Appendix B

Report by Professor Pettitt and Dr Reeves in relation to error

Error in Assessment of Risk for Black Sigatoka

Prof. Tony Pettitt
Dr Robert Reeves
School of Mathematical Sciences
Queensland University of Technology
12th September 2007

1 Introduction

In the draft IRA report (BA 2007), in Sections 10.6 and 10.13 (part B, pages 116 and 126) the details of the calculations required for the probability of transfer based on estimates of factors one, two, three and four, where factor four has three components, (A,B,C), are not given, and the consistency of model input values summarized in Table 10.10 with the values assessed for each factor could not therefore be checked. Consequently, where risk mitigation measures were asserted to impact these factors, the impact on model input values could not be assessed. This was of concern as indicative transfer values quoted in the report as 0.0015 times the unrestricted transfer values given in Table 10.10 of the draft IRA report resulted in a risk that exceeded the ALOP, as opposed to achieving the ALOP as asserted in the draft IRA report.

In order to resolve this discrepancy, a request for information was made to Biosecurity Australia to clarify these points, and correspondence from Biosecurity Australia (dated 11 September 2007) was subsequently received explaining in detail the calculations involved. Upon examination of this correspondence, it is apparent that an error remains in the way that the transfer values were calculated for the systems approach to risk management involving area of low pest prevalence, trash minimisation and post-harvest treatment.

The draft IRA report records (part B, page 138) that the IRA team assessed that trash minimisation would reduce the level of spore contamination by 80% to 90%, implying an average reduction to 15% of the pre-measure level. This figure of 15% is used when the measure of trash minimisation is assessed in isolation. However, this figure is reduced to 10% for the systems approach to risk management, implying that the measure has become substantially more effective, with no justification or explanation for the use of the smaller figure.

While it is reasonable to expect that the measure would be similarly effective in a systems approach, given independence of the measures, there appears no sound basis for the measure to become more effective.

The effect of this error is to underestimate the transfer-exposure values, and hence the probability of entry establishment and spread and therefore the risk. When this error is corrected, the restricted risk for black Sigatoka is assessed to exceed the ALOP.

2 Detail of Error

2.1 Calculation procedure

According to correspondence received from Biosecurity Australia, the transfer-exposure probabilities are calculated from factors 1 to 4 as follows:

$$p_{trans} = f_1 \times f_2 \times f_3 \times f_4$$

where

$$f_4 = 1-(1-f_{4B} \times f_{4C})^n$$

with p_{trans} the probability of transfer, factors 1 to 4 represented by $f_1 \cdots f_4$, factor 4A, or the number of viable spores lifted represented by n, f_{4B} representing factor 4B or the area of host surface as a proportion of the area of the proximity zone, and f_{4C} representing factor 4C or the efficiency with which spores adhere to host plant surfaces.

According to correspondence from Biosecurity Australia, factor 3 is calculated by multiplying together the probability of suitable weather conditions with the proportion of infected waste from which spores would be uplifted. This proportion of infected waste is calculated by assuming that each piece of waste has 100 viable spores (in the unrestricted case), each spore has a probability of 0.01 of being uplifted, and a binomial density is used to calculate the probability of one or more spores being uplifted. The binomial density also implies that 1 or 2 spores will be uplifted, which is the value of factor 4C, according to the correspondence received.

2.2 Risk Management – Scenario B

The IRA team assessed that the risk mitigation measures would reduce the level of black Sigatoka spores on export bananas by 80-90% for trash minimisation, 90% for areas of low pest prevalence, and a further 90% for post-harvest treatment. The IRA team considered that this would have no impact on the importation and distribution, but would only impact on the probability of transfer. According to the received correspondence, the reduction of 90% for use of an area of low pest prevalence, would reduce the number of spores on a piece of waste from 100 to 10, thus reducing the probability of uplifting one or more spores to approximately 0.1.

The reduction in 80-90% in spore levels due to trash minimisation results in a figure of 15 spores instead of 100 being present on a piece of banana waste. Leaving aside the issue that this does not correctly represent the uncertainty in the expert assessment, the figure of 15 spores out of 100 corresponds to a reduction of 85%, halfway between the ends of the quoted range, and so suitably represents an average value.

The reduction of a further 90% due to post harvest treatment appears to be modelled by reducing the binomial proportion from 0.01 to 0.001, which is a reasonable approach in this context.

However when the systems approach, consisting of the three measures in combination, is assessed, it is asserted in point 4 of the correspondence, that "combining low pest prevalence and trash minimisation means that there would only be one spore (rather than 100) on a banana that might be uplifted." However this is inconsistent with the treatment of trash minimisation in isolation, and inconsistent with the IRA team's stated opinion that spore levels would be reduced by 80-90%. The combination of these assumed independent measures should result in a reduction to $0.1\times0.15=0.015$ of the spores available for uplift on a piece of banana waste. Thus on average, a piece of banana waste will have 1.5 spores available for uplift, not one spore, as asserted in the correspondence. Of course, this is an average figure, individual pieces of waste will have an integral number of spores, but on average, there will be 1.5, not 1.

The probability of uplifting viable spores from a piece of banana waste should therefore be assessed to be 1.5% without post harvest treatment or 0.15% with post harvest treatment, 50% greater than the values used in the draft IRA report.

Substituting these values into the BA spreadsheet model, results in a median probability of entry establishment and spread of 3.21E-02, with a 95th percentile of 7.68E-02, and a 5th percentile of 9.67E-03. When added to the median probability of entry establishment and spread reported for scenario A, 3.06E-02, the overall probability of entry establishment and spread has an estimated median of 6.27E-02, which exceeds the ALOP.

3 Conclusions

The risk calculations for black Sigatoka, cannot be relied upon, as the risk associated with scenario B has not been assessed correctly. This is due to incorrectly assuming the risk mitigation measures would reduce factor 3 in the probability of transfer by a factor of 0.001. The correct factor consistent with the IRA team's stated opinion and the assessment of trash minimisation as an individual measure, is 0.0015. Using the correct figure results in an overall restricted risk of entry establishment and spread of black Sigatoka that exceeds the ALOP. This is assuming that all other elements of the model are correct, and all other model values are chosen appropriately.

References

Biosecurity Australia (2007) Revised Draft Import Risk Analysis Report for the Importation of Cavendish Bananas from the Philippines, Part B. Biosecurity Australia, Canberra.

Pettitt, A.N. and Reeves, R.W. (2007). *Report on Methodological Issues pertaining to Revised Draft Import Risk Analysis Report for the Importation of Cavendish Bananas from the Philippines.* Annexure to the ABGC submission in response to "Revised Draft Import Risk Analysis Report for the Importation of Cavendish Bananas from the Philippines".

Appendix C

Reports by Professors O'Neill and Basford in relation to error

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Tony Heidrich
Chief Executive Officer
Australian Banana Growers' Council Inc
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Dear Mr Heidrich

MATERIAL ERROR IN REVISED DRAFT IRA REPORT FOR BANANAS

As requested, I have reviewed the letter from John Cahill to you dated 19 March 2007.

I agree with the statement contained in that letter that the draft IRA report "should reflect a range of 1 to 2 spores as the input value as opposed to the (rounded down) value of 1 spore used in the revised draft report".

I disagree with the suggestion implicit in that letter that the use "of the (rounded down) value of 1 spore" rather than "a range of 1 to 2 spores" is not a material error but is rather a difference of expert opinion.

The use of "1 spore" as the input value is a material error because it does not reflect the IRA team's expressly stated opinion in the draft IRA report as to the efficacy of the trash minimisation measure. An input value of "a range of 1 to 2 spores" is the only input value that correctly reflects that opinion.

Having regard to the IRA team's expressly stated opinion in the draft IRA report, I do not believe that:

- there is any rational statistical or mathematical basis for the use of "1 spore" as the input value in the draft IRA report; or
- any statistical expert could reasonably and fairly form the opinion that "1 spore" is an appropriate input value to model the opinions expressed in the draft IRA report.

I have reviewed the FOI documents attached to the letter from Louise van Meurs to Stuart Clague dated 17 March 2008. Nothing in those documents causes me to alter the views which I have expressed above.

The use of "1 spore" (rather than the correct value of "a range of 1 to 2 spores") has caused the statistical model to underestimate the restricted probability of the entry, establishment and spread of black Sigatoka, and therefore the restricted risk of black Sigatoka. The IRA team would have been misled by relying on the results of that modelling based on this error. I note from the FOI documents that Biosecurity Australia's statistical consultant has calculated that the use of the correct input value would "result in the risks exceeding ALOP".

Yours sincerely

TJ O'Neill

Professor Terry O'Neill[1]
Monday, 14 April 2008

[1] Terence O'Neill is Professor of Applied Statistics and Head of the School of Finance & Applied Statistics, College of Business & Economics, The Australian National University.

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14 April 2008

Tony Heidrich
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PO Box 309
BRISBANE MARKET QLD 4106

Dear Mr Heidrich

Draft IRA Report

I am writing in response to your request for me to review the letter from Biosecurity Australia to you on 19 March 2008.

Firstly, I note that the IRA team has correctly concluded that the draft IRA report should reflect a range of 1 to 2 spores as the relevant input value in the calculation of the estimate of the restricted probability of entry, establishment and spread of black Sigatoka under risk mitigation measures, as opposed to the (rounded down) value of 1 spore used in the revised draft IRA report. That conclusion is consistent with the view which I expressed in my letter to you of 5 October 2007.

You have asked my opinion as to whether the use of a rounded down value of 1 spore as the relevant input value in the revised draft IRA Report was an error.

You have also asked my opinion as to whether the use of a range of 1 to 2 spores, as opposed to 1 spore, as the relevant input value in modelling the opinions expressed by the IRA team is a matter about which experts could reasonably differ.

The use of 1 spore as the relevant input value to estimate the restricted probability of exposure-transfer with Scenario B for the combined effect of low pest prevalence and trash minimisation is not consistent with the IRA team's stated opinion as to the efficacy of those two independent measures.

The use of a range of 1 to 2 spores (or an average of 1.5 spores available for uplift) as the relevant input value in that calculation is consistent with the IRA team's stated opinion.

For that reason, it is my view that the use of 1 spore as the relevant input value in the revised draft IRA Report was in error.

...2/.

Having regard to the IRA team's stated opinion as to the efficacy of the risk mitigation measures, I do not believe that the use of a range of 1 to 2 spores as opposed to 1 spore as the relevant input value in modelling the opinions expressed by the IRA team is a matter about which experts could reasonably differ.

Yours sincerely

Kaye Basford

Kaye E. Basford
Professor of Biometry

CC: Stuart Clague, Senior Associate, Corrs Chambers Westgarth Lawyers

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Wednesday, October 24, 2007

To: Tony Heidrich
Chief Executive Officer
Australian Banana Growers' Council Inc

Dear Mr Heidrich

ERROR IN REVISED DRAFT IRA REPORT

I have reviewed the following documents

1. Attachment 1 to the letter to you from Biosecurity Australia dated 11 September 2007.
2. The report by Professor Pettitt and Dr Reeves dated 12 September 2007 which describes a modelling error in the risk analysis for black Sigatoka.
3. The response by Biosecurity Australia to the report by Professor Pettitt and Dr Reeves dated 24th September 2007.

I agree with the conclusions reached by Professor Pettitt and Dr Reeves in their report in respect of the modelling error (other than the highlighted sections which I am unable to verify without access to Biosecurity Australia's spreadsheet model).

In particular, I consider that the statement *"combining low pest prevalence and trash minimisation means that there would be only 1 spore (rather than 100) on a banana that might be uplifted"* in Attachment 1 to the letter from Biosecurity Australia on 11th September is incorrect because it is inconsistent with the IRA team's stated opinion that the trash minimisation measure will reduce the level of black Sigatoka spores on export bananas by 80-90%. In 3.3.1, page 18, of part B of the IRA, Biosecurity Australia states "*The model uses average values rather than worst case values. The consistent use of worst case values leads to a result that would significantly overestimate the risk.*" However, when considering the combination of the risk mitigation measures of areas of low pest prevalence and trash minimization, Biosecurity uses a value of 90% for the reduction of black Sigatoka spores by trash minimization. This is not the average value of 85%, rather it is a best case scenario for the effect of trash minimization. It does not comply with the stated intention of Biosecurity Australia to use average values.

Having regard to the IRA team's stated opinion as to the efficacy of the trash minimization measure, I agree with Professor Pettitt and Dr Reeves that combining low pest prevalence and trash minimization means that there would, on average, be 1.5 spores on a banana that might be uplifted. The use of the best case scenario of 1 spore on a banana will lead to an over optimistic view of the effect of the risk mitigation procedure of trash mininimization.

The modelling error has caused the IRA team to underestimate the restricted probability of entry, establishment and spread for black Sigatoka.

Yours sincerely

Professor Terry O'Neill[1]

[1] Terence O'Neill is Professor of Applied Statistics and Head of the School of Finance & Applied Statistics, College of Business & Economics, The Australian National University.

Curriculum Vitae

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Present Position

Head, School of Finance & Applied Statistics, ANU since 1.1.01

Professor of Applied Statistics, ANU since 1.6.01

Date and Place of Birth

30 December, 1951, Adelaide – Australian Citizen

Academic Qualifications

1972 B.Sc., Adelaide University

1973 B.Sc., Honours 1 in Statistics, Adelaide University

1976 M.S. in Statistics, Stanford University, CA, USA

1976 Ph.D. in Statistics, Stanford University, CA, USA

1998 Accredited Statistician (AStat), Statistical Society of Australia

Academic Awards

1967-1968	Commonwealth Secondary Scholarship
1969-1972	Commonwealth Tertiary Scholarship
1971	The David Murray Prize, Adelaide (top science student)
1971	Sir Ronald Fisher Memorial Prize, Adelaide (top of 3rd year statistics)
1973	Offer of a Commonwealth Overseas Postgraduate Scholarship
1973-1976	CSIRO Postgraduate Studentship in Statistics at Stanford University
1984	Fulbright Fellow in Statistics & Biostatistics at Stanford University
1994	Elected Ordinary Member of the International Statistical Institute
1997	Elected as Fellow of the Institute of Mathematical Statistics Citation: '*for significant contributions to discrimination/classification theory and survival analysis; for excellence in collaborative biomedical research and road safety research; and for leadership in education*'
1998	Awarded the Honorary Rank of Fellow of the American Statistical Association for '*outstanding contributions to statistics*'
2004	Best paper award – College Teaching & Learning Conference USA

2005 Best paper award – EABR & TLC Conference Greece

2006 Australian Pesticides & Veterinary Medicines Authority Science Fellow in Statistics

Publications

Over 70 publications in international refereed journals.

Statistical Consulting

Thirty years experience as a consultant to industry & government including the following major clients:

- Commonwealth Department of Defence, Canberra
- Neilson Associates Pty. Ltd., Management Consultants, Canberra
- ACT Administration, Canberra
- Civil Aviation Authority, Canberra
- Tasman Institute, Melbourne
- Federal Office of Road Safety, Commonwealth Govt., Canberra
- Price Waterhouse, Canberra
- AT&T Bell Laboratories, NJ, USA
- Deacons, Graham and James, Solicitors & Barristers, Canberra
- Australian Customs Service, Canberra
- ACIL Consulting, Canberra & Melbourne
- Department of Natural Resources & Environment, Victorian Govt., Melbourne
- Health Services Division of the Commonwealth Department of Health and Aged Care, Canberra
- Bureau of Transport Economics, Australian Govt., Canberra
- Australian Automobile Association
- Revenue Management Branch, ACT Govt., Canberra
- Australian Wool Innovation Limited
- Australian Banana Growers' Council
- Civil Aviation Safety Authority
- Australian Fisheries Management Authority
- Department of Agriculture, Fisheries and Forestry
- Bureau of Rural Sciences
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5 October 2007

Tony Helrich
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Dear Mr Heidrich

Draft IRA Report

I have reviewed the following documents:

- Extracts of draft IRA Report,
- Attachment 1 to the letter to you from Biosecurity Australia dated 11 September 2007, and
- Report by Professor Pettitt and Dr Reeves dated 12 September 2007.

The IRA team's stated opinion is that risk mitigation measures would reduce the level of black Sigatoka spores on export bananas by 80-90% for trash minimisation, 90% for areas of low pest prevalence, and 90% for post-harvest treatment. When using the Systems approach to integrate different risk management measures, the individual reductions due to areas of low pest prevalence, trash minimisation and post-harvest treatment are multiplied together because they are independent of one another.

Hence, in Scenario B on page 140 of the draft IRA Report, the mitigation measure for areas of low pest prevalence and trash minimisation would reduce the proportion of fingers from which spores are uplifted to 1.5%, rather than 1%, of that in the unrestricted scenario. This is consistent with the statement by Professor Pettitt and Dr Reeves that combining areas of low pest prevalence and trash minimisation means that on average, a piece of banana waste will have 1.5 spores available for uplift.

Similarly, in Scenario B on page 141, the mitigation measure for areas of low pest prevalence, trash minimisation and post-harvest treatment will reduce the proportion of fingers from which spores are uplifted to 0.15%, rather than 0.1%, of the unrestricted estimate for this parameter.

I agree with Professor Pettitt and Dr Reeves that in the draft IRA Report there is an underestimation of the restricted probability of exposure-transfer with Scenario B for the mitigation measures for:

- The combined effect of low pest prevalence and trash minimisation, and
- The combined effect of low pest prevalence, trash minimisation and post harvest treatment.

This error in the draft IRA Report results in underestimates of the restricted probability of entry, establishment and spread of black Sigatoka with these risk management conditions.

Please contact me if you wish to discuss this further.

Yours sincerely

Kaye Basford

Kaye E. Basford
Professor of Biometry

CC: Stuart Clague, Senior Associate, Corrs Chambers Westgarth lawyers

Appendix D

Report by Professor Pettitt and Dr Reeves in relation to methodological issues

Key Statistical Issues with IRA Methodology

Prof Tony Pettitt
Dr Robert Reeves
School of Mathematical Sciences
Queensland University of Technology
28th April 2008

Executive Summary

Serious deficiencies in the methodology for Import Risk Assessment are likely to make it understate the actual risk of a decision to import a commodity. Import decisions based on the methodology are likely to result in costs and consequences which are greater than those consistent with Australia's ALOP (Acceptable Level of Protection).

The main reasons for this are:

- Failure to adequately characterise consequences of pest or disease entry, establishment and spread;
- Failure to consider the total risk of the importation, instead considering pests and diseases on an individual basis; and
- Failure to properly consider uncertain knowledge in estimating the probability of entry, establishment and spread of a pest or disease.

The methodology (i) assesses consequences, setting a decision threshold (the ALOP), and (ii) estimates the probability of entry, establishment and spread, expressed as a probability distribution representing uncertain knowledge. The 50th percentile of this distribution is compared to the decision threshold, which implies that

- precise knowledge of the probability of entry, establishment and spread represents the same risk as imprecise knowledge of the probability of entry, establishment and spread;
- the cost associated with underestimating the risk is the same as that associated with over estimating the risk; and
- close to the ALOP threshold, we are ambivalent about exceeding or meeting the ALOP.

This contradicts three self evident principles:

- imprecise knowledge carries a greater risk than precise knowledge;
- the cost associated with underestimating the risk is very significant, while the cost associated with overestimating the risk is negligible; and
- the great majority of import decisions should result in Australia's ALOP being maintained.

A sustainable and consistent methodology may embody these self-evident principles by comparing the 95th, or some other high percentile, of the probability distribution of entry, establishment and spread to the decision threshold.

Small changes in model parameters may cause an estimated probability of entry, establishment and spread to change value from less than the ALOP threshold to more than it, as for example in the pest risk assessment for black Sigatoka. Thus a buffer is required in the decision reflecting the uncertainties in the estimated probability. This reinforces the need for use of the 95th or other high percentile.

Since volume of trade is a key determinant of the probability of entry, establishment and spread, actual trade which takes a value greater than that used in the assessment should trigger a re-assessment of the risk.

1 Introduction

This report has been prepared at the request of the Australian Banana Growers Council to form part of its submission to the review of quarantine. This report summarizes and discusses relevant issues which were stated in our previous submissions to Biosecurity Australia in the import risk assessment process for the importation of Cavendish bananas from the Philippines. (Pettitt and Reeves 2004, 2007).

We briefly outline the import risk assessment process, as it has been applied to the assessment of banana imports, and review the way it arrives at its recommendations, which form the basis of the decision to import a commodity, and if so, what management measures are required to reduce the risk to an acceptable level.

Our view is that there are serious deficiencies in the methodology which are likely to understate the actual risk of a decision to import a commodity. Thus import decisions based on the recommendations are likely to result in costs and consequences which are greater, over time, than those which the methodology may lead one to expect.

The main reasons for this are:

- Failure to adequately characterise consequences of pest or disease entry, establishment and spread;
- Failure to consider the total risk of the importation, instead considering pests and diseases on an individual basis; and
- Failure to properly consider uncertain knowledge in estimating the probability of entry, establishment and spread of a pest or disease.

Recommendations arising from the methodology are based on (i) the assessed consequences, which sets a decision threshold (the ALOP), and (ii) the estimated probability of entry, establishment and spread, expressed as a probability distribution because knowledge of the exact value is uncertain. In particular, we object to comparing the 50th percentile of this distribution to the decision threshold, which implies that

- precise knowledge of the probability of entry, establishment and spread represents the same risk as imprecise knowledge of the probability of entry, establishment and spread;
- the cost associated with underestimating the risk is the same as that associated with overestimating the risk; and
- close to the threshold, there is just as much chance of exceeding ALOP as meeting it.

The consequence of this last point is that, given that models and input values are reasonable, we expect that outcomes over multiple import risk assessments will be calibrated according to the 50th percentile. That is, we may expect that in approximately half of assessments the actual probability of entry, establishment and spread will be greater than the assessed probability. Therefore we may expect that in approximately half of those cases in which the assessed probability of entry, establishment and spread is close to the ALOP threshold, that the ALOP will be exceeded.

These three implications are in opposition to three self evident principles that we believe an import decision process under uncertain knowledge should embody:

- imprecise knowledge carries a greater risk than precise knowledge;

- the cost associated with under estimating the risk is very significant, while the cost associated with over estimating the risk is negligible; and
- the great majority of import decisions should result in Australia's ALOP being maintained.

A sustainable and consistent methodology ought to embody these self-evident principles, rather than opposing or ignoring them. This would be achieved by comparing the 95th or some other high percentile, to the decision threshold.

In the following sections we further discuss and substantiate the points above, and raise some additional issues relating to adequately assessing uncertainty so that the 95th (or other high) percentile can be reliably gauged. We first give an overview of the import risk assessment process, as it has applied to the importation of bananas and other similar risk assessments.

2 Import Risk Assessment Process

The pest risk assessment process, as it has applied to the import of bananas, and other commodities such as apples, follows a procedure specified in the Import Risk Assessment Handbook published by Biosecurity Australia. A brief outline of the process is given to make this report self contained.

Possible pests or diseases associated with the importation of the commodity are categorised as significant or not, based on such factors as whether they are already present in Australia, and whether they are likely to pose any threat to the environment or primary production. Each significant pest is then subjected to a pest risk assessment.

In the Pest Risk Assessment, the likely consequence of the pest or disease establishing is categorised on a six point scale from *negligible* to *extreme*, by considering whether impact in various categories such as impact on the environment, local and international trade, etc, is discernible at expanding geographical levels from local through to national. The likely consequence then determines a threshold probability of entry, establishment and spread. Probabilities of entry, establishment and spread above this threshold are determined to present an unacceptable risk. Probabilities of entry, establishment and spread below this threshold are determined to present an acceptable risk, that is, to conform to Australia's Acceptable Level of Protection (ALOP).

The probability of entry, establishment and spread for a pest is estimated by considering Monte Carlo simulations of an import and distribution model. The model represents the various importation and distribution pathways, and requires estimates of the probability of the pest or disease surviving each step in the pathway, and estimates of such quantities as the prevalence of the disease in source plantations, the volume of trade, and specific parameters for each different pest or disease, for example, the number of disease spores on a discarded banana peel. These parameters are estimated with reference to the available scientific literature, where available, and the scientifically informed opinion of the IRA team, with input from stakeholder groups. In general, a range of values is specified for these parameter values, expressing one or more of the following (i) uncertainty in the knowledge of the actual values, representing, for example, differences in expert opinion, or guesstimates by the IRA team; (ii) natural variation in the quantity; or (iii) sampling error where specific studies are available.

The outcome of this approach is that the probability of entry, establishment and spread is estimated as a probability distribution, ranging from a minimum value, through a most likely value, to a maximum value. The range incorporates allowances for uncertain knowledge of the model parameters where expert opinion is relied upon, natural variation in the model parameters, and sampling error in parameters where data is available.

The median value of this distribution, also referred to as the 50th percentile, is then compared to the decision threshold determined by the likely consequences, as described above.

If the threshold is exceeded for the pest, then the analysis is repeated with various management measures, whose impact on the various model parameters is estimated by the IRA team, resulting in a new, lower, median probability of entry, establishment and spread. This is repeated with different sets of management measures until the median probability of entry, establishment and spread falls below the decision threshold for a given set of measures. Such measures, when applied in the prescribed way, are then considered to satisfy Australia's ALOP.

Such measures are recommended for each pest of quarantine significance, and the recommendation is made that import may proceed if all such measures are in place. The implication is made that a decision consistent with this recommendation will result in Australia's ALOP being met.

In the following sections we address specific issues with this methodology. We first address the fact that each pest is addressed in isolation, then consider the assessment of consequences, and finally consider the representation of uncertain knowledge, and in particular the use of the 50th percentile.

3 Each pest or disease is modelled in isolation

The import risk assessment process, as described above, considers a pest risk assessment for each significant quarantine pest in isolation. An overall decision is made on the basis of management measures that reduce the probability of entry, establishment and spread below the consequence determined threshold for each individual pest. It is assumed that such measures taken in combination will ensure that the overall risk of importing the commodity will conform to Australia's ALOP. However this is not guaranteed to be the case. The number of quarantine pests is a significant risk factor that is not considered in the methodology – the probability increases with each additional significant quarantine pest that one of them will become established. This results from basic laws of probability. It is the combined risk, due to all significant quarantine pests, that must be assessed to meet Australia's ALOP. However the methodology does not assess this combined risk. It is possible for all management measures to meet the required thresholds, and yet taken together present an unacceptable risk. For example, the probability of losing $100 in a bet is 0.01. I consider an acceptable risk any game where the probability of losing $100 (per pay cheque) is 0.05 or less. Such a bet is clearly an acceptable risk for me. However, if the bet is made 10 times in quick succession (corresponding to 10 quarantine pests) the probability of losing $100 is 0.1, and there is a possibility of losing more than $100. This game clearly does not fit my criteria of an acceptable risk. Yet the IRA methodology, if applied to this situation, would conclude that the second game presents an acceptable risk because each of its constituent bets, when considered in isolation, presents an acceptable risk. This is clearly fallacious reasoning, and it is of grave concern that import recommendations are made on such a basis.

4 Assessment of Consequences

The possible losses due to the introduction of pests and diseases, to individual producers, local communities, regions, primary industry sectors, and the country as a whole, are potentially very large. These possible consequences must be assessed appropriately. In particular, losses accumulate across different categories, such as environmental consequences, or effects on trade. The scheme used in the import risk assessment process provides for little or no possibility of adding or accumulation of consequences across categories. It also gives undue weight to the geographical significance of the loss, rather than assessing the value of the loss in each category. In order to make quality judgements about the risk, these potential losses need to be accurately estimated, and a value placed on potential losses that reflects both their economic value and the social and environmental values of the broader community, both present and into the future. The current framework fails to accurately value the likely consequences of a disease or pest incursion in this way. Decisions based on it, therefore, are likely to be out of step both with community values and economic realities. A detailed criticism of the rules used in assessing consequences is included in Pettitt and Reeves (2007a).

5 The proper consideration of uncertain knowledge

In assessing the probability of entry, establishment and spread of a pest or disease, uncertainty in knowledge of the various parameters and quantities used in the modelling must be taken into account. This must apply both to judgements about parameter values or quantities which form the inputs to the model, and to the output of the model, the probability of entry establishment and spread of a pest or disease. The methodology adequately handles uncertainty in the input stages, by allowing for a probability distribution to be defined for each quantity. This establishes the probable range within which the quantity will lie, and may be used to express the judgement that some values (for example near the centre of the range) are more probable than others. Relatively more certain knowledge is expressed by a narrow range of possible values, whereas relatively less certain knowledge is expressed by a wide range of possible values.

However the methodology does not adequately consider the uncertain knowledge implied in the estimate of the probability of entry, establishment and spread produced by the model. This estimate is in the form of a probability distribution over the possible values of the probability of entry, establishment and spread, which establishes a range of plausible values. The range of this distribution is an important risk factor, as the risk associated with a decision is increased if there is greater uncertainty about the probability of entry, establishment and spread. The more uncertainty there is about the probability of entry, establishment and spread, the more conservative a decision needs to be to maintain the same level of risk.

However the pest risk assessment methodology fails to take this into account. The methodology uses the median, or 50th percentile, of the distribution of the probability of entry, establishment and spread. With this approach, the spread of the distribution of possible values is not taken into account. In fact, a narrow spread of the distribution, indicating very good knowledge of the probability of entry, establishment and spread, will be given the same risk as a wide spread indicating very poor knowledge or, equivalently, substantial uncertainty, but which has the same median value. This violates the common sense principle stated above, that as uncertainty about the probability of entry, establishment and spread increases, all other things being equal, so should the risk.

One way to take the range of this distribution into account (and therefore the preciseness of knowledge regarding the probability of entry establishment and spread), is to consider the 95th or some other high percentile in relation to the decision threshold.

If the probability of entry, establishment and spread is known precisely, the spread of possible values will be very small, and the 95th percentile will give much the same answer as the 50th percentile. As the spread increases, however, indicating less certain knowledge, the median will have to decrease if the 95th percentile is to continue to fall below the decision threshold. This behaviour takes account of uncertain knowledge by forcing a more conservative decision (lower median probability of entry establishment and spread) as the uncertainty increases, so maintaining the same level of risk.

A related criticism of the use of the 50th percentile in making the decision is that this implies that the cost of underestimating the risk is the same as the cost of overestimating the risk. In terms of decision theory, the 50th percentile is being treated as the optimum (in terms of minimising losses) estimate for the probability of entry, establishment and spread. This implies a symmetric loss function – i.e. where the loss incurred by underestimating the loss is the same as the loss incurred by overestimating the loss. However the import decision is characterised by an extremely asymmetric loss function. The losses incurred by overestimating the probability of entry, establishment and spread are negligible, while those incurred by underestimating the probability of entry, establishment and spread are increasingly large as the underestimate becomes smaller. An optimum estimate of the probability of entry, establishment and spread in decision theory terms (that is the estimate that minimises expected loss) will be a large percentile, giving a value in the upper end of the distribution. This once again reinforces that a large percentile such as the 95th percentile should be used rather than the 50th in the decision making process.

The implication of basing the decision on the 50th percentile, given that input values and their ranges are appropriately chosen and underlying models are reasonable, is that over time the actual probability of entry, establishment and spread will exceed the assessed probability of entry, establishment and spread approximately 50% of the time. Of all cases where the assessed probability of entry establishment and spread, based on the 50th percentile, is close to the threshold, a proportion approaching half will result in the ALOP being exceeded. The greater the uncertainty involved in the estimate of the probability of entry establishment and spread, the more seriously exceeded the ALOP may be, and the greater the chance of consequential loss. Clearly community expectations are (by definition) that decisions should satisfy Australia's ALOP in the great majority of import decisions. This point is important as in the recent Banana IRA (Biosecurity Australia 2007), a number of pests were found to have median probabilities of entry, establishment and spread close to the threshold. Indeed, the IRA guidelines encourage this, as the management measures are required to be "as least trade restrictive" as possible. Therefore the minimum possible measures which will meet the ALOP are found. The methodology followed is to assess measures individually and in combination until a set of measures which meets the ALOP is found. This approach is bound to result in management measures which, though they meet the ALOP, are close to the threshold. Thus we believe that up to about half of the decisions where management measures are applied may actually result in the ALOP being exceeded. The significance of using the 95th percentile for comparing to the decision threshold is that it implies that only up to 5% of such decisions may end up exceeding the ALOP, given that models are reasonable, and input values and their ranges correctly identified.

The percentile used for the decision may therefore be interpreted as the degree of risk aversion which is acceptable to the Australian community. The 95th percentile indicates a preference for low risk, with the probability of exceeding the ALOP limited to a maximum of 5% on a decision to import. A decision based on a lower percentile indicates a preference for higher risk, with a corresponding increase in maximum probability of exceeding the ALOP. A decision based on the 50th percentile has a probability of exceeding the ALOP of up to 50%. When this percentile is close to the threshold, this is consistent with an attitude of ambivalence about whether the ALOP is met or exceeded, i.e, we do not mind either way. This would seem to be inconsistent with both government policy and community attitudes. A decision based on the 95th (or other high) percentile is consistent with an attitude that we very much want the ALOP to be met.

In the following section we discuss an example from the Banana IRA (Biosecurity Australia 2007), which illustrates the dangers of using the 50th percentile for decision making, and other deficiencies in the methodology.

5.1 The case of Black sigatoka

In the most recent IRA for the import of bananas from the Philippines IRA (Biosecurity Australia 2007), black Sigatoka is assessed to meet Australia's ALOP after a combination of management measures are put in place. The decision is based on assessing the median probability of entry establishment and spread to be 0.0488, which is below the threshold probability of 0.05. However this assessment does not consider the uncertainty in the estimated probability. In our submission to Biosecurity Australia (Pettitt and Reeves 2007), we point out several problems with this analysis. Firstly many parameter values involved in the calculation are treated as if known exactly, and given a specific value rather than a range and distribution. Thus uncertainty in these model values is not correctly modelled. Secondly, a parameter value is incorrectly rounded down, which, if corrected, significantly increases the assessed median probability of entry, establishment and spread, so much so, in fact, that the threshold for meeting the ALOP is exceeded. The details of this error are available in the attached report (Pettitt and Reeves 2007b). In addition, other small plausible changes to the model parameters, such as adjusting the assumed number of spores on a discarded banana peel, or varying the assumed volume of trade, may equally cause the median probability of entry, establishment and spread to jump above the ALOP. In short, uncertainty in the choice of model and parameters, and potential for oversights and errors, which are difficult to entirely eliminate from a complex modelling and elicitation exercise such as a pest risk assessment, means that a median value close to the threshold cannot be asserted to meet the ALOP, because this imputes a precision of knowledge about the estimated probability of entry, establishment and spread which just does not exist. To treat the median as the best estimate is to misunderstand and ignore the uncertainties inherent in modelling and estimating the model parameters. In order to account for this uncertainty, as we argue above, some large percentile, such as the 95^{th} , should be considered instead of the median, for decision making purposes.

6 Volume of Trade

The probability of entry establishment and spread increases with increasing volume of trade, and this reality is reflected in a quantitative analysis. Thus good forecasts of future trade are critical to correctly assessing the risk. In fact, the risk must be assessed to be acceptable with any plausible volume of trade. As volume of trade is such a significant factor in the risk, volume of trade which increases beyond the values used in the pest risk assessment should trigger a re-assessment of the risk, and the management measures required to minimise it.

7 Conclusions

In this submission, we have made several key points which need to be addressed in order for the Import Risk Assessment Process to reliably and consistently evaluate the risk associated with importing a commodity. To summarize, the consequences of a pest or disease incursion must be evaluated rigorously in economic terms and according to the social and environmental values of the wider community; it is inadequate to assess the risk of each quarantine pest in isolation – the total risk presented by the decision to import a commodity must be assessed, considering all quarantine pests in combination; and uncertainty must be recognized and consistently used in the determination. This involves both recognizing uncertainty in all model parameters, and making use of the uncertainty found in the probability of entry establishment and spread. This may be achieved by using the 95^{th}, or some other high percentile, instead of the median for decision making. Making use of the 95^{th} (or other high) percentile recognises that risk increases as knowledge becomes more uncertain; that the cost of under estimating the risk is very great, while the risk of over estimating the risk is negligible; and recognises an appropriate degree of risk aversion, for example that at least 95% of import decisions result in the ALOP being met.

A consequence of the uncertainty and complexity of the modelling is that assessed probabilities of entry, establishment and spread close to the threshold offer no assurance that the ALOP will be met. As discussed with reference to the pest risk assessment for black Sigatoka, small changes in model parameters, or errors such as rounding down, may result in the estimated probability of entry, establishment and spread appearing to meet the ALOP by a small margin. This reinforces the need to use the 95th or some other large percentile to buffer against such circumstances.

We also point out that volume of trade directly influences the probability of entry, establishment and spread, and trade volumes which exceed those used in the assessment ought to trigger a re-assessment.

For these reasons, the import risk assessment process as it currently stands provides no assurance that Australia's ALOP will be met, and will continue to be met into the future. Indeed, it is our opinion that decisions based on this framework, even given that model values are assessed reasonably, will inevitably underestimate the risk of importation. The implication is that the Australian public will be subjected to unwarranted and avoidable costs, and undesired degradation of environmental and social values.

References

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Pettitt, A.N. and Reeves, R.W. (2007a). *Report on Methodological Issues pertaining to Revised Draft Import Risk Analysis Report for the Importation of Cavendish Bananas from the Philippines.* Annexure to the ABGC submission in response to "Revised Draft Import Risk Analysis Report for the Importation of Cavendish Bananas from the Philippines".

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Error in Assessment of Risk for Black Sigatoka

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1 Introduction

In the draft IRA report (BA 2007), in Sections 10.6 and 10.13 (part B, pages 116 and 126) the details of the calculations required for the probability of transfer based on estimates of factors one, two, three and four, where factor four has three components, (A,B,C), are not given, and the consistency of model input values summarized in Table 10.10 with the values assessed for each factor could not therefore be checked. Consequently, where risk mitigation measures were asserted to impact these factors, the impact on model input values could not be assessed. This was of concern as indicative transfer values quoted in the report as 0.0015 times the unrestricted transfer values given in Table 10.10 of the draft IRA report resulted in a risk that exceeded the ALOP, as opposed to achieving the ALOP as asserted in the draft IRA report.

In order to resolve this discrepancy, a request for information was made to Biosecurity Australia to clarify these points, and correspondence from Biosecurity Australia (dated 11 September 2007) was subsequently received explaining in detail the calculations involved. Upon examination of this correspondence, it is apparent that an error remains in the way that the transfer values were calculated for the systems approach to risk management involving area of low pest prevalence, trash minimisation and post-harvest treatment.

The draft IRA report records (part B, page 138) that the IRA team assessed that trash minimisation would reduce the level of spore contamination by 80% to 90%, implying an average reduction to 15% of the pre-measure level. This figure of 15% is used when the measure of trash minimisation is assessed in isolation. However, this figure is reduced to 10% for the systems approach to risk management, implying that the measure has become substantially more effective, with no justification or explanation for the use of the smaller figure.

While it is reasonable to expect that the measure would be similarly effective in a systems approach, given independence of the measures, there appears no sound basis for the measure to become more effective.

The effect of this error is to underestimate the transfer-exposure values, and hence the probability of entry establishment and spread and therefore the risk. When this error is corrected, the restricted risk for black Sigatoka is assessed to exceed the ALOP.

2 Detail of Error

2.1 Calculation procedure

According to correspondence received from Biosecurity Australia, the transfer-exposure probabilities are calculated from factors 1 to 4 as follows:

$$p_{trans} = f_1 \times f_2 \times f_3 \times f_4$$

where

$$f_4 = 1 - (1 - f_{4B} \times f_{4C})^n$$

with p_{trans} the probability of transfer, factors 1 to 4 represented by $f_1 \cdots f_4$, factor 4A, or the number of viable spores lifted represented by n, f_{4B} representing factor 4B or the area of host surface as a proportion of the area of the proximity zone, and f_{4C} representing factor 4C or the efficiency with which spores adhere to host plant surfaces.

According to correspondence from Biosecurity Australia, factor 3 is calculated by multiplying together the probability of suitable weather conditions with the proportion of infected waste from which spores would be uplifted. This proportion of infected waste is calculated by assuming that each piece of waste has 100 viable spores (in the unrestricted case), each spore has a probability of 0.01 of being uplifted, and a binomial density is used to calculate the probability of one or more spores being uplifted. The binomial density also implies that 1 or 2 spores will be uplifted, which is the value of factor 4C, according to the correspondence received.

2.2 Risk Management – Scenario B

The IRA team assessed that the risk mitigation measures would reduce the level of black Sigatoka spores on export bananas by 80-90% for trash minimisation, 90% for areas of low pest prevalence, and a further 90% for post-harvest treatment. The IRA team considered that this would have no impact on the importation and distribution, but would only impact on the probability of transfer. According to the received correspondence, the reduction of 90% for use of an area of low pest prevalence, would reduce the number of spores on a piece of waste from 100 to 10, thus reducing the probability of uplifting one or more spores to approximately 0.1.

The reduction in 80-90% in spore levels due to trash minimisation results in a figure of 15 spores instead of 100 being present on a piece of banana waste. Leaving aside the issue that this does not correctly represent the uncertainty in the expert assessment, the figure of 15 spores out of 100 corresponds to a reduction of 85%, halfway between the ends of the quoted range, and so suitably represents an average value.

The reduction of a further 90% due to post harvest treatment appears to be modelled by reducing the binomial proportion from 0.01 to 0.001, which is a reasonable approach in this context.

However when the systems approach, consisting of the three measures in combination, is assessed, it is asserted in point 4 of the correspondence, that "combining low pest prevalence and trash minimisation means that there would only be one spore (rather than 100) on a banana that might be uplifted." However this is inconsistent with the treatment of trash minimisation in isolation, and inconsistent with the IRA team's stated opinion that spore levels would be reduced by 80-90%. The combination of these assumed independent measures should result in a reduction to $0.1\times0.15=0.015$ of the spores available for uplift on a piece of banana waste. Thus on average, a piece of banana waste will have 1.5 spores available for uplift, not one spore, as asserted in the correspondence. Of course, this is an average figure, individual pieces of waste will have an integral number of spores, but on average, there will be 1.5, not 1.

The probability of uplifting viable spores from a piece of banana waste should therefore be assessed to be 1.5% without post harvest treatment or 0.15% with post harvest treatment, 50% greater than the values used in the draft IRA report.

Substituting these values into the BA spreadsheet model, results in a median probability of entry establishment and spread of 3.21E-02, with a 95th percentile of 7.68E-02, and a 5th percentile of 9.67E-03. When added to the median probability of entry establishment and spread reported for scenario A, 3.06E-02, the overall probability of entry establishment and spread has an estimated median of 6.27E-02, which exceeds the ALOP.

3 Conclusions

The risk calculations for black Sigatoka, cannot be relied upon, as the risk associated with scenario B has not been assessed correctly. This is due to incorrectly assuming the risk mitigation measures would reduce factor 3 in the probability of transfer by a factor of 0.001. The correct factor consistent with the IRA team's stated opinion and the assessment of trash minimisation as an individual measure, is 0.0015. Using the correct figure results in an overall restricted risk of entry establishment and spread of black Sigatoka that exceeds the ALOP. This is assuming that all other elements of the model are correct, and all other model values are chosen appropriately.

References

Biosecurity Australia (2007) Revised Draft Import Risk Analysis Report for the Importation of Cavendish Bananas from the Philippines, Part B. Biosecurity Australia, Canberra.

Pettitt, A.N. and Reeves, R.W. (2007). *Report on Methodological Issues pertaining to Revised Draft Import Risk Analysis Report for the Importation of Cavendish Bananas from the Philippines.* Annexure to the ABGC submission in response to "Revised Draft Import Risk Analysis Report for the Importation of Cavendish Bananas from the Philippines".