeding the ALOP is illustrated, while in the bottom curve a chance of 5% of exceeding the ALOP is illustrated. The three cases illustrated clearly represent different risks, yet this is not acknowledged by the draft IRA report.

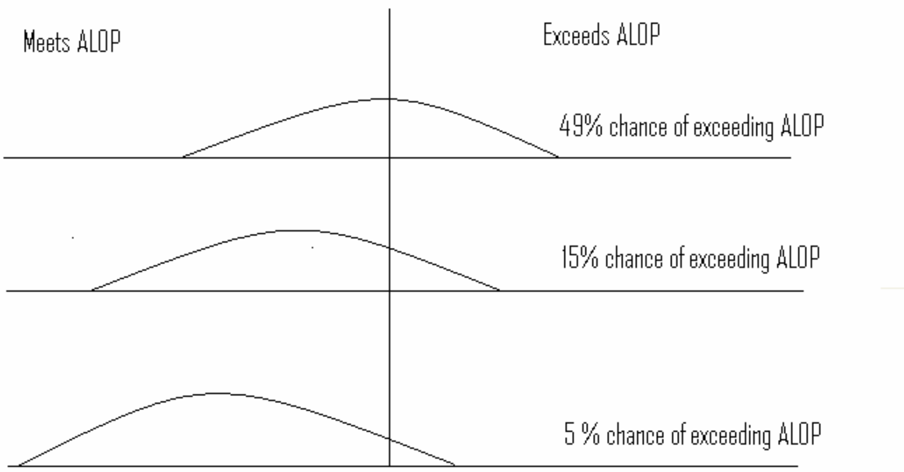

Figure 1. Illustration of different risk scenarios which are all said to meet the ALOP according to the draft IRA report

The information made available in the PEES distribution is therefore not being used consistently to make comparable decisions in each case.

This is exacerbated by a lack of transparency in reporting the PEES distribution in each case. Stakeholders have a right to know what the chance of exceeding the ALOP is in any particular case, so that revisions may be sought in those cases which represent the greatest risk of exceeding the ALOP, and the threats posed by each pest under managed import can be rated consistently in comparison to each other. This information should not be withheld from stakeholders, as it is important in their own risk mitigation measures should imports be authorised. There is no practical basis for withholding this information, as it is trivially produced from the PEES distributions. Its absence is a serious lack of transparency.

3.2 Detailed Assessment of Consequences

Consequences are assessed through the assignation of categories of consequence ranging from negligible to severe, based on the geographic extent of the impact, ranging from local to national in impact. These impact scores ranging from “A” (unlikely to be discernible at a local level) to “G” (highly significant at the national level) are applied to a range of different categories of direct and indirect impact, such as effect on environment, effect on human health and so on, which are referred to as criteria in the Draft IRA Report. A set of rules is used to reduce the set of impact scores for each criterion to a single assessment, ranging from “extreme” to “negligible”.

The effect of this system of rules is to, for the most part, select out the most significant impact score from the various criteria, and ignore the other impact scores. Exceptions to this occur when (i) all impact scores are the same, the overall consequence is the next highest category, and (ii) the highest consequence category (extreme) may be assigned if one impact score is “G”, more than one impact score is “F”, or one impact score is “F” and all others are “E”.

Thus the consequences fail to combine additively, and in most cases simply select the most highly rated consequence. Because of the inclusion of irrelevant criteria (see discussion below) this problem is further exacerbated, and addition of consequences is effectively prevented in all pests considered in the Draft IRA Report. This is a serious methodological flaw that gives no confidence that the consequences for each pest are adequately assessed.

3.2.1 Inclusion of Irrelevant Criteria

When irrelevant criteria are included in this consequence assessment scenario, they will be assessed as having negligible consequences, not discernible at any level. Such is the case in the Draft IRA Report with the criteria “Direct Impact – Human Life and Health” and “Indirect Impact – Effect on Foreign Trade”. These are irrelevant to the assessment (both assessed as *A – unlikely to be discernible at any level*) because in the first case, there is no anticipated possibility of a direct threat to Human Life and Health. In the second case, there is an insignificant amount of exports of bananas from Australia. The inclusion of irrelevant criteria should not prevent the addition of other consequences to give a greater combined consequence than each relevant consequence individually. Yet this is the effect of the draft IRA Report's rules when irrelevant criteria are included in the consequence assessment.

The consequence of including these irrelevant criteria is that according to the rules, the consequence level is determined exclusively by the criterion with the greatest impact, with the single exception that two "F" criterion will be assessed as 'Extreme'. This is a serious flaw in the consequence assessment process, as it effectively removes any consideration of consequences across a range of criterion additively combining to increase the overall consequence.

For example, if all relevant criteria were assessed as E under the rules, with two irrelevant criteria assessed as A, then the overall consequence would be assessed as *moderate*. However if the irrelevant criteria were removed from consideration, then the consequence would be assessed as *high*. In both cases, the actual consequence is no different. The effect of including irrelevant criteria is however to make the consequences appear lower. This is a serious methodological problem with the draft IRA Report, which provides no confidence that the consequences have been adequately assessed.

3.2.2 Weighting of Criteria

The rules used by the Draft IRA Report place the same weight on all criteria. Yet these criteria are arguably of different levels of significance in assessing the consequence of a pest incursion. For example, a direct criterion is impact on human life and health. For this to be highly significant at the national level, we may imagine people becoming ill and dying all around Australia, at levels significant enough to effect most families and businesses. Alternately, the criterion "*Any other aspects of environmental effects not covered above*", which includes "*significant reduction, displacement or elimination of other plant species,"* could be rated "G" if a plant disease which gained entry to Australia, was likely to eliminate a dozen non-commercial species in each state or territory of Australia. Both these consequences would be rated the same under the procedures established by the draft IRA Report, yet such judgements are highly subjective, and do not necessarily reflect the same severity of consequence. These hidden value judgements should be a matter of close public scrutiny in any particular assessment, rather than hidden within the framework of rules.

There is no reason why consequences cannot be assessed on a triple bottom line basis according to standards of economic modelling, for the criteria listed as important. This would avoid the systematic bias of the current rule based system, would provide a robust framework in which consequences across the different categories could be combined additively as should be the case, and would ensure that each criterion is weighted in the analysis according to its significance on a triple bottom line basis.

4 Mixed Modelling Approach

The draft IRA Report adopts an inconsistent approach to modelling unknown quantities. On many occasions, the draft IRA report adopts a maximum figure, for example, on page 77 (part B) in relation to scenario D of Moko, the draft IRA Report states that "*It was considered that no more than 1% of uncontrolled consumer waste* *would be littered around the garden."* In the same paragraph, it states that "*For other uncontrolled waste it was considered that no more than 0.1% would be littered by the roadside."*

This would be a valid way of conservatively estimating the risk, assuming that all such maximum values were chosen correctly, if the approach was adopted consistently throughout the report. However there are many instances where a range of values is used, rather than a maximum value alone, with the consequence that the average value, or mid-point of the range (for uniform distributions) is of most importance in determining the 50th percentile. For example in the importation pathway, imp5 for Moko is given the range 1.00E–05 to 1.00E–03. (part B p73).

If this second approach were adopted consistently, and all such ranges were chosen appropriately to reflect the state of knowledge about each model quantity, then given no errors in the model itself, the 95th or another high percentile could be used reliably to estimate the risk.

However the draft IRA approach selects some values using the first approach, that is estimating a maximum or highest possible figure, but selects other values based on the second approach, that is selecting a minimum and maximum of a range, with the average having the most weight in determining the 50th percentile. Therefore neither the 50th percentile (appropriate if the first approach is adopted consistently) nor the 95th or some other high percentile (appropriate if the second approach is adopted consistently) adequately represents the risk when combined with the consequences.

As a consequence no confidence can be placed in the assessment of risk based on this inconsistent approach, because both the 50th percentile and the 95th percentile may underestimate the true risk.

5 Areas of Low Pest Prevalence

A risk management strategy adopted in the draft IRA report for several pests is to adopt and ensure an area of low pest prevalence, where the pest or disease prevalence is controlled to be no more than a given rate. To guarantee an area of low pest prevalence involves a consideration of the epidemiology and characteristics of each particular pest or disease, as well as some general statistical considerations with regard to inspections to ensure that the maximum prevalence level is maintained. In this section we discuss those general methodological factors related to inspections for areas of low pest prevalence generally, with illustration from the recommendations for Moko disease and black sigatoka. For example, it is proposed in the draft IRA document that prevalence for Moko of no more than 0.06 cases per hectare per year, combined with visual inspection and post harvest chlorine treatment, would achieve Australia's ALOP.

The low prevalence rate implies averaging across both space and time, as at a minimum, a single case must be detected. However the draft IRA report gives no indication on what kind of averaging is appropriate, or what kind of inspection regime is appropriate. For example, if cases were averaged over a year, then the prevalence rate could exceed the threshold significantly for significant portions of a year without any action to halt the export. If 12 months of inspections were required to be averaged, it may be up to 12 months in which exports would continue at a level significantly beyond the ALPP threshold. This clearly presents an unacceptable risk of introducing the disease.

In the following subsections, we develop these ideas further with reference to Moko and Black Sigatoka.

5.1 Moko

The draft IRA requires (at page 97, Part B) that "all proposed measures must be monitored, verified and audited by trained BPI and AQIS staff as specified in Chapter 20" and (at page 99 Part B) that the Philippines would have to meet a number of requirements, including "establishing the specific level of the relevant pest to sufficient precision".

It is possible that the prevalence of Moko may vary significantly over a short period of time. The inspection regime must be able to detect any increase over the specified prevalence without delay. Action must follow promptly. Any disease hot spot that emerges from time to time, if allowed into the export chain, for however short a time, would cause a significant and unjustifiable risk of introducing the disease into Australia. Areas of low pest prevalence, as suggested in the draft IRA report must be demonstrated over a 12 month period before exports to Australia may commence. However cessation of exports must follow immediately on the detection of any Moko case in a production area.

The inspection methodology adopted must provide a 95% confidence that the current prevalence is below the maximum prevalence defined for the ALPP. In the case of Moko disease, this would require that the upper bound of the 95% confidence interval for the prevalence, based on the data from the current inspection, is below the rate specified. In the example below, we assume that the specified prevalence is 0.06 cases per hectare per year, as specified in the risk management procedure combining area of low pest prevalence, visual inspection and chlorine disinfection (see part B page 103).

This confidence interval may be calculated based on the posterior density for the parameter of a Poisson distribution, using a non-informative Jeffreys prior, so that twice the prevalence is distributed according to a chi-squared distribution with $1+2x$ degrees of freedom, where x is the number of cases observed in the production area in the weekly inspection. (See for example Lee 2004).

The table below gives a 95% credible interval (CI) for the prevalence (cases per hectare per year) for a variety of sizes of production area when no cases are observed in the weekly inspection.

Area (Hectares)	Lower Bound of 95% CI	Upper Bound of 95% CI
50	0.001	2.612
100	0.000	1.306
200	0.000	0.653
500	0.000	0.261
1000	0.000	0.131
3000	0.000	0.044

95% CIs for prevalence in cases per hectare per year, based on Chi-squared posterior for a Poisson rate with non-informative Jeffreys prior, for different size production areas, when zero cases are reported in a weekly inspection.

As can be observed, the upper bound of the confidence interval exceeds 0.06 for all tabulated production areas below 3000 hectares. Therefore the minimum area for which an area of low pest prevalence can operate in this context is about 3000 hectares. A weekly count of zero cases in a smaller area cannot provide a 95% level of probability that the current prevalence is below the threshold of 0.06.

If even one case is observed in a weekly inspection in a production area of 3000 hectares, the upper bound of the credible interval exceeds 0.06. This is true for all the tabulated production areas in the table below.

Area (Hectares)	Lower Bound of 95% CI	Upper Bound of 95% CI
50	0.112	4.861
100	0.056	2.431
200	0.028	1.215
500	0.011	0.486
1000	0.006	0.243
3000	0.002	0.081

95% CIs for prevalence in cases per hectare per year, based on Chi-squared posterior for a Poisson rate with non-informative Jeffreys prior, for different size production areas, when one case is reported in a weekly inspection.

Therefore a detection of any case should immediately result in suspension of export activities, as the prevalence can no longer be said with 95% probability to be below the threshold of 0.06 cases per hectare per year. The prevalence must be adequately shown to be below the 0.06 threshold with 95% probability in a statistically valid way before exports can be allowed to resume. Such a method should take into consideration that the prevalence may have increased at the detection, and should not rely on historical data that precedes the detection, except to compare the rates before and after the detection. The reason for this is that averaging over a period of time may obscure and disguise the significance of a detection that is due to an increase in the disease prevalence at the time of the detection, and falsely lead to the conclusion that the prevalence is acceptable when it is not.

We conclude that an area of low pest prevalence for Moko must be established based on a minimum area which may statistically be demonstrated to allow a small increase in disease prevalence to be immediately detected with high probability. This minimum area must be linked to the acceptable rate of prevalence. The lower the acceptable prevalence, the larger the area of low pest prevalence must be.

5.2 Black Sigatoka

With black sigatoka, an area of low pest prevalence has a case rate of no more than 0.1%. The Draft IRA Report claims "*The level of the pest prevalence for Black Sigatoka would be demonstrated by weekly surveys with a case rate below 0.1% for a minimum of 3000 inspected mats*." However no detail is given about a specific inspection regime which would ensure that the case rate was below 0.1% with a specified level of confidence. Given that the prevalence of black sigatoka disease may increase quickly, and that elevated levels of black sigatoka disease in bananas feeding into the export chain to Australia present an unacceptable risk of introducing the disease into Australia, then action to halt exports must promptly follow any evidence that the case rate has exceeded the 0.1% level. Exports to Australia should remain halted until the area of low pest prevalence can be reliably and statistically validly re-established.

To have confidence that the case rate is below 0.1%, a 95% credible interval for the case rate based on the observed number of cases, should have an upper bound of 0.1% or less. Because of the large sample size, and the small number of cases, a Jeffreys credible interval for a binomial proportion would be appropriate. 95% credible intervals for 0, 1 and 2 cases detected in 3000 mats are tabulated below.

Cases	Case Rate, Lower bound	Case Rate, Upper Bound
0	1.64E-07	0.000837
1	3.6E-05	0.001557
2	0.000139	0.002137

95% Jeffreys credible intervals for a binomial proportion based on a sample of 3000.

Observing 0 cases in a sample of 3000 is therefore required to ensure that the case rate is below 0.1%, with 95% probability. Observing 1 or more cases in 3000 signals that the case rate can not confidently be asserted to be below 0.1%, and immediate further action is required. This should include immediate cessation of export activities until either (a) the case rate can be shown to be less than 0.1%, or (b) the area of low pest prevalence can be re-established using the agreed protocols. A statistically valid approach for (a) would be to increase the sample size substantially, by, for example, examining 3000 additional mats. Then the total sample size would be 6000 mats. 95% credible intervals for 0,1 and 2 cases detected in 6000 mats are tabulated below.

Cases	Case Rate, Lower bound	Case Rate, Upper Bound
0	8.18E-08	0.000419
1	1.8E-05	0.000779
2	6.93E-05	0.001069

95% Jeffreys credible intervals for a binomial proportion based on a sample of 6000.

If no further cases were found, then 1 observed case in a sample of 6000 mats provides a 95% probability interval upper bound of 0.078%, and the case rate could be asserted to be below the 0.1% threshold with confidence.

If, however, further cases are found in the additional sample, then (b) must be pursued.

6 Calculation of Densities

The draft IRA Report relies on calculations of the density of host plants such as bananas and helciconias within various proximity distances such as a circle of radius 30m or 5m for different pest risk scenarios. However at least one of the calculations used in chapter seven to calculate the relevant densities is erroneous. For example, on page 59 (Part B) in reference to the density of bananas and *Heliconias* in Other Areas, the draft IRA report argues "*In other areas, it was assumed that there were approximately 20% more home gardens with heliconias than banana plants and that the average garden with heliconias had two heliconia clumps. Therefore, when considering both types of plants, plant density is increased by about 40%. Given that the density of banana mats in home gardens in other areas is 3–18 per km^2, the density of both banana mats and heliconia clumps is approximately 4.2–25.2 per km^2 in other areas.*"

This logic and the associated calculation are erroneous. Plant density is not increased by 40%, presumably obtained by multiplying the 20% of more home gardens by 2. The correct procedure is to increase the density by a factor of 2, and add an additional 20%, which then represents the heliconia plants (2 in every applicable garden, in 20% more gardens than bananas), and add the original density (representing the banana plants -1 in every applicable garden). Thus the density of heliconias and bananas together should be 3.4 times the density of bananas, not 1.4 times the density as represented in the draft IRA report. Thus all other factors being correct, the density of bananas and heliconias in other areas should be 10.2-61.2 per km^2.

The correct logic, as outlined above, has been used by the draft IRA Report to calculate the density of bananas and heliconias in home gardens in grower areas (part B page 59). In this case, the assumption is that the same percentage of gardens have heliconias as bananas, and where each banana growing garden has one banana plant, a heliconia growing garden will have three heliconia plants. Therefore, the total density for heliconias and bananas will be four times the density for bananas.

This error affects the calculation for the probability of heliconia and banana plants being within a 30 m and also a 5m radius in home gardens in other areas (part B, page 77) for Moko Disease; the probability of host plants being within a 30m radius for black sigatoka disease (part B, p115).

7 Variability in Proportions and Clustering

7.1 Independence of discarded infected banana waste

The draft IRA Report establishes its estimate of the probability of entry establishment and spread by considering the situation of a single discarded infected/infested banana or its waste. This is then translated to a probability of entry establishment and spread by considering the number of infected bananas entering Australia during one year. However no consideration is given in the methodology for the situation where a cluster of banana waste is discarded, as in a home compost heap, for example. The infectivity, or chance of establishment of the pest or disease may be greatly increased by such a cluster of waste, over and above what may be expected by the same number of waste bananas distributed independently in space and time.

The various biological factors which may contribute to this possible synergy of clustered infected waste must be examined specifically for each pest. Without such explicit examination, the risk for a pest may well have been underestimated through neglect of this factor.

7.2 Variance Inflation

In the presence of clustering, the variance of the distribution for the probability of entry establishment and spread would be increased over that which would be expected in the independent case. It is important to correctly estimate the variance of the probability of entry establishment and spread, in order that its percentiles can be compared against the thresholds set for deciding if the ALOP has been met or not. By ignoring the effect of clustering, the variance of this distribution is likely to be under-estimated. This variance contains important information which is essential to properly evaluating the risk, as we discuss below.

7.3 Use of Averages to smooth disease hotspots

The draft IRA report takes the view that risk is associated with the total amount of viable pest or disease organisms or infective material that is likely to be imported into Australia over the course of a year of trade. A key assumption is that any disease hot-spots will be averaged out over the course of a year: "*One component of variability arises because pests and diseases will often cluster, either spatially or temporally. As a result, the values used in the model should depend on the time of year or the particular location from which bananas were sourced. However, much of this variation can be taken into account in the model by basing the analysis on a year's production, and using information averaged over a number of years.*" (p17, Section B, Draft IRA Report).

We disagree with the draft IRA's conclusion that the effect of disease clusters can be taken into account by using figures averaged over a number of years. This is because significant disease clustering, as for example a disease outbreak in a particular packing shed or region which goes undetected in its early phases is likely to significantly increase the probability of entry establishment and spread over and above that represented by the 50th percentile of the model probability of entry establishment and spread.

As discussed above, the draft IRA report assumes that the probability of entry establishment and spread is determined by the independent action of individual banana waste, assessed assuming that there is no influence or effect of any accompanying infected waste. Indeed the assumption is that the process of importation and distribution would effectively randomize infected bananas. We do not believe that this is a reasonable assumption in the case of undetected disease hotspots. In this case, with elevated disease prevalence levels, particularly in those diseases such as Moko which are systemic, that several clusters in a case of bananas may well carry the infection, and that hands of bananas bought by consumers would also be likely to be infected. Infected banana waste could easily be discarded in a cluster, for example in a home compost heap, at one time, or over a short period.

Such a cluster of infective material may well present quite a different risk to single discarded banana skins.

It needs to be investigated for each pest whether such clustering is likely, and if so, whether this presents a disease risk over and above that represented by the bananas forming the cluster acting independently. A cluster of diseased bananas will not generally present a lesser risk than each acting independently, but may well present a greater risk, due to threshold levels of inoculum being present in one location at the same time.

Due consideration has not been given to this likely event in the draft IRA Report, which may have caused the risk to be underestimated.

7.4 Moko- imp2

Another example of how variability is not sufficiently addressed in the draft IRA Report occurs in relation to Moko disease. On page 71, in relation to imp2, the draft IRA Report relies on the average number of detected cases per hectare reported by the Philippines in the period 1998-2001, 0.708 cases per hectare per year. However the average for any particular year will vary, perhaps significantly from this figure, and indeed this very fact is then discussed and substantiated.

The risk assessment methodology then has a number of courses which could be taken. The best method is to assess the variability in this data, and account for the observed trends, and to base the analysis on the appropriate distribution. This approach would then require consideration of the 95th or other high percentile in determining the risk, and is the most methodologically sound approach. This has not been done in the draft IRA Report. The second course that could be taken is to select the maximum yearly average as the appropriate figure for analysis, on the grounds that this will accurately reflect the risk in the years during which Moko is most prevalent. However this approach should be adopted consistently throughout, as discussed in Section 4.

The prevalence figure actually adopted is not reported in the draft IRA report. However working backwards from the figures given in the draft IRA report, the prevalence figure adopted can be calculated as follows:

Prevalence (per hectare per week) = $imp2 \times f3 / (f5 \times f4 \times f2)$,

where f2, f3, f4, f5 are factors two, three, four and five respectively.

Using the minimum and maximum values of the range reported for imp2, and factors two to five, factor 1, the prevalence per hectare per week is calculated to be from 2.00E-2 to 2.18E-2.

When this is compared to the prevalence data given in part C, page 50, this value is seen to be approximately the average detected incidence in 2001, in the context of an apparent rising trend in incidence, also noted in the draft IRA report, part B, page 71. While this was the maximum prevalence out of the four years for which data are available, there is no reason to suppose that this would be the maximum prevalence possible, especially as there appears to be a rising trend.

If we look at the approximate averages for each year, as estimated from the graph in part C, page 50, (0.05, 0.04, 0.07, 0.073) as draws from a normal density, the standard deviation is approximately 0.016, with a mean of approximately 0.06. Therefore we might expect that averages in future years would not exceed $0.06+3\times0.016 = 0.108$ cases per hectare per 4 weeks, or a figure of 2.70E-2 cases per hectare per week. However this figure would be an underestimate if the rising trend continues into future years, and additional years of data would be required to have confidence in this figure.

In the absence of additional data from subsequent years that can put this apparent rising trend in context, it would be prudent to adopt a higher average value for this range for factor one, say perhaps increasing it by 50% to about 3.00E-02 cases per hectare per week. As a minimum range, the year 1999 has an average of about 0.01 cases detected per hectare per week, which would seem appropriate. The maximum range would then be assigned as 5.00E-02 cases per hectare per week, assuming a uniform distribution.

8 Underestimation of uncertainty

8.1 Uncertain quantities given a specific value

There are many instances in the draft IRA Report when model quantities are assigned a specific exact value, in spite of no or very little firm evidence about the actual quantity. The effect of this is to misrepresent the uncertainty in the estimate of the PEES, so that 95th percentiles, and other high percentiles do not reasonably represent the uncertainty or possible variability in the estimate of the PEES. The examination of 95th percentiles therefore provides a false sense of security, as the distribution of the PEES does not fully represent the uncertainty or possible variation due to these quantities which are misleadingly given a precise value. It may also introduce a bias into the estimation of the 50th percentile, and thus the estimate of risk as defined in the draft IRA report.

8.1.1 Black sigatoka

For example, in the risk analysis for Black Sigatoka, many quantities are assigned to the four factors comprising the transfer probability as a single precise value, where the draft IRA report acknowledges that no firm evidential basis exists. As an example, the draft IRA report states "*Given the uncertainties concerning the likelihood that plant fragments with fertile pseudothecia would mature and produce ascospores, Factor 2 was considered to have a value of 5.00E–01 in grower areas and 2.00E–01 in other areas."* In this case, in spite of uncertainties, a precise value is given for each of grower and other areas.

Another example in which this takes place is on page 127 (part B), in relation to factor 3 of the exposure – transfer considerations. A figure of 100 viable spores per piece of banana waste is used to calculate percentages of waste from which contaminating spores become airborne due to water splash. This figure is treated as if it is certain and without any variability applies to each piece of banana waste. However it is most assuredly no better than a guess, which has two dimensions of variability attached. Firstly, the number of contaminating spores will vary from piece of waste to piece of waste. Secondly there is no certain knowledge about this actual distribution, and the figure used is a guess. Therefore lack of knowledge should also be represented by a distribution. Other examples include the evaluation of imp3a and imp3b for scenario B (part B page 122, imp7 for scenario B (part B, page 123)

Proximity
On page 76 (part B) in the discussion of the proportion of waste near each exposure group, single values are given throughout the discussion, as if they were exact values. For example, a proportion of 5.6E-06 of consumer waste is said to be discarded on or within 30m of a commercial banana plantation. As discussed above, using this value in the modelling as if it was precisely known results in underestimating the variability in the distribution of entry establishment and spread, and under-estimation of the 95th and other high percentiles, and possible bias in the location of the 50th percentile. The appropriate course is to use a distribution with an average given by the estimated proportion, and range representing the uncertainty associated in knowledge of that average figure. In some cases, the average figure is also unreasonable, and this is discussed separately where appropriate.

This also applies to the discussion of proportions of waste near each exposure group for black Sigatoka, (part B, page 115 and 125), freckle (part B, page 151), banana bract mosaic virus (part B, page 174), banana bunchy top virus (part B, page 190).

8.2 Ranges Unreasonably Small

There are a number of instances in the draft IRA Report were a range of values in a uniform distribution is assigned to a quantity, expressing in this way lack of certain knowledge about the quantity. In some cases, the range assigned is unreasonably small, and is not supported by the evidence available, resulting in the same problems as described above.

9 Risk Estimates too close to the cut-off

In many of the risk management measures recommended, we find that the procedures meet the ALOP only by a small margin, and that only a small increase in the probability of entry establishment and spread is enough to cause the risk to exceed the ALOP. The increase in probability of entry establishment and spread required to exceed the ALOP is tabulated for several cases in the table below.

Pest	Management Measures	Median PEES	ALOP Threshold	Factor by which ALOP achieved
Moko	ALPP (0.06 cases per hectar per year), visual inspection, chlorine disinfection	5.74E-04	1E-03	1.74

Black Sigatoka	ALPP, visual inspection, chlorine disinfection	4.88E-02	5E-02	1.07
Freckle	ALPP and fungicide bunch sprays	0.118	0.3	2.54

Given the uncertainties inherent in the modelling, the small changes in probability of entry establishment and spread which will result in the ALOP not being met could easily be absorbed by model uncertainties or variability, especially for black Sigatoka. For example, relatively small changes in the volume of trade could easily result in the ALOP not being met.

10 Black Sigatoka

10.1 Dispersal Distances

The draft IRA report considers that 30m is a reasonable estimate of the dispersal range of a small number of spores, based on Carlier (2004). However this is completely inadequate. The draft IRA report notes that "*When inoculum is abundant it can disperse over many kilometres (Carlier et al 2000). However, when there is a limited amount of inoculum, it may only spread over short distances (Carlier 2004)"*. This statement is false. Each spore produced has exactly the same probability of spreading over large distances, whether it is produced as part of a small or large cluster of inoculum. It is less probable to spread over a large distance, but when very large numbers of spores are considered, the small probability of spreading a large distance becomes almost certain. Whether the large number of spores is due to a single large cluster of inoculum, or whether it is due to a large number of discarded banana peels, each involving modest levels of inoculum is immaterial. To select a distance of 30m as the maximum dispersal distance of spores from banana waste is therefore bound to underestimate the risk. This is an example of ignoring the tails – low probability events may often be significant factors in driving establishment and spread. To conclude that they are negligible is a dangerous procedure, when we know that these low probability events are responsible for disease spread. There is good reason to believe that dispersal probabilities of airborne fungal spores and pollen follow a mixture of power law and exponential law with increasing distance (Shaw et al. 2006), indicating that the dispersal distribution has long tails, supporting the argument that 30m is a totally inadequate estimate of spore dispersal distances.

10.2 Distribution

The draft IRA Report states on page 113 (Part B, Section 10.4.1) that "*the IRA team considered that up to 10% of the most lightly infected plant fragments would become totally infertile at this stage and the remaining plant fragments would typically retain 1–16 fertile pseudothecia per fragment"*. This statement is not compatible with the subsequent assignment of 0.9 to Dist1, the proportion of contaminated clusters remaining contaminated with fertile psuedothecia. The 10% figure is stated to apply to only the most lightly infected plant fragments, the rest of the plant fragments remaining infected. Given that the most lightly infected plant fragments make up only a small proportion of infected plant fragments, Dist1 should be much closer to 1.0

than to 0.9. Therefore 1.0 would be the appropriate value in the absence of more detailed information.

10.3 Proximity

The draft IRA Report states that "*The term 'proximity' in this report refers to the likelihood that banana waste will be discarded sufficiently close to a host plant to allow for a likelihood greater than zero of transfer of M. fijiensis to a host plant to occur"* (page 114, Section 10.5). With reference to Section 10.1 above, it is clear that any spore has a small but non-negligible probability of travelling distances of several kilometres. One cannot assume that the probability of a spore travelling more than 30m is zero. This is demonstrably not so, as one or more spores must have travelled several kilometres in the black sigatoka outbreak in North Queensland. While it is recognized that the probability of transfer may be less likely for greater distances, it is certainly not negligible as assumed in the draft IRA report.
The probability of exposure is calculated in the draft IRA report separately for each waste-point exposure group combination, and in each case is the multiplication of the probability that waste is discarded in proximity to a host, by the probability that discarded waste in the proximity of a host will lead to transfer. The probability of transfer is assessed as a product of several factors, one of which is the vegetation density of host plants in the proximity area, factor 4B. Since black sigatoka spores have been demonstrated to move a distance of 2km or more, the analysis should be based at least on this as the proximity zone.

On this basis the proportion of controlled waste discarded near commercial plantations, home gardens and other plant communities must be revised. These proportions should be close to 1 in grower areas. In non grower areas, controlled waste will not be discarded near to commercial plantations, but proportions near to home gardens and other plant communities will similarly be one. We note that since the same piece of waste may be close to one two or three amenity groups, that these proportions are not constrained to be equal to one. The proportions of uncontrolled consumer waste discarded near commercial home and other plant communities must likewise be increased for grower areas. We note that the same item of consumer waste may be near all three amenity groups. Similar revisions will be required for other uncontrolled waste.

Similarly, the probability that there will be at least 1 plant within the revised proximity of 2km, will be 1 in all cases, except for other plant communities in other areas, where it will be approximately 0.06. (based on 0.005 plants per km^2). Factor 4B will require revisions as well, and will be represented by the number of plants within the revised proximity distance multiplied by 5 * 0.7 m^2 per plant, divided by the area in square metres of the revised proximity.

10.4 Exposure – Transfer

The draft IRA report states (part B, page 118) that "*Factor 4 is then calculated by combining the number of ascospores becoming airborne from each plant fragment (4A), the proportion of target area in the proximity zone (4B) and the efficiency of spore adherence (4C)."* However no details are given as to the specifics of how this combination is to be done. This represents a serious lack of transparency in the draft

IRA report. In order for transparency the details of this calculation must be provided. These details are not provided in the spreadsheet model distributed by BA either. The same criticism applies to the discussion of probability of exposure with respect to scenario B (part B, pages 126-127), where insufficient details are given about the way the four factors were combined.

10.5 Exposure Scenario B

In reference to the calculation of the probability of exposure for scenario B, the draft IRA report states that (part B, page 127) "*Dispersal of spores by rain splash can occur during any period of rainfall or supplementary irrigation. On average, over 5 mm of rain in a day occurs on 50–75 days a year in grower areas and 30–50 days a year in other areas of Australia. Supplementary irrigation may double the number of wet days in areas where hosts of black Sigatoka occur. The likelihood that at least some rain or supplementary irrigation might occur in the time that the spores could be splash dispersed from banana waste is therefore high, possibly 20–30% in grower areas and 10–20% in other areas.*"

However the final figure of 20-30% in grower areas is inconsistent with the presented facts and reasoning. Assuming that spores may be dispersed by water splash for a period of 24 hours (it may well be a greater time), there is a chance of 50/365 to 75/365 of over 5mm of rainfall. Doubling these figures to account for irrigation gives probabilities ranging from 100/365=0.27 to 150/365=0.41 in grower areas, and 60/365=0.16 to 100/365=0.27 in other areas, not 20-30% and 10-20% as stated.

The draft IRA Report states in regard to factor 3 (part B, page 127) that "*The IRA team considered that no more than 1% of available spores would be lifted into the air. As outlined in Factor 2, there may be only 100 viable spores on each fruit finger when it is disposed of. Consequently no spores would be lifted from about 35% of waste. From the remaining 65%, one or two viable spores would be lifted.*"

The figure of 65% is then multiplied by the chance of getting significant rain or irrigation, 20-30% for grower areas, and 10-20% for other areas, to give values for factor 3 (part B page 127) of "*between 1.30E–01 and 1.95E–01 in grower areas and between 6.50E–02 and 1.30E–01 in other areas.*"

The figure of 65% appears to be based on the assumption of a Poisson Distribution with mean of 1 (100×0.01). This figure is highly dependent on the number of viable spores. For example, if the number of viable spores was 150, then the Poisson mean would be 1.5 (150×0.01) and no spores would be lifted in only 22% of cases. If the number of viable spores was 200 instead of 100, the percentage in which no spores would be lifted would be only 13.5%. In this case factor 3 should be increased by a factor of 87.5/65 = 1.35.

Under the subsequent discussion of factor 4 on page 127, the draft IRA report asserts that only 1 or 2 viable spores would be lifted into the air via water splash. However this is incorrect. There is approximately a 7.5% chance of 3 or more spores being lifted into the air. Given that one or more spores are lifted into the air, the average number so lifted given a Poisson distribution with mean 1 would be 1.6. If the number of viable spores on a piece of waste was 200 instead of 100, this average would be increased to 2.3, increasing factor 4 by a factor of about 2.3/1.6= 1.4.

In addition, the probability of exposure should be higher still if rainfall of less than 5mm per day causes spore dispersal.

11 Moko

11.1 Calculation of Imp5

The draft IRA report states that the infection of clean clusters would depend on various factors including the number of processed infected bunches (part B, page 74). It says in relation to imp5 that "*This step is related to the proportion of infected clusters that are harvested (Imp2).*" (part B, page 74). A range of between 1.00E–05 and 1.00E–03 is then assigned to imp5, which is identical to the range assigned for imp2. We may infer then that the deliberations relied upon by the IRA team were equivalent to assuming that for every infected cluster entering the packing shed, an additional cluster would be infected, through the mechanisms described. This is reflected also in the risk management measures for Areas of Low Pest Prevalence, and Visual Inspection, which preserve this one to one relationship between imp2 and imp5, so that for each infected cluster, another will be assumed to be infected during the packing process. In the risk management measures involving chlorine treatment, we see that imp5 is reduced from imp2 by a factor of 10, reflecting the assumed efficacy of the chlorine disinfection, such that only one new infection arises for every ten infected clusters.

However, it is unlikely that each infected cluster will give rise to only one additional infected cluster. This issue is addressed in the ABGC's response to the draft IRA Report, in the chapter devoted to Moko. There it is argued that 8 or 9 infected hands from a symptomless infected bunch may give rise to up to 53 additional infected hands. Three of these are expected to arise through use of a contaminated knife, while the remainder arise from contamination of wash water. Therefore for every infected hand (or cluster) up to another 6 hands (or clusters) will acquire the infection.

Based on this logic, imp5 should be about six times greater than imp2. Therefore in assessing the restricted risk of areas of low pest production in Table 9.20 (part B page 99), imp5 should be revised upwards from U(2.88E–07, 2.65E–05) and U(4.81E–08, 4.41E–06) for 0.03 and 0.005 cases per hectare per year respectively, to U(1.73E–06, 1.59E–04) and U(2.89–07, 2.65E–05) respectively. This assumes that imp2 has been correctly specified. Elsewhere we take issue with the value of imp2.

Similarly, the values of imp5 reported in Table 9.21 for visual inspection, and Table 9.23 for area of low pest prevalence and visual inspection should also be revised upward by a factor of six.

The draft IRA report assumes that chlorine disinfection will "*reduce the risk of new fruit infection by 90%*" (part B, page 101). Therefore in assessing imp5 in risk management strategies involving chlorine disinfection, imp5 is reduced by a factor of 10 from imp2, in Table 9.22 (part B, page 101), Table 9.24 (part B, page 102), Table

9.25 and Table 9.26 (part B, page 103). This reduction is too great. Based on the assumption that each infected cluster will cross infect 6 other clusters, this reduction should be by a factor of 10/6=1.67.

Thus the ranges for imp5 given in Table 9.26, should be, for example, U(3.46E–08, 3.17E–06) and U(6.90E–08, 6.36E–06) for 0.03 and 0.06 cases per hectare per year respectively.

This represents a sevenfold increase in the number of infected clusters entering Australia with the recommended management options which do not involve chlorine disinfection, putting the risk well over the ALOP. In the case of measures involving chlorine disinfection, this represents a 60% increase in the number of infected clusters entering Australia. This alone, in the case of low pest prevalence with 0.06 cases per hectare per year, with visual inspection and chlorine treatment, is sufficient to place the probability of entry establishment and spread within 10% of the threshold above which ALOP is not met. If chlorine disinfection is not as efficacious as the figure used, the situation is even worse.

The analysis is clearly very sensitive to the relationship between imp2 and imp5. Yet this relationship is treated as certain in the pest risk assessment for Moko. Throughout, imp5 is related to imp2 by a factor of exactly 1. This factor is not known exactly, but may plausibly be considerably greater. This is not considered in the draft IRA report, with the consequence that risk management measures not involving chlorine disinfection, which are asserted to meet Australia's ALOP, will not do so, even if this cross infection factor is as small as just over 2. Those which do involve chlorine disinfection are highly sensitive to the actual efficacy of chlorine disinfection, so that no confidence can be placed in the assertion that the probability of entry establishment and spread is actually below the threshold defining Australia's ALOP for Moko.

For example, in the case of low pest prevalence with 0.06 cases per hectare per year, with visual inspection and chlorine treatment, revising the value of imp5 as above results in the following probabilities of entry establishment and spread, based on simulations of the spreadsheet model distributed by BA:

Scenario B, asymptomatic hosts	2.32E-04
Scenario B, bananas and *Heliconias*	3.58E-04
Scenario C	2.60E-05
Scenario D	2.89E-04
Total PEES	9.05E-04

As we note below, the total PEES is an estimate only of the median, subject to some bias due to the shapes of the densities concerned. The estimated bias found to apply below would be sufficient to make the risk due to the total probability of entry establishment and spread exceed the ALOP.

11.2 Proximity

The draft IRA report argues that the probability of asymptomatic carrier hosts being within a 30 or 5m is 1 for grower areas, and 0.1 for other areas. This second figure is incorrect, as it is derived from consideration of climatic conditions suitable for the survival of Moko in the asymptomatic hosts. The draft IRA Report states that (part B page 78), "*Taking temperature and the population density and area into account, the IRA team estimated that about 10% of the readily accessible parts of other areas would be suitable for the survival of Moko in asymptomatic carrier hosts.*"

The only consideration here should be whether the asymptomatic carrier hosts are within the 30 or 5 m distance, and considering the ubiquitous nature of the asymptomatic hosts, this should be a probability of 1 in other areas, just as it is in grower areas.

The suitability of areas for survival of Moko due to environmental considerations such as temperature is properly considered under the probability of establishment, and indeed the draft IRA report reduces the probability of establishment in other areas for just this reason: "*The establishment of Moko in the other areas is less likely to be successful than in grower areas. The climate during cooler periods of the year could lower the likelihood of establishment of the pathogen in these areas. On this basis, the establishment value for each of the exposure groups was considered to be of Uniform distribution with a minimum of 0.5 and a maximum of 0.8.*" (part B, p91)

Similarly, population density of the other areas is an irrelevant factor and should have no bearing on the calculation of the probability of carrier hosts being within the relevant 30 or 5m radius of discarded waste. The only factor of relevance is the density of asymptomatic hosts. It is not clear how "area" has been taken into consideration in the deliberations of the IRA panel, though it is clear that any consideration of area will be methodologically incorrect, as the only factor of relevance is the density of hosts.

11.3 Proportion of waste near each exposure group

11.3.1 Other Areas

The draft IRA report states that no banana plants grow at controlled waste facilities in other areas, and bases its analysis on this assumption. However this assumption is not supported by the local area survey (BA February 2006). Only four out of 54 respondents had knowledge of the distance banana plants grew from the facility, the rest not knowing. Out of those four, none reported bananas growing at the tip itself. This does not provide a basis to conclude that bananas do not grow at tips in non-grower areas. The data, zero out of four, is consistent with a rate from zero up to 44% of tips with bananas. However the data is not consistent with no bananas growing at the tip. In fact four respondents had knowledge of bananas growing in the vicinity, albeit not at the facility itself. Therefore it is reasonable to conclude that bananas do grow in the vicinity of waste facilities in other areas, and that in a small proportion of them, there will be bananas growing at the tip itself. To estimate what this proportion may be, we note that in grower areas, the ratio of facilities with banana plants to those without was found to be 2/45. As a rough estimate, we may apply this ratio to the 4/54 of other area facilities that have banana plants in the vicinity, to get a proportion of 0.3% of facilities where banana plants grow at the tip. We note that there are considerable uncertainties in this figure, and that it could be much higher.

The pest risk assessment is deficient in not considering correctly that there is likely to be a small proportion of controlled waste facilities in other areas where banana plants are growing at the tip, and should be revised taking this into account.

This revision should be applied to all pest risk assessments.

11.3.2 Grower Areas

The draft IRA report states in respect of banana plants growing at controlled waste facilities in grower areas that "*Averaged over all the controlled waste facilities in grower areas, the IRA team considered that no more than a proportion of 8.74E–05 of the waste would be within 30 m of the plants at the facility and no more than 1.00E–09 could be within 5 m".* (part B, page 76). This proportion must be a product of two factors, the proportion of controlled waste facilities where banana plants are growing, and the proportion of waste at such a facility that is within the specified 30m or 5m radius of the banana plants which are growing there. Using the survey conducted of municipal councils (Local government area survey, February BA 2006), it was reported that 4% of municipal tips in grower areas have banana plants growing at the tip. The approximate standard error of this figure based on the 47 respondents is three percentage points, and due to the large number of non-respondents (32), there may be significant bias in the reported figure. Therefore the survey data would be consistent with a figure as high as 10%. In fact a Jeffreys 95% credible interval gives a range from 0.9% to 13%.

The draft IRA Report concludes that "*no more than a proportion of 8.74E–05 of the waste would be within 30 m of the plants at the facility"* For this to be consistent with the survey information, there must be a proportion of 8.74E-05/0.13 = 6.72E-04 of waste near banana plants at a facility with banana plants. For this to be true, the size of the facility would need to be $30\times30\times\pi/6.72\text{E-}04 = 4.2\text{E}6$ square metres, or 4.2 square kilometres. This assumes that waste is distributed uniformly over the facility, and that there is just one banana plant at the tip. Since the survey report refers to banana plants, it is likely that there would typically be more than one banana plant, so that the required size of the facility to support the contention of the draft IRA report would be even greater. The average size of municipal tips is certainly much less than 4.2 square kilometres. If we work off an assumed area of 0.25 square kilometres, which seems more reasonable, but which requires confirmation, then the proportion of waste near banana plants would be $30\times30\times\pi/2.5\text{E}05 = 1.1\text{E-}02$, and the maximum proportion of waste within 30m of the plants at the facility would be $0.13\times1.1\text{E-}02=1.5\text{E-}03$. This is a factor of 17 times larger than the maximum value quoted in the draft IRA report. The maximum proportion of banana waste within 5m would be given by 0.13×5×5×π/2.5E05 = 4.08E-05. This is over 40,000 times larger than the figure of 1E-09 reported in the draft IRA Report.

Both of these figures should be revised to properly reflect the survey data, and the average size of municipal waste facilities.

The same error is made in regard to black sigatoka disease, (part B, page 115), where the draft IRA report concludes that "*a proportion of no more than 8.74E–05 of the waste could be within 30 m of the plants at the facility.*" As for Moko above, this proportion should be 1.5E-03, based on the local government survey (BA February 2006). Likewise in Freckle disease, the conclusion that "*no more than a proportion of 1.00E–10 of the waste could be within 2 m of plants at the facility.*" (part B page 151) is not only inconsistent with the survey data as described above, but also inconsistent with conclusions for Moko and Sigatoka. Simple proportionality informs us that if 8.75E-05 was correct for the proportion of waste within 30m of a banana plant at a waste facility, then to get the proportion within 2m, we should divide by 225. This gives 3.9E-07, not 1.0E-10 as asserted. The correct value based on the survey data should be no more than 6.7E-06.

The error is also found in the consideration of Banana Bract Mosaic Virus on page 174 (part B), and in Banana Bunchy Top Virus on page 190 (part B), where the relevant distance is 70m instead of 30m. As with Freckle, the value given is neither consistent with the values given for Moko and Black Sigatoka, nor is it consistent with the survey data. Using the approach above, this value should instead be 8.2E-03.

12 Risk Management for Black Sigatoka

The recommended risk management procedure for black sigatoka, according to the draft IRA report, is an area of low pest prevalence, trash minimization, and post-harvest treatment. For scenario B (part B, page 141), it is assessed that these measures will affect the calculation of the probability of transfer, by reducing *"…the proportion of fingers from which spores are uplifted to about 0.1% of the unrestricted estimate for this parameter.*"

The draft IRA report goes on to say, "*The upper limit for the number of spores uplifted (Factor 4) would only be one. These reduced values were used (as described in Section 10.13) in the calculation of Factor 3 of 'Exposure – transfer' to determine the transfer values, which were about 0.15% of the unrestricted values.*"

Given that the calculations required for computing the transfer probability for both scenarios in the unrestricted case are obscure, and not transparently documented so that a reader may understand in detail how the calculations were made, it is impossible to apply these corrections to verify that the impact on the probability of entry establishment and spread is as stated. This is a serious lack of transparency, as stakeholders can not assess procedures which are not explained in detail.

The draft IRA report states that the affect of the above calculations is to reduce the transfer values of Table 10.10 (part B, page 128) by a factor of 0.0015. We have applied this factor to the values of Table 10.10, and using the spreadsheet distributed by BA, with values for scenario B as per the draft IRA report, we find that the median probability of entry establishment and spread is 3.13E-02, not 1.82E-02 as stated in the draft IRA report (part B, page 141), with a 95th percentile of 7.47E-02, well over the threshold of 0.05 for meeting the ALOP.

Combining the results of both scenarios, we find that an estimate of the combined median is 0.0313 + 0.0305 = 0.0618, which exceeds the threshold of 0.05, so that the ALOP is exceeded for this risk management measure. The combined median reported by the draft IRA report is 0.0488, which is only just below the threshold for exceeding the ALOP. This figure is either incorrect, or so sensitive to small differences asserted by the draft IRA report to have approximately the same affect, that no confidence can be placed in the assertion that this risk management measure results in the ALOP being met.

13 Consideration of the 95th Percentile in Risk Management Measures

The draft IRA report asserts that 95th percentile is considered in assessing pest risk management, saying (part B, page 18) "*However, the spread of PEES values (based on the 5th and 95th percentile values) is considered by the IRA team in reaching its recommendations.*"

However the 95th percentile appears not to be even calculated in the pest risk assessments for Moko and black Sigatoka. In the following sections we estimate this 95th percentile for Moko and black Sigatoka, and conclude that the median PEES is so close to the threshold for exceeding the ALOP that no confidence can be placed in the risk management measures asserted to control the risk to below the ALOP.

13.1 Moko

The restricted risk for Moko (based on ALPP at 0.06 cases per hectare per year, visual inspection and chlorine disinfection) significantly exceeds ALOP if the 95th percentile (rather than the 50th percentile) of the restricted likelihood of the entry, establishment and spread is taken into account. The 95th percentiles of the restricted risk scenarios are not reported in the draft IRA report, which in itself is a significant lack of transparency. However they may be established by using appropriate input values in the spreadsheet model distributed by BA. We have done this in the case of Moko disease for the risk measure described above, giving the following percentiles for the four significant (according to the draft IRA report) scenarios.

Scenario	5th Percentile	50th Percentile	95th Percentile
B – leaching – Bananas and Heliconias	2.20E-05	2.27E-04	8.07E-04
B – leaching, Asymptomatic Hosts	1.82E-05	1.46E-04	4.92E-04
C	3.23E-06	1.76E-05	4.12E-05

D	2.53E-05	1.84E-04	5.92E-04

5th , 50th and 95th percentiles of the four Moko scenarios which, according to the draft IRA report, significantly affect the probability of entry establishment and spread. These values have been generated using the spreadsheet model distributed by BA, with input values as appropriate according to the draft IRA report

Using the output histogram generated by the spreadsheet model for each of the scenarios above, the mean and variance of the PEES for each scenario can be calculated, and then a beta distribution can be fitted using the method of moments to estimate α and β parameters from the mean and variance, as per the table below.

Scenario	Mean	variance	Est. α	Est. β
B – leaching – Bananas and Heliconias	2.9507E-04	6.3142E-08	1.3782E+00	4.6693E+03
B – leaching, Asymptomatic Hosts	1.8653E-04	2.2628E-08	1.5373E+00	8.2396E+03
C	1.8957E-05	1.3662E-10	2.6304E+00	1.3875E+05
D	2.2979E-04	3.2210E-08	1.6387E+00	7.1298E+03

We may then use simulation to estimate the percentiles of the overall PEES obtained by adding together these four significant (according to the draft IRA report) scenarios, that is simulating four beta distributed random variables with the α and β parameters as indicated above, and adding them. We drew a sample of 10,000 such random variables, estimating the overall PEES to have a median of 6.78E-04, a 95th percentile of 1.39E-03, and a 5th percentile of 2.78E-04.

The overall distribution of the probability of entry establishment and spread for Moko, when risk management measures of an area of low pest prevalence (0.06 cases per hectare per year), visual inspection, and chlorine treatment is shown in Figure 2.

There are two significant factors to note. Firstly, the 95th percentile is well over the threshold of 1E-03 which indicates that ALOP will not be met. Secondly, that the median is greater than the sum of the medians, used in the draft IRA report to represent the overall PEES for risk analysis purposes.

In failing to properly simulate the overall PEES, the draft IRA Report uses an approximate estimate, the sum of the individual scenario medians, for the true median of the overall PEES. In this case, the nature of the approximation would appear to underestimate the median of the overall PEES by about 15%.

Based on the simulations described above, we may calculate the percentile at which the ALOP threshold is exceeded for Moko disease with the above risk management measures in place. Our calculations show that this threshold is exceeded at a percentile of 81%. This may be interpreted to mean that given the uncertainties and variability assumed by the draft IRA report, there is about a 19% chance that the ALOP will be exceeded for Moko with the risk management measures described above.

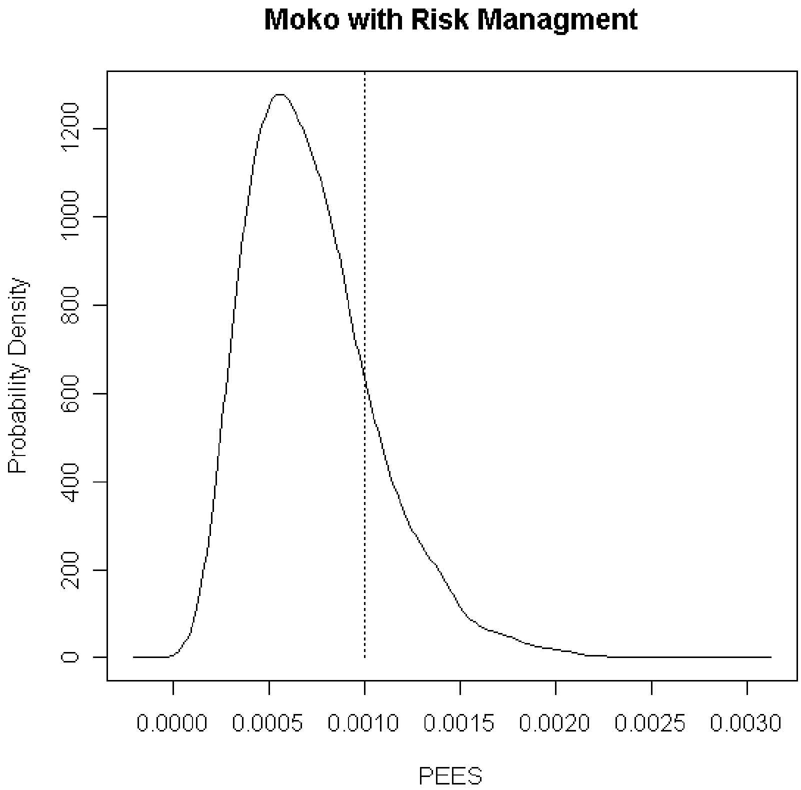

Figure 2. Approximate distribution of the probability of entry establishment and spread for Moko, with risk management measures consisting of an area of low pest prevalence (0.06 cases per hectare per year), visual inspection, and chlorine disinfection. The threshold for exceeding the ALOP at 0.001 is shown as a dotted line. The chance of exceeding the ALOP is approximately 19%.

Given that the draft IRA report does not adequately represent either uncertainty or variability, as discussed above, this 19% chance of exceeding the ALOP is likely to be much greater in reality.

We conclude that the 95th percentile in relation to the overall PEES has not been effectively considered in the draft IRA report, or that any such consideration has not been reported. With a greater than 19% chance of exceeding the ALOP, little confidence can be placed in the risk management measures asserted to manage the risk to below the ALOP.

13.2 Black Sigatoka

We may estimate the 95th percentile of the overall probability of entry establishment and spread for black Sigatoka with the recommended risk management measures using the same procedure as above. Our simulations for Scenario A and B give the following values:

Scenario	5th Percentile	50th Percentile	95th Percentile
A	2.34E-03	3.05E-02	1.48E-01
B	9.42E-03	3.13E-02	7.47E-02

5th , 50th and 95th percentiles of the two black Sigatoka scenarios which, according to the draft IRA report, significantly affect the probability of entry establishment and spread. These values have been generated using the spreadsheet model distributed by BA, with input values as appropriate according to the draft IRA report

As we note above, our simulation results for Scenario B, based on the information provided in the draft IRA report differ from those presented in the draft IRA report, such that the median PEES is increased by a substantial factor.

As described above, beta distributions were fitted as per the table below.

Scenario	Mean	variance	Est. α	Est. β
A	4.6439E-02	2.3071E-03	8.4492E-01	1.7349E+01
B	3.5053E-02	4.0507E-04	2.8919E+00	7.9610E+01

Using the simulation method as described above, we find that the 5th percentile is approximately 0.023, the 50th percentile is approximately 0.069, and the 95th percentile is approximately 0.182, and the percentile at which the ALOP is exceeded is approximately 31%. We may conclude that there is approximately a 69% chance that ALOP is exceeded with this risk management measure, given that all input values and ranges have been appropriately chosen, and the model is otherwise sound. In reality the chance of exceeding the ALOP will likely be considerably greater, given the various points discussed in this report.

In Figure 3, we show the approximate distribution for the probability of entry establishment and spread for black Sigatoka, with risk management measures as recommended.

14 Conclusions

We conclude that there are significant errors in the draft IRA Report and its associated risk modelling that prevent it from validly assessing the risk according to the stated methodology. These include an error in the calculation of the density of banana and *Heliconia* plants in home gardens in other area, which results in an under estimate of the probability of entry establishment and spread in relation to Moko and Black Sigatoka; incorrect interpretation of survey data which provides for a maximum rate of bananas growing at waste facilities in grower areas of 13%, rather than 4% as used in the report, which underestimates the probability of entry establishment and spread in all quantitative pest risk assessments; the incorrect reduction of a proximity probability in Moko disease due to temperature, which underestimates the probability of entry establishment and spread; a calculation error in the probability of factor 3 in exposure scenario B for black sigatoka which underestimates the probability of entry establishment and spread; and an apparent error or inconsistency in calculating the median PEES for scenario B in black Sigatoka with risk management. The presence of these errors causes us to have no confidence that the draft IRA report truthfully represents the risk of the various risk management measures, according to its stated methodology.

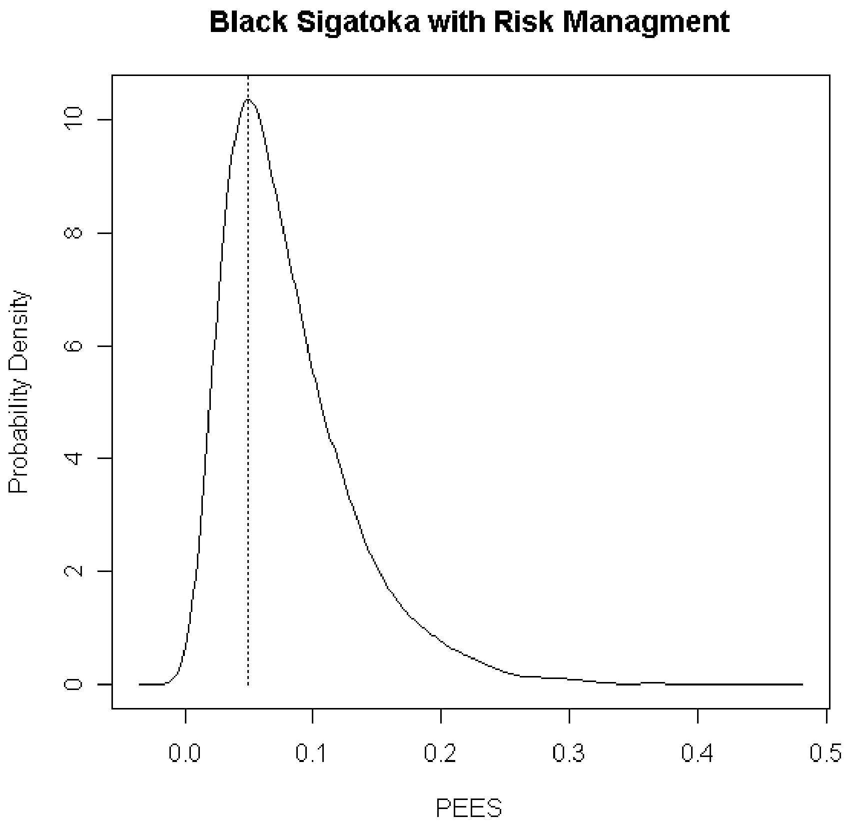

Figure 3. Approximate distribution of the probability of entry establishment and spread for black Sigatoka, with risk management measures consisting of an area of low pest prevalence, visual inspection, and chlorine disinfection. The threshold for exceeding the ALOP at 0.051 is shown as a dotted line. The chance of exceeding the ALOP is approximately 69%

In addition, we find that the methodology is deficient in several important aspects. These are that

- risk for each pest is treated individually, and the overall risk of trade as represented by all pests collectively is never considered or assessed. While each pest may be found individually to be below Australia's ALOP, this does not necessarily imply that the risk aggregated over all pests is below Australia's ALOP;
- risks judged to be below the ALOP have probability of entry establishment and spread estimated to be very close to the threshold, such that given the uncertainties inherent in the modelling, no confidence can be placed on the assertion that the ALOP has been met;
- clustering and variability has not been specifically considered for each pest;
- uncertainty in probability of entry establishment and spread has not been considered in determination of risk;
- consequences are not assessed consistently, have inappropriate weightings, are not considered to be additive, and include irrelevant criteria which reduce the resulting aggregated risk;

- the procedure adopted is a mixture of two incompatible methodologies such that no confidence can be placed on the outcome being appropriately risk averse;
- 95th percentiles, or indeed the distribution of probability of entry establishment and spread, are not considered appropriately in forming a view that a management measure satisfies the ALOP.

For these reasons we believe that no confidence can be placed in the conclusions of the draft IRA Report as it currently stands, and that the risks estimated are likely to underestimate the true risk associated with importation of bananas from the Philippines.

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