AQIS Quarantine Operations Risk Return
ACERA 1001 Study J
Imported Plant-Product Pathways

Final Report

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Contents

Table 1: Table of definitions used throughout the text.

Term	Definition
Assumption	An *assumption* is a statement of belief about some condition that can't be proven. Assumptions can be considered reasonable or unreasonable in the face of evidence. Assumptions are made in order to use or connect statistical arguments. The important assumptions for the study are described in Section 5.3.
Caveat	A *caveat* is an identification of potential shortcomings in the analysis. The study caveat is explained in Section 5.4.
CSP	*CSP* stands for continuous sampling plan. A CSP is a method for determining whether or not to inspect a consignment, based on the recent inspection history of the pathway, and some parameters that the pathway manager sets. More information about the CSP approaches is available in Section 3.2.
Enhanced Inspection	For the purposes of this report, *enhanced inspection* is to inspect all of the consignments on a pathway, where the inspection is carried out according to the usual work instructions. Thus, enhanced inspection of the fresh oranges pathway would involve the usual 600–unit sample applied to all of the consignments of fresh oranges. Also see *monitoring*, below.
Leakage	*Leakage* is the amount of undetected biosecurity risk material that passes through an intervention point.
Monitoring	We will use *monitoring* to describe the inspection of less than 100% of the consignments of a pathway. Thus, monitoring the fresh oranges pathway would involve the usual 600–unit sample applied to only some of the consignments of fresh oranges; the remainder would be released on documentation. Monitoring would be performed for pathways that are considered low risk by the pathway manager. Also see *enhanced inspection*, above.
Pathway failure (PF)	A *pathway failure* will be any kind of non-compliance associated with a consignment on a pathway, including failures that do not necessarily represent a biosecurity risk. For example, inadequate documentation for a consignment is a pathway failure, as is contamination by a pest or disease.
Quarantine failure (QF)	A *quarantine failure* will be non-compliance that is a biosecurity risk associated with a consignment on a pathway. For example, contamination by a pest or disease is a quarantine failure, but inadequate paperwork is not.
Sampling	We will use *sampling* to refer to the selection of individual units within a consignment as part of the usual inspection procedure. For example, the selection of 600 oranges from a consignment will be referred to as sampling.

1

Executive Summary

1.1 Background

Quarantine inspection assists in safeguarding Australia's biosecurity status by monitoring import pathways for contamination. Once identified, contaminated pathways can be mitigated. Using inspection history to analyse intercepted biosecurity risk is an important process in ensuring that inspection regimes and resourcing match a commodity's risk profile and pathway failure rate.

This project, by the Australian Centre for Excellence in Risk Analysis (ACERA) and Plant Quarantine staff, reviewed the risk–return potential of imported-plant product pathways to optimize the allocation of Department of Agriculture, Fisheries and Forestry (DAFF) inspection resources. Specifically, our goal was to find a way to reduce the amount of inspection without unduly increasing the leakage, defined as the amount of quarantine contamination that passes undetected. This report summarizes the results of a statistical risk analysis of inspection data for plant-product pathways.

The target of risk return for imported-plant product pathways is to implement reduced monitoring rates for identified low-risk pathways while still maintaining an acceptably low level of risk of new quarantine incursions, and to allocate the ensuing resources to managing high-risk pathways. Of the 10 pathways examined, 7 were found to be low risk. The resources used to sample these at the border can be partially reallocated to pathways of greater risk. Overall, compliant suppliers will be rewarded and risky pathways will be more adequately addressed. The project team used an evidence-based risk approach, as recommended by Beale et al. (2008), to determine high and low risk based on the inspection failure rate and end use of each pathway.

This report documents ACERA project 1001J, which is a pre-cursor to a future project, ACERA Project 1101C, *Quarantine Inspection and Auditing Across the Biosecurity Continuum.*

1.2 Methods

The data used for this project were sourced from two DAFF databases: AIMS and Incidents. We used AIMS data to determine the pathway volume, namely the number of consignments, for each pathway and sub-pathway. We determined the failure status of each consignment using a combination of AIMS and Incidents data. Each consignment either (i) passed inspection, or (ii) returned a pathway failure that was not a quarantine failure, or (iii) returned a pathway failure that was also a quarantine failure. A description of the exact steps can be found in Section 4.0.2.

In order to use the volume data to compare the inspection algorithms, it was necessary to make the following assumption.

1. The inspection data are assumed to be representative of all commercial consignments that are in scope for each pathway.

Also, we used a combination of AIMS and Incidents data to determine the failure status of each consignment. In order to use the interception data to compare the inspection algorithms, the following extra assumptions were made.

2. The approach rate of contamination in the future will not differ substantially from that of the last two years of the data.
3. The temporal patterns of contamination in the future will not differ substantially from that of the last two years of the data.

Finally, in order to estimate inspectorate performance, we needed to assume that

4. Inspection effectiveness was 90%.

More information is given in Section 5.3.

1.3 Results

Ten imported-plant product pathways were selected based on regional officer advice, and inspection of AIMS and Incidents data, as case studies for statistical analysis for this project. Simulation experiments were carried out on the inspection history for each pathway.

Based on the findings of the imported-plant product pathways case studies, the pathways can be categorized into three groups:

1. low pathway failure rates and high supplier-specific compliance, therefore suitable for targeted inspection reductions (Dried apricots, dried dates, hulled sesame seeds, coir peat, and green coffee beans);
2. acceptable pathway failure rates but no motivation for targeted reductions (dried seaweed, baby corn); and
3. unacceptably high pathway failure rates that suggest further intervention would be useful (mangosteen, blueberries, and fresh garlic).

Following these results, the project team has identified a number of risk–return initiatives that can be implemented by the department.

1. An effective statistical tool called Continuous Sampling Plan 3 (CSP–3) has been identified that provides a recipe for allocating inspection resources in a way that responds flexibly to differences in contamination rates between pathways and changes in contamination rates within pathways.

   The following five commodities have demonstrated low pathway failure rates and a level of supplier specific compliance that make them suitable for a supplier-targeted reduction to inspection rates: dried apricots, dried dates, hulled sesame seeds, coir peat, and green coffee beans.

   It is recommended that a continuous sampling plan be employed for these five commodities, using a system of Customs Integrated Cargo System (ICS) profiles and quarantine rulers within the AQIS Import Management System (AIMS) to enable practical implementation of random sampling. Recommended CSP–3 parameters for the five pathways are presented in Table 1.1, which summarizes the outcomes of this report (See Section 5 for details).

2. It is strongly recommended that the CSP–3 algorithm be deployed as an analysis tool in conjunction with simulation and inspection data to assist in determining statistically justified inspection regimes for imported-plant product pathways. Supplier-targeted inspection regimes were developed for each of the five suitable pathways using simulation experiments

on past inspection history to identify the parameters required to deploy such a continuous sampling plan.

Briefly, using CSP–3 will result in the following inspection regime for each *supplier*:

(a) start in *enhanced inspection mode*, or *enhanced* mode, which means inspecting all consignments, until a defined number (called the clearance number, *CN* in Table 1.1, for example, 10) of successive compliant consignments have been observed. Then,

(b) switch to a reduced sampling regime, called *monitoring mode*, which involves fully inspecting a reduced number of consignments (the proportion of consignments inspected is called the monitoring fraction, *MF* in Table 1.1, for example, 10%) until a quarantine non-compliance is detected.

Following a non-compliance, the next four consecutive consignments must be inspected, after which monitoring is again used if all four are clean. If any subsequent non-compliance occurs within a specific number (for example, 10, usually the same as CN) of inspections of a previous non-compliance, then the supplier's inspection regime is switched back to the above enhanced mode.

Table 1.1: Summary table for all pathways for the reporting period, which is July 1 2008 until the latest record. *Number* is the average number of consignments per year. *Fail* is the percentage of consignments in which arthropod, pathogen, or contamination is detected. The remaining columns are blank for those pathways for which CSP–3 is *not* recommended. Explanations are provided in Chapter 6. If CSP–3 is recommended then *MF* and *CN* present the recommended monitoring fraction and clearance number respectively, *PIC* and *Leak.* provide the simulated post-intervention compliance rate and expected annual leakage rate respectively, *Red.* is the estimated reduction in the number of inspections carried out per year, and *Sav.* is the percentage by which the count of inspections would be reduced. Those products with *ex.* appended identify pathways for which the data represent one country only.

Pathway	Number	Fail (%)	MF (%)	CN	PIC (%)	Leak. (%)	Red.	Sav. (%)
Dried Apricots	368	0.44	10	10	99.87	0.13	208	56.5
Coir Peat	73	0.56	10	10	99.95	0.05	33	45.2
Hulled Sesame Seeds	150	0.81	50	10	99.83	0.17	70	46.7
Dried Seaweed	94	0.93						
Dried Dates	183	1.10	10	10	99.70	0.30	63	34.4
Baby Corn	341	1.53						
Green Coffee Beans	1131	2.33	50	10	99.00	1.00	481	42.5
Blueberries (ex. A)	430	5.36						
Fresh Garlic	213	13.11						
Mangosteen (ex. B)	132	20.37						

3. Baby corn demonstrated potential for reduced sampling rate, however, supplier targeting did not show a statistical benefit over random sampling. No high-volume suppliers demonstrated consistent compliance records to support reduced inspection rates. Nonetheless, inspection savings will still be made for lower volume importers. It is also recognised that supplier targeting using a continuous sampling plan may result in improved supplier compliance over time because of the incentive of reduced inspection rates.

4. The following three commodities are not suitable for reduced inspection due to high failure rates: fresh garlic, mangosteen, and blueberries. Remedial action should be considered for

these horticultural pathways to improve pathway cleanliness and compliance with pest freedom conditions.

5. Dried seaweed as a pathway already has a reduced sampling rate applied, because inspection is mandatory only if treatment documentation is unavailable. The available data can not necessarily be considered to be a representative sample of the pathway. Temporarily setting that concern aside, the results indicated that this is a very low failure rate pathway. The simulation results suggest that implementing a further CSP-style sampling regime will not be of benefit, and current system should be maintained and reviewed at a later date.

6. Analytical exercises such as this one allow the identification of low-risk pathways using statistical tools and historical inspection data. The inspectorate can use CSP–3 or a similar inspection algorithm to judiciously reduce inspection effort in these low-risk pathways, which will free up inspection time for higher-risk pathways. The advantage of using CSP–3 for the reduction is that low-risk pathways are monitored, and increases in the risk status can be detected reasonably quickly, and increasing the intervention is automatic upon that detection.

1.4 Other Recommendations

A number of data collection and electronic system constraints where identified as severely hampering the ability to undertake this form of commodity specific analysis on a routine and across pathway basis. An Information and Communication Technology (ICT) reform process has commenced within DAFF and the following recommendations are provided to inform this reform process of system improvements required for future ICT systems to support risk-return inspection regimes for more plant and commodity based pathways. See Chapter 7 for more detail.

1. Support the incorporation of supplier-targeted inspection regimes into the entry management system for appropriate risk–return pathways by enabling the automated review of a suppliers compliance history.
2. Incorporate leakage surveys in reduced inspection regimes to verify the estimation of inspection effectiveness, used for analysis of each import pathway.
3. Ensure the quarantine risk of an interception is recorded within the AIMS database with actionable or non-actionable quarantine status recorded to streamline statistical analysis of quarantine failure rates.
4. Identify at least a sample of the intercepted pests down to species in a systematic way to enable informed evaluation of pathway risk (see ACERA Project 1101E, *Sampling for Invasives*).
5. Develop a system to support the simultaneous analysis of multiple pathways (see ACERA Project 1101C, *Quarantine Inspection and Auditing Across the Biosecurity Continuum*).
6. Develop in-house expertise to sustain and build on the ACERA 1001J progress that is documented within this report, (see ACERA Project 1101C, *Quarantine Inspection and Auditing Across the Biosecurity Continuum*).
7. Be prepared to alter the algorithm in ad-hoc ways to allow for local knowledge or seasonal patterns in volume.

2

Introduction

The projected biosecurity risks associated with specific import pathways for plant commodities are documented in the AQIS Import Conditions (ICON) database, Import Risk Analyses and/or Risk Assessments, however the connection between the assessed risk and the inspection frequency have not been adequately addressed. Previous ACERA projects have focused on non-commodity pathways to develop tools that can be used to support the allocation of quarantine inspection resources. To date these tools have not been applied to pathways of known, variable biosecurity risk such as imported plant products.

Imported-plant product pathways are subject to inspection procedures at the pre-border and border parts of the biosecurity continuum. Plant Quarantine Operations use inspection procedures to verify that Australia's plant import quarantine requirements are being met. The frequency and rate of inspection need to be determined for each commodity based on the quarantine risk assessed.

This report suggests some sampling plans that permit the flexible and automatic allocation of inspection resources towards pathways that have higher contamination rates, discusses the advantages and disadvantages of these sampling plans, and evaluates the sampling plans on ten plant-product pathways using inspection data.

3

Inspection Regime

3.1 Introduction

An effective risk-return focused inspection regime for plant commodity pathways requires the flexibility to respond to and protect against emerging patterns of non-compliance while not over-investing effort in sub-pathways that are essentially clean and therefore low risk. This trade-off of inspection resources will ideally involve reducing inspection rates to a monitoring role for the essentially clean sub-pathways and using inspecting all consignments from the more contaminated sub-pathways.

The term sampling is widely used in the quarantine context to refer to the randomly-selected portion of a consignment for inspection. However, sampling can also refer to the random selection of consignments from a pathway for inspection. To avoid confusion within this report we use the term monitoring to refer to the random selection of consignments for inspection.

The ability to detect patterns of non-compliance within the inspection history of an import pathway is crucial to determining accurate inspection rates based on pathway risk. Medium and long-term shifts in non-compliance are particularly important. Short-term shifts, ie. spikes representing once-off pathway failures, can only reliably be captured when the entire pathway is inspected, or sampled with sufficient frequency that a spike of sufficient duration will be detected. By adopting a risk-return strategy for the pathway, the inspectorate acknowledges that undetected spikes are possible, and decides that the risk of undetected spikes is acceptable and inspection resources are better directed towards higher risk inspection needs.

We emphasise that the only condition under which the pathway should be monitored, as opposed to fully inspected, is when it is deemed acceptable that there be some residual leakage from the pathway. Monitoring regimes will most likely be applied because of the low-risk nature of the commodity, for example, due to the specified end use or identification of intercepted pests as non-actionable and not of quarantine concern.

3.2 Candidate Sampling Plans

3.2.1 CSP Family

The effective review of an inspection regime requires employment of a monitoring technique. Here we introduce the continuous sampling plan (CSP) family of algorithms as the recommended pathway monitoring technique for imported-plant product pathways. The original CSP algorithm of Dodge (1943) is now called CSP–1. CSP–3, which we advocate here, was introduced by Dodge and Torrey (1951), along with CSP–2.

The basic premise of each of the CSP inspection designs that we reviewed is that a pathway is either being *monitored* or undergoing *enhanced inspection* at any given time, and the decision that the inspectorate must make is: how to use the inspection history of the pathway. Typically, the inspection regime will adopt the following very general pattern:

1. start in enhanced inspection mode,
   - inspect all consignments until the inspection history reaches a given condition, say C,
2. switch to monitoring mode:
   - inspect at a specific monitoring rate f until the inspection history reaches a different given condition, say, M, then switch back to enhanced inspection mode.

We now briefly review two of the simpler inspection algorithms, CSP–1 and CSP–2, before providing a review of the recommended approach, CSP–3.

CSP–1

CSP–1 is the simplest of the three algorithms. Referring to the pattern immediately above,

- C is satisfied by the observation of i successive compliant consignments.
- M is satisfied by any observation of non-compliance while the pathway is in the monitoring mode.

CSP–2

CSP–2 is the same as CSP–1, except

- M is satisfied by two observations of non-compliance within k successive consignments while the pathway is in the monitoring mode. It is usual to take $k = i$.

CSP–3

For CSP–3, the inspection algorithm is as follows,

- C is satisfied by the observation of i successive compliant consignments.
- M is satisfied by two observations of non-compliance that are within k inspections of one another. Usually, $k = i$.

Note that *in addition to the above prescription*, when any non-compliance is detected, the next four consignments will all be inspected, i.e., the monitoring process will be replaced by inspecting each of the next four consignments. The choice of four is arbitrary, but standard for CSP–3. This shift is temporary and is done regardless of whether the non-compliance is the first or subsequent failure detected in any number of consignments.

To summarize CSP–3, if the system is in monitoring mode, then the consignments are being randomly selected for inspection at rate f. If a non-compliant consignment is intercepted, then the next four consignments are inspected, and if they are all compliant, the system returns to monitoring. If another non-compliant consignment is found within i inspections of the previous non-compliance, then the system switches to enhanced inspection mode.

3.2.2 Other Approaches

During the development of this project we included other approaches in our simulation experiments, for example, the CUSUM approach of Bourke (2002), however, they did not perform as well as the CSP family in the experiments that we ran, and their structure suggested that implementation could be more complicated.

3.3 Recommendation: CSP–3

We recommend the deployment of a continuous sampling plan, CSP–3, on a supplier-specific basis for the import pathways documented herein. The basis of this recommendation is the outcome of a large number of simulation experiments performed using approximately 5.5 years of historical inspection data from 2005–2011.

It is important to note that for a number of the case study pathways the simulation experiments provided only modest evidence for the superiority of CSP-3 over alternatives such as CSP-1. However, the interpretation of the results of the simulation experiment has to be tempered by a recognition that the historical inspection data cover only a few years of interaction to support the pathway picture.

The reason that we recommend CSP–3 ahead of CSP–1 is that CSP–3 allows for the possibility of isolated leakage incidents, or random once-off non-compliance, without shifting immediately to an enhanced inspection mode and penalizing suppliers with concomitant 100% inspection rates. Deploying a monitoring regime in a pathway can only be acceptable when some small amount of leakage is acceptable. Pathways in which leakage is unacceptable should be inspected at 100%. Given that trace levels of leakage are accepted, CSP–3 tries to identify systematic shifts in the quarantine failure rate, and respond to those.

The reason that CSP–3 is chosen ahead of CSP–2 is that the former provides temporary increased scrutiny of the pathway to see if a leakage incident seems likely to be part of a trend, and not simply an isolated failure. Therefore CSP–3 represents a compromise between the measured approach of CSP–2, which allows for some leakage, and the focused approach of CSP–1, which keeps watch for upward shifts of the failure rate.

The reason that we recommend that CSP–3 be deployed by supplier, as opposed to by country, or both, is due to the results of the simulation experiments discussed in Chapter 5. The results of the simulation experiments often showed strong support for supplier-specific application. Also, it is preferable for pathway management that if a quarantine failure is observed then the supplier of the consignment should receive greater scrutiny. Therefore the recommendation is based on a combination of simulation results, prudence, and knowledge about the pathway.

The entire algorithm is specified in terms of just two parameters: i and f. The trade-off between the parameters i and f can be interpreted as follows. A high i means that once a pathway is in enhanced inspection mode, it will take a larger number of compliant consignments in order to achieve monitoring mode. Consequently, we can think of i as being the amount of evidence that we need for concluding that a non-compliant supplier has cleaned up their pathway, or equally, a penalty upon the supplier for a non-conformity. A high f means that we are more likely to detect changes in the underlying rate.

3.3.1 Choosing CSP–3 Parameters

We used a set of simulation experiments to develop a recommendation for values to use for the monitoring fraction[1] f and the clearance number i. These experiments are documented in Chapter 5, and the results are detailed for one pathway (dried apricots) in Chapter 6 and the balance of the pathways in Appendix D.

Our general goal was to use the simulation experiment to determine the combination of CSP algorithm, sub-pathways, and CSP parameters that would deliver a post-intervention compliance (defined herein) of 99% or better. We were also interested in determining whether there was evidence that using the CSP algorithms was better than random sampling. Based on the results, the pathways can be categorized into three groups:

[1]We use the label "monitoring fraction" instead of "sampling fraction", which is ingrained in the motivating statistical literature.

1. low pathway failure rates and high supplier-specific compliance, therefore suitable for targeted inspection reductions (Dried apricots, dried dates, hulled sesame seeds, coir peat, and green coffee beans);
2. acceptable pathway failure rates but no motivation for targeted reductions (dried seaweed, baby corn); and
3. unacceptably high pathway failure rates that suggest further intervention would be useful (mangosteen, blueberries, and fresh garlic).

The sets of parameters provided in Table 1.1 seem tentatively suitable, based on the results of the simulation experiments detailed in Chapter 6 and Appendix D.

3.4 Implementation

Implementation of the recommended monitoring system may be challenging. In order to monitor each supplier using CSP–3, it will be necessary to keep a record of the suppliers' inspection histories. Specifically, it will be necessary to develop a data table that records for each combination of supplier and tariff the following information:

1. the current compliance status (monitor / enhanced / temporarily enhanced), and
2. the number of inspections since the last fail.

Three obvious strategies are: (a) embed the inspection algorithm within AIMS and automate the switching rules; (b) regularly extract AIMS data for manual analysis, and feed back the prescribed states into the parameter rules; or (c) identify a subset of high-volume, compliant suppliers using AIMS profiles, and run the CSP algorithm for those suppliers only, using a spreadsheet that is maintained by the Biosecurity Plant Division.

3.4.1 Embedding within AIMS

The first strategy would require that extra fields be made available in AIMS records to permit the automated assessment of the compliance history of a supplier's past consignments, and that there be some way of storing supplier and/or country-specific status flags (monitor/enhanced) for each commodity for which the algorithm is used. This strategy has the advantage of being automated and relatively easily generalized without the need to employee additional resources or training to undertake each consignment assessment, and can be applied to additional import pathways as analysis becomes more regular. The full automation of compliance analysis via use of a Quarantine Ruler system is the most preferable option for implementing risk return inspection regimes. However initiating this level of upgrade within the current IT infrastructure would be costly and lengthy to develop and is not feasible considering an ICT upgrade is currently being planned for the future. The interim solution will involve the external handling of inspection data to ensure the suggested risk return strategies advocated within this report can be implemented in the immediate future.

3.4.2 Regular Data Extraction

The second strategy might work for a small handful of pathways but would rapidly become overwhelming. It is to be avoided at all extents.

3.4.3 External Handling

Discussions with the Cargo Targeting and Effectiveness Program, and Electronic Systems Tactical Enhancements Program, have identified the following method of employing a continuous sampling plan.

Using dried apricots as an example, continue current 100% mandatory referral profile to AIMS from ICS for the commodity tariff code. All commodity consignments would continue to be referred from the ICS to AIMS. 100% of consignments would have their commercial documentation reviewed by AQIS staff. A quarantine ruler applied to this tariff code would auto-direct entry officers, via the AIMS profile light system and an automated AIMS document direction, to check the plant quarantine web-based dashboard to determine the required sampling rate.

The plant quarantine dashboard created by Electronic System will be accessible by a hyperlink. Officers will enter the supplier code and commodity tariff code. The dashboard will pull real time data from AIMS to populate the supplier's compliance history. Advice on the required sampling rate for each commodity will be required to ensure the system is effectively implemented, and can be provided to entry management via training and instructional material. Training of regional entry management officers will be required to ensure this is effectively used.

3.5 Why not IRIS?

Previous ACERA work in the area of the allocation of inspection resources has used the IRIS tool (see, e.g., Robinson et al., 2009). The IRIS tool works best for pathways that have very large volumes — for example, multiple thousands of units — and that have only a small number of sub-pathways, for example, regions. We tried to use the IRIS tool for the pathways considered in this report but it proved to be unhelpful, compared with the simulation experiments. This was because there were too few inspections available in the history of each pathway, with the possible exception of green coffee beans.

4

Data Preparation

4.0.1 Extraction

The data used during this analysis were retrieved from two AQIS databases: AIMS and Incidents. Approximately five and a half years of inspection data for each pathway were retrieved, using tariff codes and importer descriptions as search terms. Consignment information was sourced from AIMS, and the corresponding insect or pathogen interceptions recorded were derived from the Incidents database.

The majority of commercial consignment data in AIMS is electronically referred from the Customs Integrated Cargo System (ICS). The ICS data are collected for Customs purposes and, based on tariff codes and importer responses to quarantine and imported food declarations, are transferred to AIMS when quarantine conditions are required. There is a risk that a small proportion of consignments relevant to the analysis have not been identified due to incorrect tariff codes or description fields. The project team has worked with the assumption that the majority of commercial consignment details have been entered correctly and incorporated into each pathway analysis. AIMS records are not static; changes made in ICS or broker records for tax or other purposes will affect AIMS records.

4.0.2 Data Cleaning

Following data extraction, manual filtering was required to remove any consignment entries that were incorrectly included and convert the raw data into a consistent format for analysis. During this process an issue was identified with the lack of standardised recording of shipment quantities. ICS records quantities using a free-text system and importers can record shipment size in a number of units, including kilograms, pounds, cartons, or tonnes; prior to analysis this data needs to be standardised into a single measurement unit.

After manipulation and standardisation, the AIMS dataset was merged with the incidents dataset to form one comprehensive datasheet for analysis. The incidents and pathway failure data used were sourced from both the Incidents database and from the AIMS negative inspection results. A pathway failure was recorded for consignments with a negative inspection record due to document or non-commodity specific failures with the consignment, such as packaging. A quarantine failure was recorded within this review for consignments with a recorded detection of quarantine concern, such as a live arthropod, pathogen, or contamination such as seed or soil. Pathway failure and quarantine failure are represented as PF and QF respectively throughout the case study figures and tables.

Determining the quarantine risk of pathway failures was a significant issue for the project team because the Incidents database is primarily used by the Operational Science Program (OSP) to record identified invertebrate or pathogenic interceptions. However, for a range of reasons, identification of specimens to a species level is not always undertaken. Hence, the Incidents database does not consistently contain species identification information, which prevented the reviewing of the biosecurity risk of the reviewed imported plant-product pathways. Therefore any pest or disease intercepted during inspection was deemed a quarantine failure for the pathway. Pathway failures that were not directed to OSP for identification, such as plant material contamination or insects that were unable to be collected, are generally not recorded in the database. The Incidents database cannot be used as the only source of inspection failure information. To ensure an accurate representation of quarantine failure for each pathway, all failed AIMS entries were manually reviewed and failures added to the manipulated data, along with information from the Incidents database. Adding negative inspections required the manual searching of AIMS comment fields.

The data preparation was a painstaking process. Overall, an average of 3–4 days was required to complete each individual commodity dataset.

4.0.3 Analytic Timespan

The available data comprised inspections over the last 5.5 years. Due to a change in the AIMS recording system, the 2005 data consisted of only two and a half months, and data for 2011 were necessarily incomplete.

The simulation experiment was performed on all of the data, however, only the inspections corresponding to the most recent 2.5 years were reported against. The two reasons are (a) that the early performance of the inspection algorithm is discarded, and (b) that the results reflect the current status of the pathway as much as possible. Discarding the early performance of the inspection algorithm is useful because including it will distort the long-term results. The distortion occurs because the algorithm always starts with all pathways under enhanced inspection, that is, being completely inspected, for a set number of inspections. So it is possible to think of the first three years of the simulation as being a 'burn-in' period, during which the algorithm establishes a pattern.

Also, this temporal window was selected as providing a reasonable compromise between timeliness, that is, not including any data that were too old, and having enough data available for the comparisons to be valid.

5

Simulation Experiment

5.1 Introduction

This chapter presents the design of simulation experiments that have been run on past inspection data for each commodity pathway. The simulation experiments were undertaken to provide insight into the validity and suitability of different inspection regimes.

AQIS has a large volume of interception data. It comprises plant pests classified to various taxonomic levels from pathways. These data provide a valuable risk profile for commodities coming from specific origins and therefore a basis for comparing the likely utility of different sample designs.

Theoretical considerations are useful when nothing is known about the properties of the process. If suitable historical inspection data are available, then simulations of the algorithms should be undertaken to replace the theoretical assumptions made during model development. Simulations run using real data will provide the most accurate picture of the validity of the required inspection regime. For example, the theoretical performance of the CSP family can be specified if we assume that the underlying approach rate is always the same. This assumption does not sit comfortably with operational experience, nor with our analyses of the inspection histories of the pathways, which show shifts in approach rates (see, for example, Figure D.26). By using historical inspection data, we allow for the demonstrated propensity of a pathway to have such shifts in approach rates.

5.2 Design

The simulation experiments are designed as follows. We nominated a range of different inspection designs, as outlined above, and for each selected a range of control parameters.

- CSP–1, CSP–2, and CSP–3: all combinations of monitoring fraction $f = 0.1$, 0.25, 0.33, and 0.5, and clearance number $i = 5$, 10, 20, and 40; repeated 100 times for each combination.

We looped through the inspection history of the product in the following way. See Table 5.1 for a row-by-row example of the process.

1. For each line, we determined whether or not the pathway(s) that the line belonged to were flagged for enhanced inspection or monitoring. If any pathway was flagged for enhanced inspection, then the line was inspected. If not, then the line was inspected with probability equal to the monitoring fraction. That is, for each line that was flagged for monitoring, a random number between 0 and 1 was generated, and compared with the nominated monitoring fraction f. If the random number was below f, then the item was 'inspected', otherwise it was released.

Table 5.1: Simulation walk-through for CSP–1, using an import compliance clearance number 2 and monitoring fraction 50%. The columns to the left of the vertical bar are sourced from the inspection history. *Cons.* identifies the order in which the consignments arrive. *Fail* reports whether or not the known inspection history for the consignment was a quarantine fail. *Mode* reports whether the pathway is in Enhanced inspection or Monitoring mode at the time of inspection. The x_i and x_d columns report the random numbers that correspond to inspection and detection respectively; if $x_i < 0.5$ then a monitored consignment is inspected, and if $x_d < 0.9$ then a contaminated consignment that is inspected is intercepted. The *Insp.* and *Det.* columns record these outcomes. Finally, *Count* reports the number of inspections since the last detected contamination.

Cons.	Fail	Mode	x_i	x_d	Insp.	Det.	Count	Notes
1	N	E	0.40	0.80	Y	N	1	Enhanced Inspection — clean.
2	N	E	0.90	0.70	Y	N	2	Clean. Move to Monitoring.
3	N	M	0.70	0.50	N	N	2	Not inspected.
4	N	M	0.40	0.80	Y	N	3	Clean.
5	Y	M	0.30	0.20	Y	Y	0	Contaminated. Enhanced mode!
6	N	E	0.90	0.30	Y	N	1	Clean.
7	Y	E	0.90	0.95	Y	N	2	Contamination not detected. Move to monitoring mode.
8	N	M	0.70	0.20	N	N	2	Not inspected
9	N	M	0.80	0.90	N	N	2	Not inspected
10	N	M	0.25	0.55	Y	N	3	Clean.

2. Simulated detection involved generating another random number between 0 and 1, and comparing this number with the nominated inspection effectiveness e. If the random number was below e *and* the item was contaminated with quarantine risk material, then the contamination was detected. Otherwise the item was passed.

3. The pathways to which the item belonged were then flagged according to the inspection algorithm, and the updated status was used for subsequent inspections.

One of the strengths of the CSP family of algorithms is that it provides an easy way to focus inspection resources on specific parts of the pathway, or sub-pathways. We examined four different strategies for splitting the pathway:

1. no splitting,
2. split by country of origin,
3. split by supplier, and
4. split by both country and supplier.

The results at the end of each simulated inspection run were aggregated. Here we report two performance indicators: the simulated post-intervention compliance for the pathway (PIC, Robinson et al., 2011) and the expected number of non-compliant consignments leaked during the time period under scrutiny. A brief summary of the PIC is provided in Appendix C.

5.3 Assumptions

The results are based on several important assumptions, listed with a brief commentary as follows.

- Inspection effectiveness is assumed to be 90%. This assumption was made based on discussions with the pathway managers. Leakage surveys that could be used to estimate inspection effectiveness are not available on this pathway. It is possible that the inspection effectiveness may vary by consignment characteristics; for example consignment size. It is certain that effectiveness is depends on within-consignment prevalence.

  This assumption is important because without assuming some value for inspection effectiveness, we would have been unable to estimate the pathway leakage or compliance, and therefore unable to compare the different inspection algorithms. If this assumption of 90% effectiveness is wrong then the estimated leakage rates and compliance rates will be inaccurate.
- The data are assumed to be representative of commercial consignments for each pathway. In fact, we only have access to the data for the entries that were recorded in AIMS. There may be relevant consignments in the Self-Assessed Clearance (SAC) pathway, which do not necessarily appear in AIMS, but these are likely to be small, as the upper limit for declared SAC value is $1000. Also, there may be other consignments of the same product but with incorrect tariff codes.

  This assumption is important because it allows us to draw conclusions about the whole plant product pathway from the available inspection data. If this assumption is wrong then there will be consignments that should be counted that are not. Note that SAC entries that fail inspection are upgraded to AIMS, and therefore will appear in our data.
- We assume for the simulations that the approach rate of contamination in the future will not differ substantially from that of the last two years of the data.

  This assumption is important because it enables us to make some comment about the future performance of the inspection algorithms that we are comparing based on their performance using historical data. If this assumption is wrong then it should rapidly become obvious in the inspection data; the proposed monitoring regime is designed to detect changes in the approach rate with high probability.
- We assume for the simulations that the temporal patterns of contamination in the future will not differ substantially from that of the last two years of the data. That is, we assume that the inspection history represents the full range of patterns of non-compliance that are relevant to the question at hand.

  This assumption is important because our inspection algorithm is designed to respond to patterns of non-compliance, and if future patterns of non-compliance are different from historical patterns then the simulation results will not represent future conditions.

The simulation results are reported only for the period July 1 2008 until the newest entry, although the algorithm was applied to the full dataset (starting at 12 October 2005) as a burn-in strategy. That is, the simulation was performed on the entire inspection history, but we report only the results of the inspections that were undertaken since July 1 2008. This temporal window was selected as providing a reasonable compromise between timeliness, that is, not including any data that were too old, and having enough data available for the comparisons to be valid. See Section 4.0.3.

The analysis can be repeated with more up-to-date data as they become available. The full suite of simulations takes a few hours on a Sun SunFire X4600M2, with eight AMD Quadcore 2.3GHz CPUs and 64GB memory, running Red Hat Enterprise Linux Server 5.6 (RHEL 5.6).

5.4 A Caveat

In addition to the assumptions outlined above, it is important to note that we have only been able to perform the simulation experiments using the available inspection data. Many of the smaller suppliers will not have had sufficient time to reach the clearance number and move to a monitoring regime. Hence if the pathway is largely clear, as we would require because we recommend implementation of CSP-3 only on imported-plant product pathways that have acceptably low approach rates, then we can expect that the realized inspection rate will decrease with time, as the smaller importers build the compliance history necessary to qualify for the reduced inspection regime. From this point of view, the results of the simulation experiment are conservative: in time, the same levels of compliance will be able to be maintained with less effort.

6

A Case Study

Here we present one of the case studies: dried apricots. Details of the others are available in Appendix D.

6.1 Dried Apricots

For this analysis, 'dried apricots' refers to dried *Prunus armeniaca* without seeds. The dried apricots pathway is an excellent candidate for CSP–3 monitoring by supplier; the high-volume suppliers all have excellent importation records in terms of quarantine compliance, and the very few instances of contamination detected on this pathway have been in consignments that were sent by low-volume suppliers.

6.1.1 Import Conditions

Dried fruit generally represent a lower quarantine risk than similar fresh commodities. However, dried commodities can pose serious quarantine risks because the process of drying is insufficient to eliminate disease agents. In some cases, dried fruit will contain viable seeds which may be of a quarantine concern, such as *Prunus* spp. which can carry seed-borne diseases such as Plum Pox Virus. All dried fruit may potentially introduce exotic insect pests and are considered a high risk of introducing khapra beetle if originating from a host country.

An Import Permit is not required. Phytosanitary certificates are required for all Full Container Load (FCL) consignments. Non-FCL consignments do not require a phyto cert. Dried fruits are required to be commercially produced and packed. "Exposed" (exposed to insect infestation) produce are to be subject to mandatory fumigation with methyl bromide. Prior to entry, all consignments must pass an AQIS quarantine inspection on arrival to verify that the shipment is free of soil, live insects, rice hulls, contamination with restricted and prohibited seed and other material of quarantine concern (e.g. leaf or stem material, faeces, animal remains etc.) and packed in new, clean bags.

Consignments are inspected by selecting sample cartons at random for inspection. Samples are collected from the consignment at the rates outlined in Table 6.1.

No formal import risk assessment has been undertaken for dried apricots.

6.1.2 Pathway Summary

A flowchart of the pathway is presented in Figure 6.1.

6.1.3 Analysis

This section provides a statistical overview of the data. The full dataset comprises 1661 consignments with record creation dates ranging from October 2005 to December 2010, and comprises

Table 6.1: Quarantine inspection sampling rates for dried apricot by consignment size.

Shipment Size (Cartons)	Sample size inspected (Cartons)
2–50	2
51–500	3
501–1500	5
1501–3200	8
3201–10000	13
10000+	20

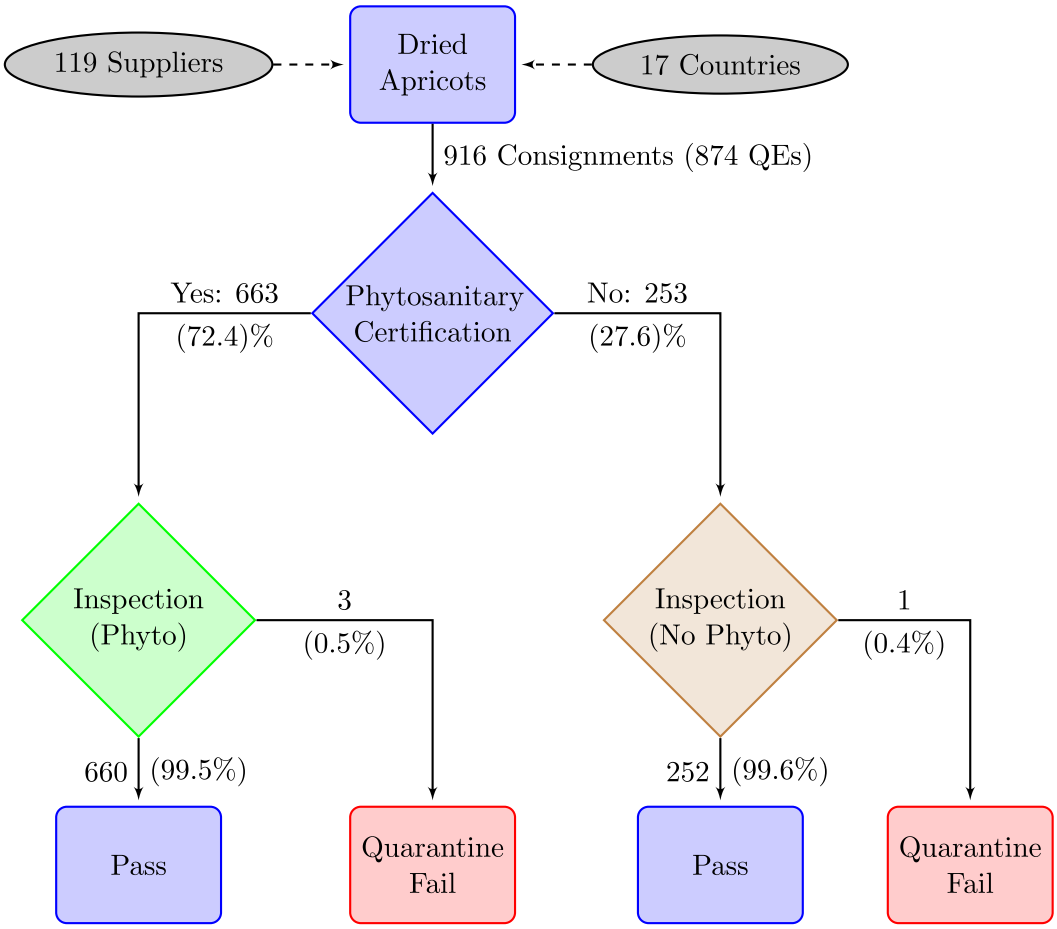

Figure 6.1: Dried apricots consignments flow chart with statistics for July 2008 to December 2010. A quarantine failure was recorded for consignments with a detection of quarantine concern, such as insect, pathogen, or contamination. QEs refers to the number of quarantine entries, which may differ from the number of consignments.

entries from 17 countries and 157 suppliers.

A smoothed plot of the quarantine failure rate against time is presented in Figure 6.2. A brief explanation of the figure follows. The raw data are the date of the inspection and whether the inspection was a fail (counts as '1') or a pass (counts as '0'). The figure was constructed using a moving window along the dates, taking the average of all the inspection results. So, for example, the height of the line at 30 December 2006 would be the average of all the results from 30 December 2005 to 30 December 2007. The height of the line at 31 December 2006 would be the average of all the results from 31 December 2005 to 31 December 2007. These values would probably not differ much, so the line is smooth. The window is quite wide, so the outcome is a smooth line that captures the broad patterns of failures without jiggling around excessively. This approach enables easier interpretation of the patterns of the data.

The line is complemented by a shaded region that represents a 95% confidence interval around the line. Loosely speaking, we can interpret the total height of the shaded area as telling us about the amount of information that we have of the true location of the line. A smaller height implies more information and might correspond, for example, to a greater number of inspections available in the window, or to the average being closer to zero.

The figure shows a failure rate descending smoothly from just under 1% to less than 0.3%. The failure rate for the entire period was 0.54%, and for the analysis period (everything after June 2008) was 0.44%.

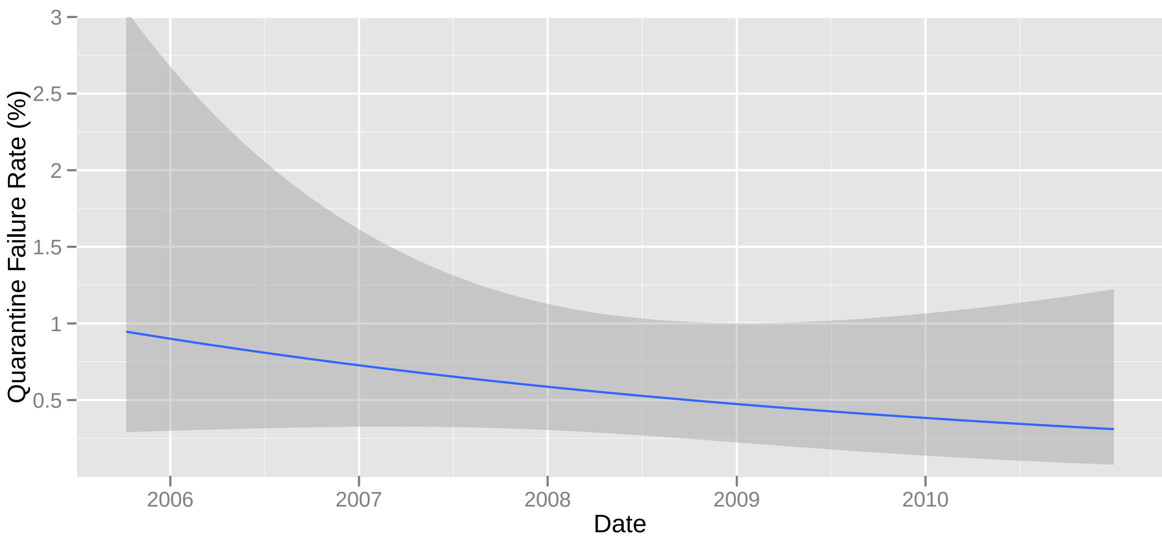

Figure 6.2: Quarantine failure rates (%) for dried apricots, smoothed by date, with a 95% confidence interval (shaded region) added, A 95% confidence interval is a region within which we are reasonably sure that the true line lies. Formally, it is a pointwise interval which, if computed from an independent sample of the same size multiple times, will include the true values evaluated at the observations approximately 95% of the time. The width of the shaded region indicates the uncertainty of the line, which becomes narrower as the number of inspected consignments increases.

Annual inspection statistics are provided in Table 6.2. The count of consignments is stable across the time period, but the tonnage doubles in 2010, and is on track to stay equally high in 2011.

The pattern of quarantine failure counts by country and supplier is presented in Table 6.3. The statistics in Table 6.4 summarize the inspection data for those countries with at least five consignments during the key time period and Table 6.5 summarizes the inspection data for the suppliers with at least twenty consignments.

The pathway is very diverse, with a large number of suppliers that have very little activity, and a few suppliers with considerable import records. Revealingly, the top eleven suppliers by consignment counts have flawless quarantine inspection records (Table 6.5). This is a very encouraging pattern for risk–return pathway management.

Finally, we examined graphical summaries of both the failure rate against consignment size, and at the supplier level, the consignment count and the average quarantine failure rate. Neither summary showed substantial patterns, and they are not included here.

Table 6.2: Pattern of inspections, pathway failures, and quarantine failure counts for dried apricots by year. *Count* is the number of consignments imported during the study period, *PF%* is the percentage of consignments that fail for any contamination or non-commodity failure, *QF %* is the percentage of consignments with contamination of quarantine interest, and *Tonnage* is the total tons of product imported during the study period.

Year	Count	PF %	QF %	Tonnage
2005	61	1.6	1.6	1,020
2006	318	0.9	0.6	4,880
2007	236	1.3	0.8	2,924
2008	266	0.8	0.4	3,582
2009	285	0.4	0.4	4,128
2010	495	0.8	0.4	5,464

Table 6.3: Frequency of quarantine failure counts using recent data for dried apricots by country and supplier. The data cover all inspections from July 2008 to December 2010.

Failures	Countries	Suppliers
0	15	115
1	1	4
2	0	0
3	1	0

Table 6.4: Summary statistics for dried apricots by country. See caption of Table 6.2 for explanation of column names. *QF* is the count of consignments with contamination of quarantine interest. The *Suppliers* column reports the number of suppliers that have exported from each country during the time period. The data cover all inspections from July 2008 to December 2010. We only include those countries with five or more consignments during the time period.

Country	Count	PF %	QF	QF %	Tonnage	Suppliers
a	629	0.6	3	0.5	9,426	69
b	193	0.5	0	0.0	1,218	15
c	38	2.6	0	0.0	496	9
d	28	0.0	0	0.0	381	4
e	8	12.5	1	12.5	6	7
f	6	0.0	0	0.0	<1	5

6.1.4 Simulation Results

The results are presented in Figures 6.3 and 6.4. Figure 6.3 provides the average simulated post-intervention compliance (PIC) as a function of inspection strategy and total inspection count for a range of options. The x-axis is the amount of effort, and less is preferred. The y-axis is the PIC, and higher is preferred. The grey line shows the expected PIC for random sampling, and may be used as a baseline to assess the improvement resulting from selecting a CSP strategy.

Table 6.5: Summary statistics for dried apricots by supplier. See caption of Table 6.4 for explanation of column names and scope. We include only those suppliers with at least 20 recent consignments. The *Countries* column reports the number of countries that each supplier has exported from during the time period.

Supplier	Count	PF %	QF	QF %	Tonnage	Countries
a	75	0.0	0	0.0	482	1
b	52	0.0	0	0.0	1,047	1
c	52	0.0	0	0.0	759	1
d	49	0.0	0	0.0	442	1
e	47	0.0	0	0.0	880	1
f	44	0.0	0	0.0	368	1
g	44	0.0	0	0.0	352	1
h	37	0.0	0	0.0	904	1
i	32	3.1	0	0.0	671	1
j	22	0.0	0	0.0	460	1
k	22	0.0	0	0.0	481	1
l	20	0.0	0	0.0	373	1

We note the following points, and emphasize that these points are relevant only to the simulated inspection of apricots based on existing data.

- All three CSP regimes are more efficient than random sampling, in that the average PIC returns are all substantially higher than the grey line.
- The difference between the different CSP strategies is minimal. However, of the three CSP regimes, CSP–3 seems to provide the best match with the pathway manager's goals of rewarding compliance with reduced inspection rewards, while not allowing unnecessary leakage, or over penalizing random spikes in non-compliance.
- The stratification, monitoring fraction, and clearance number all have an effect on compliance, and the effects can interact with one another.
- Stratifying by supplier seems to give the best value for simplicity and efficiency.
- Given CSP–3 and stratification by supplier, the best strategy seems to be to set the monitoring fraction to 0.1 and the clearance number to 10, in order to achieve a PIC of 99.87%.

Figure 6.4 provides leakage count profiles for all the simulations. It can be used as an alternative means for interpreting the above reasoning.

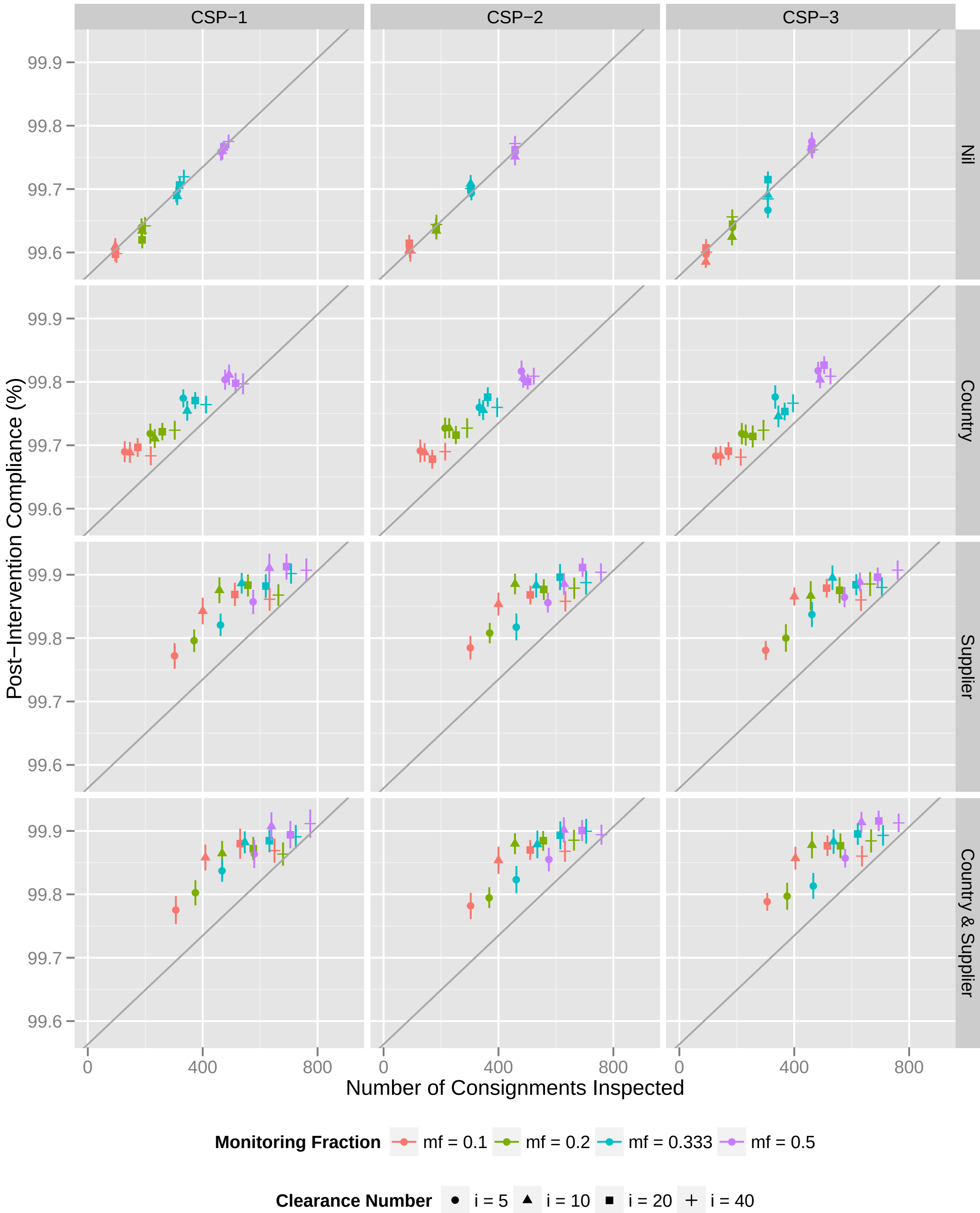

Figure 6.3: Simulated Post-Intervention Compliance (PIC) against inspection effort for dried apricot inspection history. The inspection strategies are in columns, and the stratification options are in rows. Within each panel, the monitoring fraction is delineated by symbol colour, and the clearance number is delineated by the symbol shape. Approximate 95% confidence intervals for the mean of the simulation results are delineated by the vertical line. The grey line represents the expected PIC that would result from random sampling.

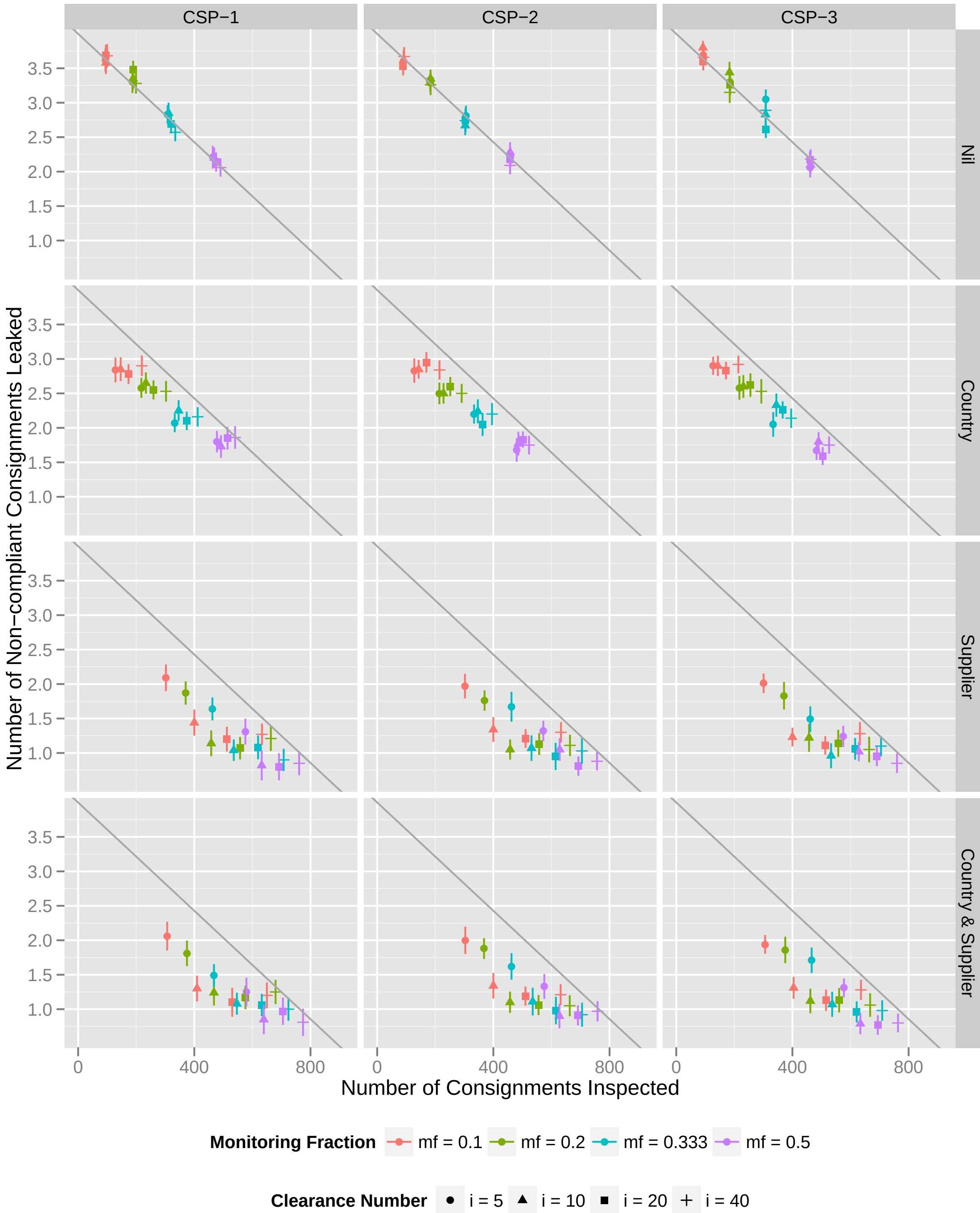

Figure 6.4: Simulated leakage count against inspection effort for dried apricot inspection history. The inspection strategies are in columns, and the stratification options are in rows. Within each panel, the monitoring fraction is delineated by symbol colour, and the clearance number is delineated by the symbol shape. Approximate 95% confidence intervals for the mean of the simulation results are delineated by the vertical line. The grey line represents the expected leakage that would result from random sampling.

7

Recommendations

This chapter details the next set of steps to be undertaken for pathway risk management in the short and medium term. The following shortcomings of the available data and the existing systems have been identified during the development of this project.

1. *Automated supplier targeting is limited in the current IT system.*

   Realisation of the risk return savings of reducing inspection regimes is dependent on the ability to implement reduced inspection rates without requiring significant additional resources for implementation. The ideal solution for reduced inspection rate implementation is by incorporating the automated review of a suppliers compliance history into the current electronic system.

   Due to the significant cost and development time a plant quarantine ruler that would enable this automated review cannot be feasibly developed in the current AIMS system. An alternative implementation of risk return is currently being developed for the interim period before the new ICT system is established. Issues around the alternative implementation include a need for increased entry management resources to manually review a suppliers past inspection compliance in order to determine if an inspection is required. A cost benefit assessment will be made and published in a review following the implementation trial to determine if the additional resources required on review is outweighed by the savings to inspection resources.

   The implementation trial will provide invaluable risk return information in addition to the recommendations identified within this report to support the ICT business case and system development.

2. *No information about inspection effectiveness is available.*

   It is generally recognized that inspections are not and cannot be perfect. Two kinds of inspection error are possible: a false positive, which is wrongly identifying a compliant consignment as being non-compliant, and a false negative, which is wrongly identifying a non-compliant consignment as being compliant.

   Of the two kinds of error, the second is of greater concern, because it leads the inspectorate to believe that the pathway may be cleaner than it truly is. The usual ameliorative action is to apply an assumed inspection effectiveness rate to correct the estimates of the pathway compliance rate.

   Estimates of effectiveness are best developed using a *leakage survey*. The principle of a leakage survey is that a subsample of those consignments that have already been inspected is inspected again, ideally with greater thoroughness than the initial inspection, if that is possible. The subsample should ideally be of a sufficient size in order to be able to estimate the effectiveness of the inspection regime with confidence. The useful lower limit will be somewhere in the order of a couple of hundred units. Examples of sample sizes and methods to derive them can be found in Appendix 1 of Cannon (2003); the relevant material is reproduced as Appendix B of this report.

As the number of pathways that are being monitored in this way increases, the overall number of leakage surveys required will also increase. It may be possible for the inspectorate to group 'like' pathways from the point of view of leakage propensity, in order to form a more efficient estimate of pathway and inspection regime risks. Therefore the inspectorate may assume that leakage rates are constant across country, supplier, and perhaps across certain tariffs, in order to allow for pooling data to obtain better (less variable) estimates of effectiveness across the pathways.

By the same token, it is possible that some pathways may be required to be stratified to enable the accurate computing of a pathways risk, for example the effectiveness of inspection may differ within species of nursery stock.

3. *Data capture systems do not support automated risk return analysis.*

   Presently the pathway data are held in two separate databases: AIMS holds the information on all the inspections, and Incidents holds information on the contamination of the non-compliant consignments. The Incidents database was used with the intention of informing the biosecurity risk of interceptions detected on each pathway. A sparsity of identifications to species level and a lack of reporting on the actionable or non-actionable quarantine status of the interception are current issues with the Incidents database. This lack of species-specific quarantine information resulted in the project team being unable to produce a suitable picture of biosecurity risk for each pathway. Subsequently all interceptions were classified as quarantine failures[1] to insure a conservative approach to assessing the quarantine risk of a pathway. In addition the Incidents database alone did not contain all the quarantine failure information required to assess failure rates for the pathway. For this reason negative inspection data within the AIMS system was also required to be reviewed to ensure quarantine failure rates where accurately represented.

   In order to analyze the pathway and deploy the inspection algorithm, it is necessary to merge the databases, or at least merge the inspection updates of additional quarantine failures. Unless all the needed information can be consolidated automatically into one database, the merge will have to be performed whenever the algorithm is to be used.

   It is recommended that advances to the AIMS database be considered to enable the employment of further risk-return analysis. Specifically the automated addition of incidents identification information to be recorded and stored in AIMS against the relevant consignment details. Information on whether an interception is of quarantine concern could be achieved with the addition of a new field in AIMS used to record whether or not the consignment is non-compliant for reasons that are related to quarantine biosecurity. Improving the AIMS database to include an actionable or non-actionable field will assist in the ability to determine a pathways actual quarantine failure rate. In addition sub-sampling of interceptions for each pathway as discussed in recommendation 4 below, will help develop a picture of the quarantine pests associated with the pathway, and in turn enable a more informed approach to determining a pathways level of risk. The use of this field would not preclude the maintenance of Incidents for other reasons, however, it would enable an integrated analysis of inspection data using only AIMS. This single point of contact would also be very beneficial in allowing the possibility for the inspection algorithm to be automated within AIMS. Even the systematic use of an agreed key word in the comments field would improve the current reporting system, although questions could obviously be raised about the reliability of such an approach.

[1] This label is used to denote a failure of the pathway to comply with quarantine regulation.

4. *Identification of risk is not systematic.* At present, the identification of pests is haphazard, depending on decisions made by the importer, the availability of scientific resources, and other factors that resist generalization. As a consequence, using the data to decide whether a pest or pathogen is a biosecurity risk must be made conservatively when assessing the risks associated with detections.

   A systematic approach based on sampling theory would allow better prescriptions to be made about the true risk of a pathway. An ACERA project that is intended to develop such an approach is underway with the Operational Science Program (ACERA Project 1101E, Sampling for Invasives).

5. *Simultaneous analysis of multiple pathways may yield advantages.*

   The trial approach used by this case study report has analysed pathways individually. This is a necessary and important starting step in the analysis of the system that comprises the pathways. However, such an analysis has two important shortcomings.

   (a) The selection of pathways for analysis is haphazard, based on regional inspectorate advice, rather than being guided by statistical principles that could be used to identify those pathways that have inspection histories with characteristics that seem likely to benefit from a risk–return inspection approach.
   (b) The pathways are being analyzed independently. It is arguably possible that insights or patterns that are determined in one pathway may be illuminating, or even useful, in another pathway. For example, it is possible that the inspection history of a supplier for one pathway may be relevant to their activities in other pathways.

   Statistical model fitting and data mining can provide insight into these conjectures. An ACERA project that is intended to develop such an approach will be undertaken with Plant Quarantine Operations following finalisation of this project (ACERA Project 1101C, Quarantine Inspection and Auditing Across the Biosecurity Continuum).

6. *Sustained innovation will be critical.*

   The outcomes of the analyses that drive this project should be reasonably stable for a year or so. However, at some point we would want to make allowance for the possibility that inspection history patterns have changed in ways that were unanticipated at this point.

   As a simple example, we may prescribe a supplier-specific monitoring plan, but later find that a country-specific plan would yield a better outcome. A re-analysis of the inspection data, including those new data that have been collected since this analysis, will be required. This re-analysis could be initially performed as a Post-Implementation Review.

   The project team should prepare for this eventuality. The analytical tools that will be deployed over the next portions of this project (1101C) will require reasonably sophisticated quantitative backgrounds and training. It is unlikely that they will be suitable for the easy grasp of pathway managers and a dedicated data review team with appropriate training and statistical aptitude should be developed to ensure the continued identification of further risk return pathways and review of implemented inspection regimes.

   The data should be reviewed at least quarterly for the first year. That process will involve, at minimum, extracting new inspection data from AIMS, merging the inspection data with an extraction from Incidents, and performing some simple spreadsheet operations. The process will be more useful to the pathway manager if deeper analysis (such as is documented here) is undertaken here by suitably skilled personnel.

7. *Informal variations to the algorithm could be worthwhile.*

   A reviewer of this report suggested "One benefit of the *just checking* stage in CSP-3 (meaning the stage after a single quarantine detection) is that it provides an entry point for monitoring at the start of each season. One could imagine that the suppliers might have a few teething problems at such a time, but fewer than a supplier starting up from scratch. The first four (say) consignments of a seasonal product could be inspected before flipping to monitoring mode, rather than the first 10 consignments for a new supplier."

   For this report, the majority of the pathways this algorithm would be applied to are not horticultural, and have no season. Also, issues such as storage of goods for months prior to shipment, or exports from different hemispheres mean it will be very difficult to determine when a season starts and finishes. Nonetheless, the idea is worth keeping in mind.

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Appendix A

Starting Surveillance

In this chapter we recommend a sequence of actions for the pathway manager to undertake if no inspection data are available for analysis.

A.1 Snapshot Survey

If nothing is known about the pathway failure rate then the best first step is to perform a snapshot survey. This survey would ideally extend for a minimum of two months (or 500–600 consignments, whichever condition is satisfied first). During the survey, every consignment would be inspected, and the outcomes of the inspections recorded in detail. Depending on the nature of the consignments, it may be worthwhile to inspect each one more intensively than the standard work instructions would suggest. For example, if the usual procedure might be to inspect 600 randomly selected units, then the snapshot survey might be of 1200 randomly selected units.

The results of these inspections can be used for several purposes:

1. define quarantine contamination, and having done so,
2. develop an understanding of the types and severity of quarantine contamination that the pathway is subject to, as well as
3. estimate the contamination rate of the pathway, and
4. identify data that would be useful to collect in the longer term.

Ideally such a survey should be undertaken with the cooperation of the OSP, so that the full range of potential contamination can be surveyed and assessed.

When the data have been analyzed, a CSP protocol can be applied to future inspection of the pathway as follows.

A.1.1 Selecting MF and CN

Recall that in order to deploy the CSP–1 algorithm, the pathway manager needs to select two numbers: the monitoring fraction (MF) and the clearance number (CN). These numbers have a straightforward interpretation:

MF controls how often the pathway is monitored. Higher values of MF are more expensive but make the sampling more sensitive to changes in the underlying contamination rate. Lower values of MF represent a lower burden on compliant pathways.

CN controls how many successive uncontaminated consignments must be inspected before a pathway can be deemed 'clean'. Higher values of CN are associated with greater conservatism in terms of pathways demonstrating that they are compliant before being shifted to monitoring.

Some useful statistics can be computed if MF, CN, and the contamination rate are known, and other useful statistics can be computed using only MF and CN. These statistics can be used to project the likely performance of the use of a CSP recipe for selecting consignments to inspect. The statistics that are most commonly used to make decisions about the values used for CSP are the average outgoing quality (AOQ, needs MF, CN, and contamination rate), the average outgoing quality limit (AOQL, needs MF and CN only), and the average fraction inspection (AFI, needs all three numbers). AOQ is the average leakage, in DAFF Biosecurity terms, and AOQL is the highest value of AOQ for all possible contamination rates between 0% and 100%.

Various look-up tables are available to read the appropriate values. They can also be reproduced by the following formulas (Dodge, 1943). Denote the true approach rate using p, the monitoring fraction by f, and the clearance number by i. Then

$$\mathrm{AOQ} = \frac{p \times (1-f) \times (1-p)^i}{f + (1-f) \times (1-p)^i} \tag{A.1}$$

$$\mathrm{AFI} = \frac{f}{f + (1-f) \times (1-p)^i} \tag{A.2}$$

AOQL is the maximum AOQ across all possible values of p, and is found numerically.

These equations can be programmed into any popular spreadsheet software, and the effects of trade-offs between different values of f and i can be determined upon the AOQ (using the estimate of p from the snapshot survey).

We provide computed values for CSP–1 purely as examples in Table A.1, using the monitoring fraction and clearance numbers determined for CSP–3 during the simulation experiments (reported in Table 1.1). To be clear: we include these values purely as examples, not for applications.

Table A.1: Examples of AOQ and AFI for sampled pathways *assuming CSP–1*, using the parameters determined for CSP–3. *Number* is the average number of consignments per year. *Fail* is the percentage of consignments in which arthropod, pathogen, or contamination is detected. *MF* and *CN* present the recommended monitoring fraction and clearance number respectively *using the CSP–3 simulations*, and *PIC* and *Leak* provide the simulated post-intervention compliance rate and expected annual leakage rate respectively. *AOQ* is the average outgoing quality for CSP–1, and *AFI* is the average fraction inspected.

Pathway	Number	Fail (%)	MF (%)	CN	PIC (%)	Leak (%)	AOQ (%)	AFI (%)
Dried Apricots	368	0.44	10	10	99.87	0.13	0.39	10.40
Coir Peat	73	0.56	10	10	99.95	0.05	0.51	10.52
Hulled Sesame Seeds	150	0.81	50	10	99.83	0.17	0.39	52.03
Dried Dates	183	1.10	10	10	99.70	0.30	0.98	11.04
Green Coffee Beans	1131	2.33	50	10	99.00	1.00	1.03	55.88

These theoretical results show that about 10% of the pathway would be sampled for dried apricots, coir peat, and dried dates, and 50% for hulled sesame seeds and green coffee beans, which is in accord with the specified monitoring fraction. The average outgoing quality is below 1%, often substantially, in all cases except green coffee beans. We do not expect that the theoretical results will be identical to those from the simulations, because the algorithms are different (CSP–1 for the theory and CSP–3 for the simulations) and because the theoretical results impose assumptions on the nature of the process that the simulations do not, but the results should be close.

A.2 CSP Without Data

If the pathway manager prefers to start a surveillance regime directly, then it is possible to start the CSP sampling algorithms from scratch. For a pathway for which nothing is known it seems sensible to start with the most conservative option: CSP–1. We advocate the use of AOQL, or a range-limited version (eg. constrain the range to be between 0% and 10% instead of 0% and 100%) to set the appropriate CN and MF. The trade-off between CN and MF can then be made based on operational considerations, as noted above.

Appendix B

Leakage Survey Sample Size

We want to estimate how many samples are needed to estimate the effectiveness to the desired level of accuracy. To do this we need a "ball park" figure for some of the parameters. We reproduce the approximate sample size formula from Cannon (2003). The needed sample size is approximated by

$$n \approx \frac{z^2 \hat{E}^2 (1 - \hat{E})(1 - \hat{a})}{w^2 \times \hat{a}} \tag{B.1}$$

where

- n is the needed sample size,
- z is the normal two-sided quantile (1.96 for 95% CI),
- w is the desired width of confidence limits,
- $\hat{E}$ is a preliminary guess at the actual effectiveness, and
- $\hat{a}$ is an estimate of the approach rate.

For example, assume the following values: we wish for a confidence interval of ± 0.1 for effectiveness, we think that the effectiveness is about 0.8, and that the approach rate is 0.05. Then

$$n \approx \frac{1.96^2 \times 0.8^2 \times (1 - 0.8) \times (1 - 0.05)}{0.1^2 \times 0.05} = 934.3 \tag{B.2}$$

Appendix C

Post-Intervention Compliance (PIC)

Here we provide a brief summary of how to compute the PIC performance indicator as used in this report. For more details and other variations, see Robinson et al. (2011).

The calculation is based on division of the items in the pathway into two strata: *enhanced inspection* and *monitored.* We estimate the number of missed consignments for each stratum and then sum them to obtain the overall count, which is used to compute the PIC.

We define, for each stratum,

v as the volume of the pathway (number of intervention units),

i as the number of units actually inspected,

b as the number of inspected units that contain biosecurity risk material (BRM) (not including those found by the leakage survey),

n as the number of units inspected in the leakage survey,

y as the number of units inspected in the leakage survey that are not compliant,

$\hat{l}$ as the estimated leakage count of units *that were inspected*,

$\hat{L}$ as the estimated pathway-level leakage count,

$\hat{a}$ as the approach count, and

e as the inspection effectiveness, defined as the proportion of non-conforming units detected among all those non-conforming units that are inspected.

The post-intervention compliance (PIC) is calculated as

$$\mathrm{PIC} = \frac{v - \hat{L}}{v} \tag{C.1}$$

If a leakage survey had been done then we would estimate $\hat{l} = i \times y/n$ and then estimate $\hat{e} = b/(b + \hat{l})$. In the absence of a leakage survey, we have assumed that inspection effectiveness e is known, and the same for each stratum. Given e, the inspection-level leakage $\hat{l}$ is

$$\hat{l} = \frac{b}{e} - b = b \times \left(\frac{1}{e} - 1\right) \tag{C.2}$$

Then, the estimated approach count for each stratum (monitored: $k = 1$, enhanced inspection: $k = 2$) is

$$\hat{a}_k = \frac{b_k}{e} \times \frac{v_k}{i_k} \tag{C.3}$$

where $v_2 = i_2$ for the enhanced inspection stratum, and $i_1 < v_1$ for the sampled stratum. Then

$$\hat{L}_k = \hat{a}_k - b_k = b_k \times \left(\frac{v_k}{i_k \times e} - 1\right) \tag{C.4}$$

and

$$\hat{L} = \sum_{h} \hat{L}_k \tag{C.5}$$

The final step is then to compute the quantity in equation (C.1).

Note that for these simulation experiments, we assume that the effectiveness is 0.9, so $\hat{l} = 0.11 \times b$, and

$$\hat{L}_k = b_k \times \left(\frac{v_k}{i_k \times 0.9} - 1 \right) \tag{C.6}$$

Appendix D

Other Case Studies

D.1 Baby Corn

For this analysis, 'baby corn' refers to immature, fresh *Zea mays* consignments imported for human consumption. The baby corn pathway has a relatively low failure rate. However, the pathway does not show evidence of being a good match for the supplier-specific sampling prescriptions that have been recommended for other imported-plant product pathways. The reason is that the pathway is dominated by one country and a small number of suppliers, all of whom have evidence of recent quarantine contamination. Therefore, there is no evidence that targeting the sub-pathways will provide better pathway compliance than random sampling. We speculate that using supplier-specific targeting may result in behavioural changes that improve the pathway compliance, and coupled with the already low failure rate, this speculation may provide enough motivation to test supplier targeting for this pathway.

D.1.1 Import Conditions

Baby corn is considered a quarantine risk to Australia because fresh produce and/or the cartons that they are packaged in may contain plant material other than the permitted commodity, and other contaminants such as straw packaging, soil, insects, arthropod eggs, disease symptoms or seeds. These contaminants also have the potential to harbour microorganisms or fungi, which could have a significant impact if introduced into Australia.

Fresh baby corn is only permitted entry into Australia if accompanied by a valid import permit, granted under the condition that all consignments are immature corn only. A phytosanitary certificate is also required for all consignments.

Prior to entry into Australia, all consignments must pass an AQIS quarantine inspection to verify that the baby corn is free from live insects and other quarantine risk material (QRM). A sample of 600 individual cobs is selected from a random number of punnets within each consignment and individually inspected for the presence of insects, pests, disease, soil, and other contamination such as weed seeds and plant trash. 60 fruit from the sample is examined further under higher magnification.

D.1.2 Pathway Summary

A flowchart of the pathway is presented in Figure D.1.

D.1.3 Analysis

The full dataset comprises 1990 consignments with record creation dates ranging from October 2005 to December 2010, and comprises entries from 6 countries and 57 suppliers.

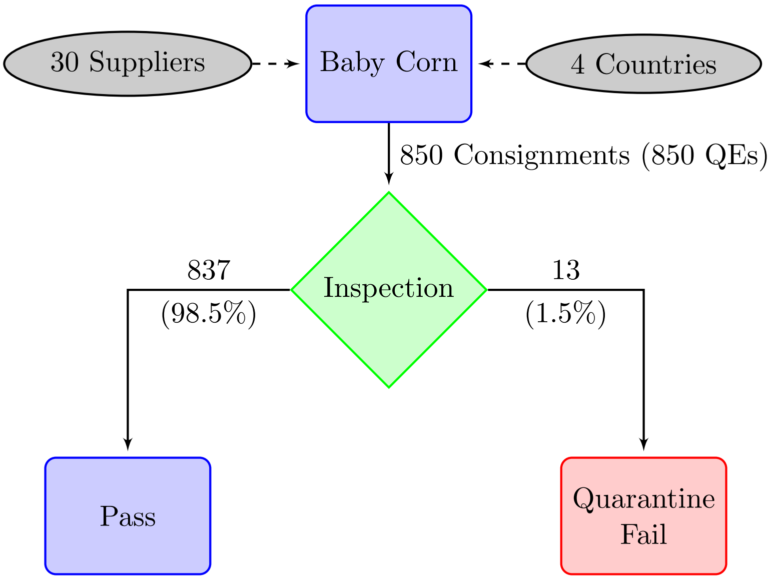

Figure D.1: Baby corn consignments flow chart with statistics for July 2008–December 2010. A quarantine failure was recorded for consignments with a detection of quarantine concern, such as insect, pathogen, or contamination. QEs refers to the number of quarantine entries, which may differ from the number of consignments.

A smoothed plot of the quarantine failure rate against time is presented in Figure D.2. The figure shows a failure rate increasing from about 0.5% to over 2%. The failure rate for the entire period was 1.21%, and for the analysis period (everything after June 2008) was 1.53%.

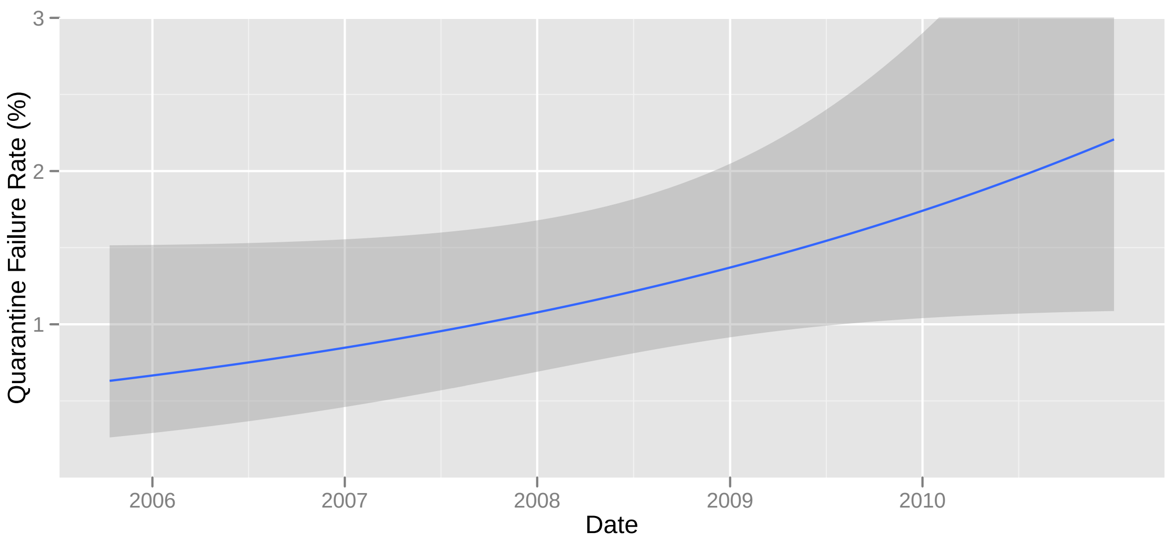

Figure D.2: Quarantine failure rates (%) for baby corn smoothed by date, with a 95% confidence interval (shaded region) added (see the caption of Figure 6.2 on page 24 for an explanation of the interval). The width of the shaded region indicates the uncertainty of the line, which becomes narrower as the number of inspected consignments increases.

Annual inspection statistics are provided in Table D.1. A pathway failure was recorded for consignments with a negative inspection record due to document or non-commodity specific failures with the consignment, such as packaging. The count of consignments is decreasing gradually across the time period.

Table D.1: Pattern of inspections, pathway failures, and quarantine failure counts for baby corn by year. *Count* is the number of consignments imported during the study period, *PF%* is the percentage of consignments that fail for any contamination or non-commodity failure, *QF %* is the percentage of consignments with contamination of quarantine interest, and *Tonnage* is the total tons of product imported during the study period.

Year	Count	PF %	QF %	Tonnage
2005	100	2.0	2.0	66
2006	485	2.1	0.4	363
2007	403	1.7	1.2	316
2008	314	2.2	0.6	303
2009	343	4.1	1.7	226
2010	345	2.9	2.0	271

Table D.2: Frequency of quarantine failure counts using recent data for baby corn by country and supplier. The data cover all inspections between July 1 2008 and 31 December 2010.

Failures	Countries	Suppliers
0	3	26
1	0	0
2	0	2
3	0	0
4	0	1
5	0	1
6	0	0
7	0	0
8	0	0
9	0	0
10	0	0
11	0	0
12	0	0
13	1	0

The pattern of quarantine failure counts by country and supplier is presented in Table D.2. The statistics in Table D.3 summarize the inspection data for all countries and Table D.4 summarizes the inspection data for the suppliers with at least twenty consignments. These tables show that all the major suppliers have recently supplied contaminated consignments.

Finally, we examined graphical summaries of both the failure rate against consignment size, and at the supplier level, the consignment count and the average quarantine failure rate. Neither summary showed substantial patterns, and they are not included here.

Table D.3: Summary statistics for baby corn by country. See caption of Table D.1 for explanation of column names. *QF* is the count of consignments with contamination of quarantine interest. The *Suppliers* column reports the number of suppliers that have exported from each country during the time period. The data cover all inspections between July 1 2008 and 31 December 2010.

Country	Count	PF %	QF	QF %	Tonnage	Suppliers
a	841	3.0	13	1.5	634	25
b	4	0.0	0	0.0	24	1
c	3	0.0	0	0.0	<1	2
d	2	0.0	0	0.0	<1	2

Table D.4: Summary statistics for baby corn by supplier. See caption of Table D.3 for explanation of column names and scope. We include only those suppliers with at least 20 recent consignments. The *Countries* column reports the number of countries that each supplier has exported from during the time period.

Supplier	Count	PF %	QF	QF %	Tonnage	Countries
a	228	3.9	5	2.2	151	1
b	206	2.4	2	1.0	81	1
c	107	3.7	2	1.9	58	1
d	100	6.0	4	4.0	39	1
e	92	0.0	0	0.0	88	1
f	21	4.8	0	0.0	15	1

D.1.4 Simulation Results

The results are presented in Figures D.3 and D.4. Figure D.3 provides the average simulated post-intervention compliance as a function of inspection strategy and total inspection count for a range of options. The x-axis is the amount of effort, and less is preferred. The y-axis is the PIC, and higher is preferred. The grey line shows the expected PIC (or leakage) for random monitoring, and may be used as a baseline to assess the improvement resulting from selecting a CSP strategy.

We note the following points, and emphasize that these points are relevant only to the simulated inspection of baby corn based on existing data.

- None of the three CSP regimes improve upon random sampling, in that the average PIC returns are all close to or below the grey line.
- The difference between the different CSP strategies is minimal. However, of the three CSP regimes, CSP–3 seems to provide the best conceptual match with the pathway manager's goals of targeting compliance with reduced inspection rewards, while not allowing unnecessary leakage, or over penalizing random spikes in non-compliance.
- The monitoring fraction has a clear effect on the compliance, but the effect of changing the clearance number seems minimal.
- Stratifying by supplier or country seems to lead to no improvement at all.

Figure D.4 provides leakage count profiles for all the simulations. It can be used as an alternative means for interpreting the above reasoning.

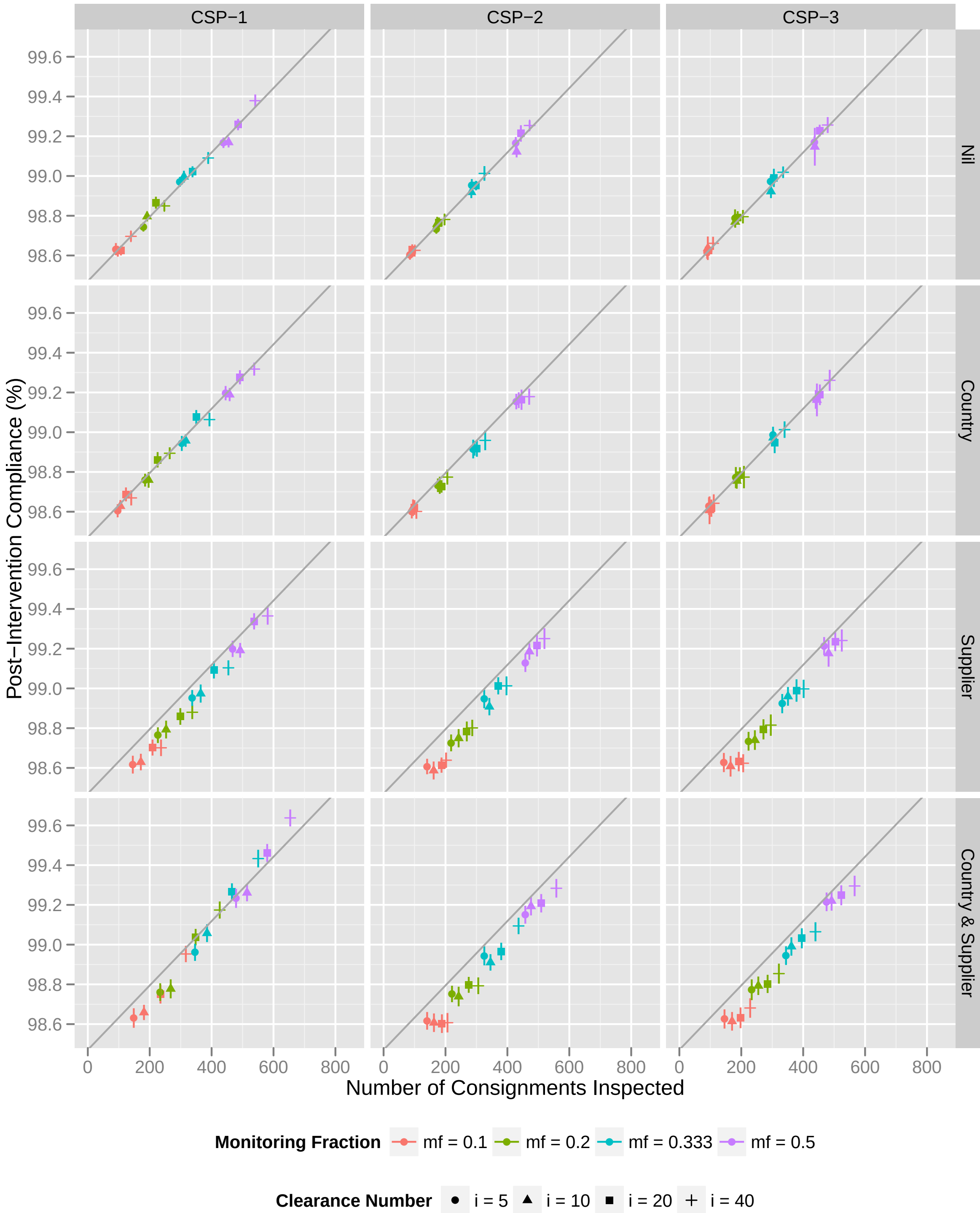

Figure D.3: Simulated Post-Intervention Compliance (PIC) against inspection effort for baby corn inspection history. The inspection strategies are in columns, and the stratification options are in rows. Within each panel, the sampling fraction is delineated by symbol colour, and the clearance number is delineated by the symbol shape. Approximate 95% confidence intervals for the mean of the simulation results are delineated by the vertical line. The grey line represents the expected PIC that would result from random sampling.

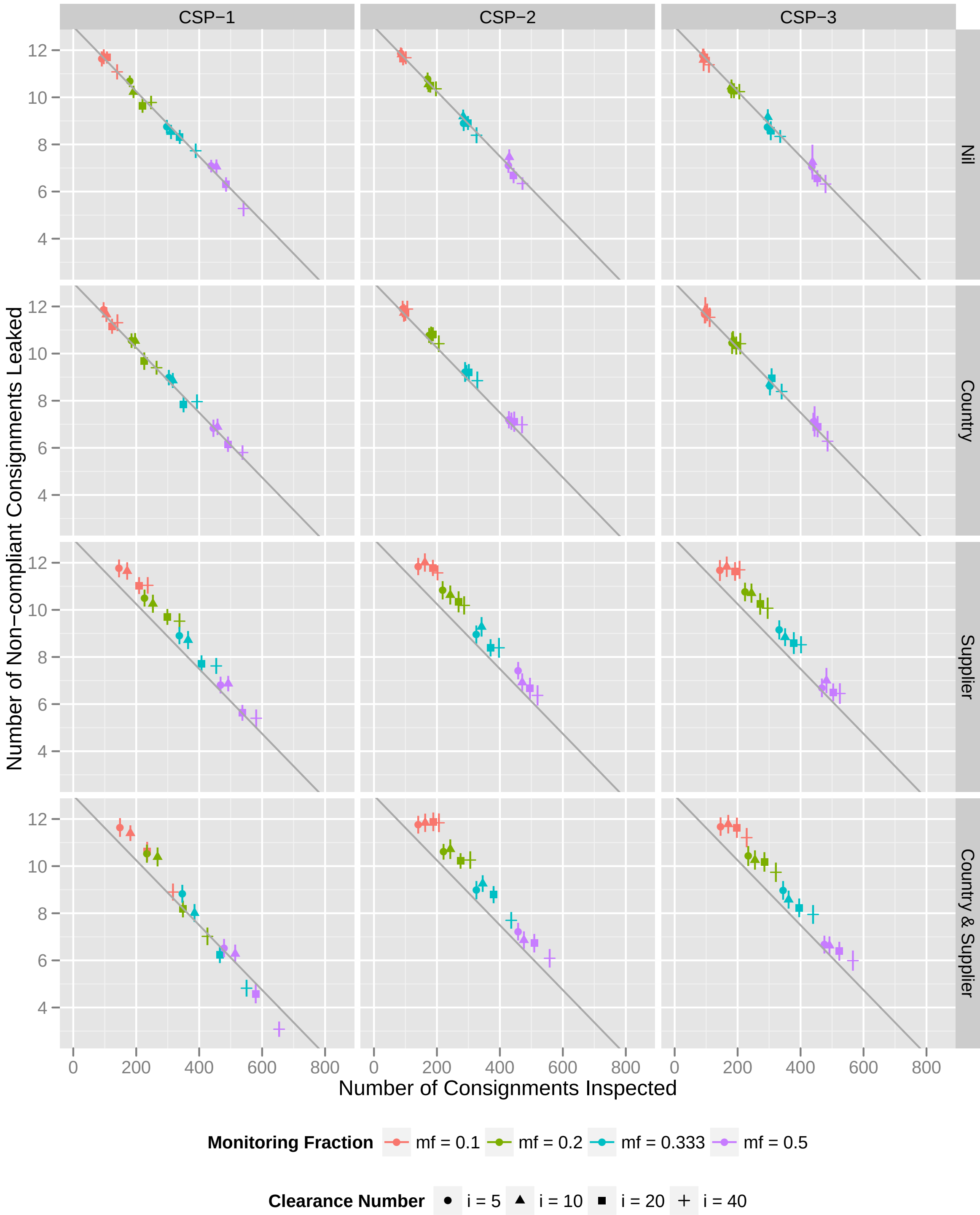

Figure D.4: Simulated leakage count against inspection effort for baby corn inspection history. The inspection strategies are in columns, and the stratification options are in rows. Within each panel, the monitoring fraction is delineated by symbol colour, and the clearance number is delineated by the symbol shape. Approximate 95% confidence intervals for the mean of the simulation results are delineated by the vertical line. The grey line represents the expected leakage that would result from random sampling.

D.2 Blueberries exported from *Country A*

For this analysis, 'blueberries' refers to fresh *Vaccinium corymbosum* or *Vaccinium angustifolium* imported from *Country A* for human consumption. Based on the 5.5 years of inspection data, this pathway has a high historical failure rate compared with the other pathways in this project. Also, the failures were mainly among the high-volume suppliers. Based on the results herein, and depending on the inherent biological risk associated with the pathway, it may be defensible to retain 100% inspection in this pathway. The historical trend suggests that the failure rate is decreasing (see Figure D.6 and Table D.5). A reduced inspection regime is not advocated by this analysis, however the decreasing failure rate indicates that the pathway may be suitable for risk–return pathway management in the future.

D.2.1 Import Conditions

Blueberries are considered a quarantine risk to Australia because fresh produce consignments, and/or the cartons that they are packaged in, can contain unidentified plant material, prohibited seeds and other contaminants such as straw packaging, soil, pupae, or insect pests. These contaminants also have the potential to harbour microorganisms or fungi, which could have a significant impact if introduced into Australia.

Blueberries are only permitted entry into Australia if accompanied by a valid import permit, granted under the condition that all produce is imported for the single end use only (i.e. human consumption). A phytosanitary certificate is also required.

Prior to entry into Australia, all consignments must pass an AQIS quarantine inspection on arrival to verify that the blueberries are free from live insects and other quarantine risk material (QRM). A sample of 600 fruits (individual berries) is selected at random from the entire consignment and individually inspected under a low magnification (10X) hand lens for the presence of insects, pests, disease symptoms, soil, and other contamination, such as weed seeds and plant trash. 60 fruit from the sample is examined further under high magnification (30X).

A formal Import Risk Analysis (IRA) has not been completed for blueberry imports, as this is a long established trade, however, a risk determination has identified 'Blueberry Rust' (*Naohidemyces vaccinii = Pucciniastrum vaccinii*) as a disease that affects blueberries and is not present in a number of Australian states. An additional declaration is required on the phytosanitary certificate for consignments entering Western Australia, Victoria, and Tasmania, declaring freedom or treatment from Blueberry Rust.

D.2.2 Pathway Summary

A flowchart of the pathway is presented in Figure D.5.

D.2.3 Analysis

This section provides a statistical overview of the data. The full dataset comprises 1516 consignments with record creation dates ranging from October 2005 to February 2011, and comprises entries from 1 country and 19 suppliers.

A smoothed plot of the quarantine failure rate against time is presented in Figure D.6. As at 2011, it is approximately 2.8%. We note a jump in the rate of quarantine failures occurring around 2010. The failure rate for the entire period was 10.36%, and for the analysis period (everything after June 2008) was 5.36%.

Annual inspection statistics are provided in Table D.5. The count of consignments increases annually across the time period, and the tonnage nearly doubles in 2010, and is on track to stay equally high in 2011.

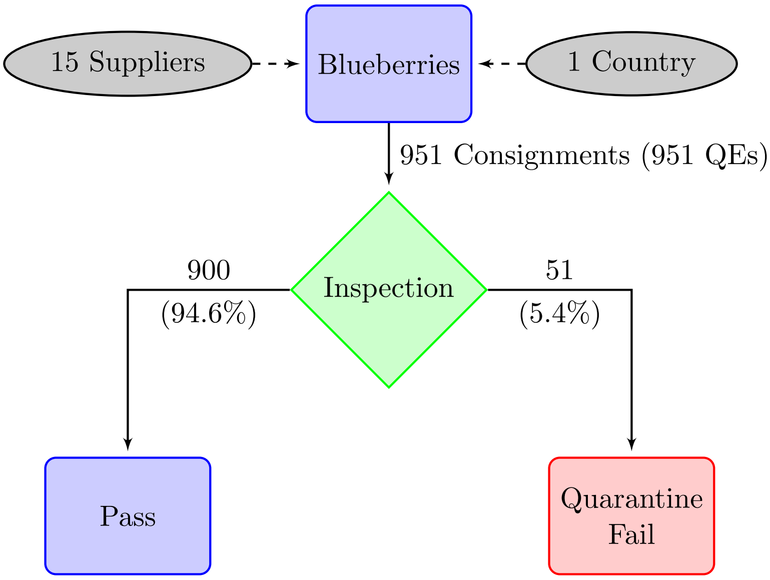

Figure D.5: Blueberries consignments flow chart with statistics for July 2008–February 2011. A quarantine failure was recorded for consignments with a detection of quarantine concern, such as insect, pathogen, or contamination. QEs refers to the number of quarantine entries, which may differ from the number of consignments.

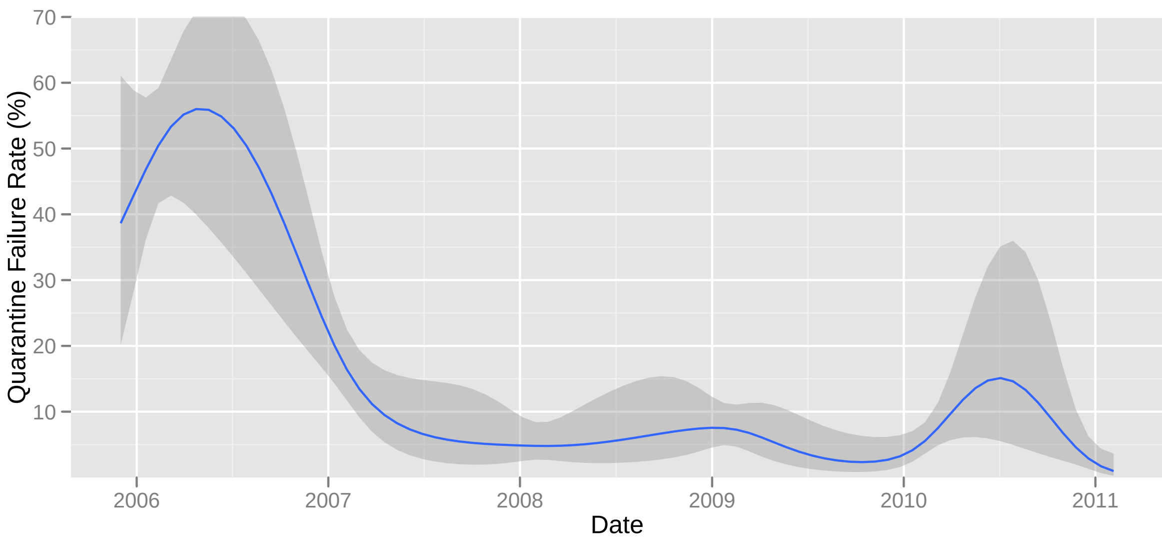

Figure D.6: Quarantine failure rates (%) for blueberries, smoothed by date, with a 95% confidence interval (shaded region) added (see the caption of Figure 6.2 on page 24 for an explanation of the interval). The width of the shaded region indicates the uncertainty of the line, which becomes narrower as the number of inspected consignments increases.

The pattern of quarantine failure counts by supplier is presented in Table D.6. The statistics in Table D.7 summarize the inspection data for the suppliers with at least ten consignments. These results show that all three of the top suppliers have a recent history of non-compliant consignments.

Finally, we examined graphical summaries of both the failure rate against consignment size, and at the supplier level, the consignment count and the average quarantine failure rate. Neither summary showed substantial patterns, and they are not included here.

Table D.5: Pattern of inspections, pathway failures, and quarantine failure counts for blueberries by year. *Count* is the number of consignments imported during the study period, *PF%* is the percentage of consignments that fail for any contamination or non-commodity failure, *QF%* is the percentage of consignments with contamination of quarantine interest, and *Tonnage* is the total tons of product imported during the study period.

Year	Count	PF %	QF %	Tonnage
2005	18	33.3	27.8	22
2006	148	52.0	42.6	221
2007	197	16.2	14.7	250
2008	287	5.9	5.2	345
2009	310	8.1	7.1	378
2010	448	4.7	4.5	672
2011	108	2.8	2.8	162

Table D.6: Frequency of quarantine failure counts using recent data for blueberries by supplier. The data cover all inspections between July 2008 and February 2011.

Failures	Suppliers
0	9
1	1
2	1
3	1
11	1
16	1
18	1

Table D.7: Summary statistics for blueberries by supplier. See caption of Table D.5 for explanation of column names. *QF* is the count of consignments with contamination of quarantine interest. We include only those suppliers with at least 10 recent consignments. The data cover all inspections between July 2008 and February 2011.

Supplier	Count	PF %	QF	QF %	Tonnage
a	310	3.5	11	3.5	447
b	281	6.0	16	5.7	442
c	111	0.9	1	0.9	138
d	52	0.0	0	0.0	74
e	48	0.0	0	0.0	76
f	47	46.8	18	38.3	31
g	28	0.0	0	0.0	30
h	18	16.7	3	16.7	16
i	15	0.0	0	0.0	15
j	13	0.0	0	0.0	9
k	10	0.0	0	0.0	12

D.2.4 Simulation Results

The results are presented in Figures D.7 and D.8. Figure D.7 provides the average simulated post-intervention compliance (PIC) as a function of inspection strategy and total inspection count for a range of options. The x-axis is the amount of effort, and less is preferred. The y-axis is the PIC, and higher is preferred. The grey line shows the expected PIC (or leakage) for random monitoring, and may be used as a baseline to assess the improvement resulting from selecting a CSP strategy. We note the following points, and emphasize that these points are relevant only to the simulated inspection of blueberries based on existing data.

- The failure rate of the pathway is quite high.
- All three CSP regimes are more efficient than random sampling, in that the average PIC returns are all much higher than the grey line.
- The difference between the different CSP strategies is minimal.
- The stratification, monitoring fraction, and clearance number all have an effect on compliance, and the effects can interact with one another.
- Stratifying by supplier seems to give the best value for simplicity and efficiency.

Figure D.8 provides leakage count profiles for all the simulations. It can be used as an alternative means for interpreting the above reasoning.

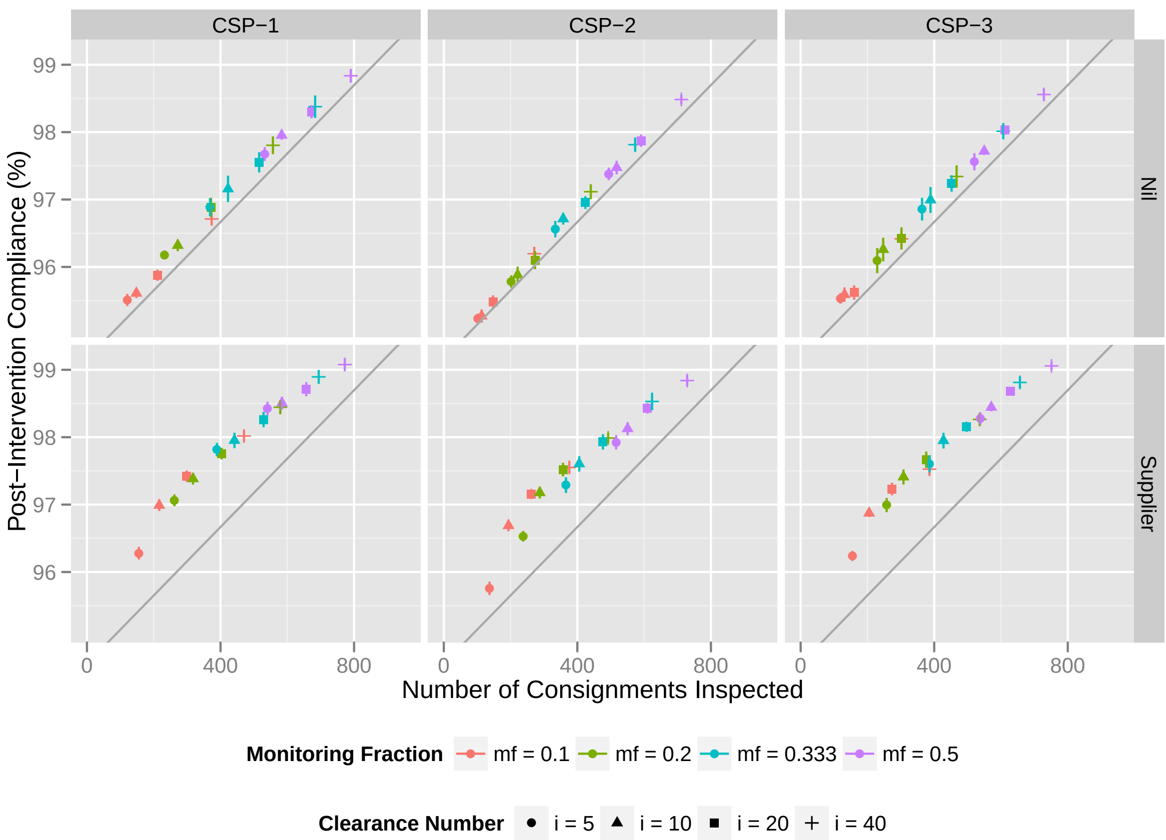

Figure D.7: Simulated Post-Intervention Compliance (PIC) against inspection effort for blueberries inspection history. The inspection strategies are in columns, and the stratification options are in rows. Within each panel, the monitoring fraction is delineated by symbol colour, and the clearance number is delineated by the symbol shape. Approximate 95% confidence intervals for the mean of the simulation results are delineated by the vertical line. The grey line represents the expected PIC that would result from random sampling.

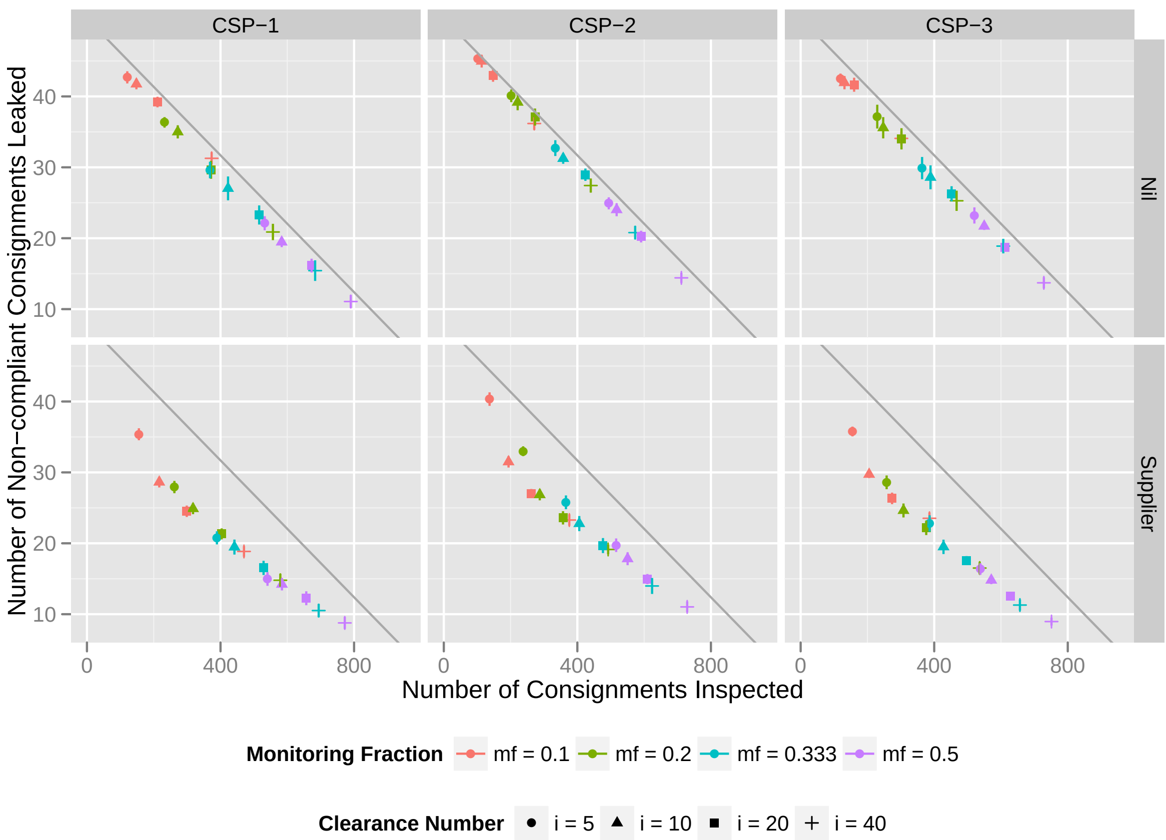

Figure D.8: Simulated leakage count against inspection effort for blueberries inspection history. The inspection strategies are in columns, and the stratification options are in rows. Within each panel, the monitoring fraction is delineated by symbol colour, and the clearance number is delineated by the symbol shape. Approximate 95% confidence intervals for the mean of the simulation results are delineated by the vertical line. The grey line represents the expected leakage that would result from random sampling.

D.3 Coir Peat

For this analysis, 'coir peat' refers to bales, blocks, bricks or briquettes composed of *Cocos nucifera* (compressed or non-compressed coconut fibre), imported for agricultural or horticultural use as a fertilizer. The coir peat pathway is tentatively suitable for monitoring using CSP–3 sampling due to its low historical quarantine failure rate. The total number of consignments of the dataset used for the coir peat simulations was very small: 190 consignments. The results reported here should be interpreted with great caution, and leakage surveys implemented with reduced inspection regimes to validate the following pathway assumptions.

D.3.1 Import Conditions

Coir peat is considered a quarantine risk to Australia as it can contain soil contamination, animal faeces and/or prohibited plant material (e.g. prohibited weed seeds) which can introduce serious plant pathogens, weeds and avian/mammalian viruses.

Coir peat is only permitted entry into Australia if accompanied by a valid import permit. A phytosanitary certificate is required for all consignments, with additional declaration that 'Based on inspection of representative samples, the coir peat is clean, free from soil, contaminant plant material and other extraneous matter'. A certificate is also required from a Government inspection agency declaring 'No visible contamination with animal material', as well as a certificate of analysis from an AQIS approved overseas laboratory detailing *Salmonella* and *E. coli* microbiological analysis.

Prior to entry, all consignments must pass an AQIS quarantine inspection on arrival to verify that the peat is free from live insects, soil, prohibited seeds, weed seeds, animal material and other quarantine risk material (QRM). FCL consignments with correct documentation will be inspected via samples provided during a tailgate inspection. A minimum of 2 samples to a maximum of 5 samples is required for non compressed products, and a minimum of 10 samples to a maximum of 15 samples for compressed products must be removed from the first layer at the end of each container. Samples will be broken open by the Quarantine officer when carrying out the inspection.

If the consignment is not accompanied by an acceptable certificate of analysis the consignment will be sampled for testing. The importer or a representative is to provide samples to the Quarantine officer during a tailgate inspection. The Quarantine officer will draw random samples from these for testing. At least 5 samples of no less than 30 grams will be sent to the National Measurement Institute (NMI) for microbiological testing. If the test results do not meet AQIS standards the consignment may be directed for treatment, re-export or destruction at the importer's expense.

A formal risk assessment has not been undertaken for coir peat. Coir peat itself is not of a quarantine concern. However, stockpiling of coir peat in countries where it is produced, such as Sri Lanka, Philippines, India and Malaysia, can lead to surface contamination with soil, prohibited seeds, animal and bird faeces, plant material and other extraneous matter. *Salmonella* and *E. coli* levels are also required by the Environmental Protection Agency.

D.3.2 Pathway Summary

A flowchart of the pathway is presented in Figure D.9.

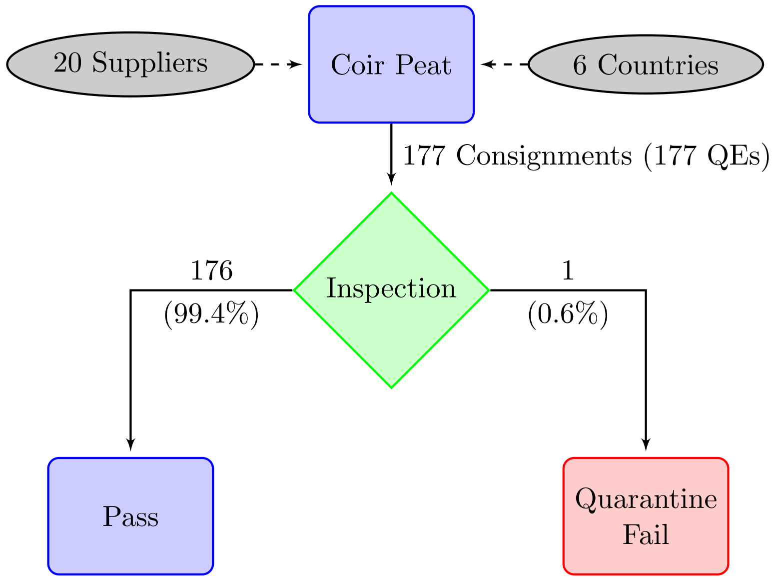

Figure D.9: Coir peat consignments flow chart with statistics for July 2008–April 2011. A quarantine failure was recorded for consignments with a detection of quarantine concern, such as insect, pathogen, or contamination. QEs refers to the number of quarantine entries, which may differ from the number of consignments.

D.3.3 Analysis

This section provides a statistical overview of the data. The full dataset comprises 190 consignments with record creation dates ranging from October 2005 to April 2011, and comprises entries from 7 countries and 23 suppliers.

A smoothed plot of the quarantine failure rate against time is presented in Figure D.10. The figure shows a failure rate hovering around 0.5%. The failure rate for the entire period was 0.53%, and for the analysis period (everything after June 2008) was 0.56%.

Annual inspection statistics are provided in Table D.8. The count of consignments is increasing sharply across the time period, and is on track to stay equally high in 2011.

The pattern of quarantine failure counts by country and supplier is presented in Table D.9. The statistics in Table D.10 summarize the inspection data for those countries with at least five consignments during the key time period and Table D.11 summarizes the inspection data for the suppliers with at least five consignments. The sole quarantine failure was from the major exporting country, but not from any of the major suppliers.

Finally, we examined graphical summaries of both the failure rate against consignment size, and at the supplier level, the consignment count and the average quarantine failure rate. Neither summary showed substantial patterns, and they are not included here.

D.3.4 Simulation Results

The results are presented in Figures D.11 and D.12. Figure D.11 provides the average simulated post-intervention compliance as a function of inspection strategy and total inspection count for a range of options. The x-axis is the amount of effort, and less is preferred. The y-axis is the PIC, and higher is preferred. The grey line shows the expected PIC (or leakage) for random monitoring, and may be used as a baseline to assess the improvement resulting from selecting a

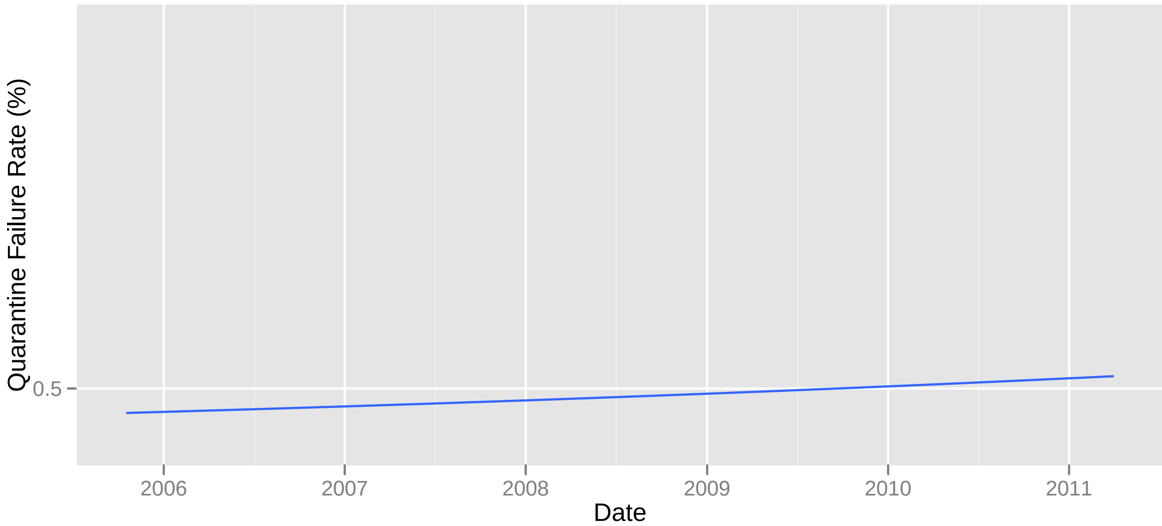

Figure D.10: Quarantine failure rates for coir peat (%) smoothed by date. The 95% confidence region covers the entire region of the graph.

Table D.8: Pattern of inspections, pathway failures, and quarantine failure counts for coir peat by year. *Count* is the number of consignments imported during the study period, *PF%* is the percentage of consignments that fail for any contamination or non-commodity failure, *QF %* is the percentage of consignments with contamination of quarantine interest, and *Tonnage* is the total tons of product imported during the study period.

Year	Count	PF %	QF %	Tonnage
2005	1	0.0	0.0	<1
2006	3	0.0	0.0	26
2007	3	0.0	0.0	5
2008	11	0.0	0.0	106
2009	33	0.0	0.0	551
2010	111	0.9	0.9	2,232
2011	28	0.0	0.0	567

Table D.9: Frequency of quarantine failure counts using recent data for coir peat data by country and supplier. The data cover all inspections between July 2008 and April 2011.

Failures	Countries	Suppliers
0	5	19
1	1	1

CSP strategy. We note the following points, and emphasize that these points are relevant only to the simulated inspection of coir peat based on existing data.

- The data are not satisfactory for this simulation exercise.

Table D.10: Summary statistics for coir peat by country. See caption of Table D.8 for explanation of column names. *QF* is the count of consignments with contamination of quarantine interest. The *Suppliers* column reports the number of suppliers that have exported from each country during the time period. The data cover all inspections between July 2008 and April 2011. We only include those countries with five or more consignments during the time period.

Country	Count	PF %	QF	QF %	Tonnage	Suppliers
a	133	0.8	1	0.8	2,639	12
b	30	0.0	0	0.0	609	7
c	8	0.0	0	0.0	139	1

Table D.11: Summary statistics for coir peat by supplier. See caption of Table D.10 for explanation of column names and scope. We include only those suppliers with at least 20 recent consignments. The *Countries* column reports the number of countries that each supplier has exported from during the time period.

Supplier	Count	PF %	QF	QF %	Tonnage	Countries
a	47	0.0	0	0.0	864	1
b	36	0.0	0	0.0	768	3
c	34	0.0	0	0.0	816	1
d	23	4.3	1	4.3	528	1

- All three CSP regimes can improve upon random sampling, in that the average PIC returns can be higher than the grey line, depending on the stratification.
- The difference between the different CSP strategies is minimal. However, of the three CSP regimes, CSP–3 seems to provide the best conceptual match with the pathway manager's goals of targeting compliance with reduced inspection rewards, while not allowing unnecessary leakage, or over penalizing random spikes in non-compliance.
- The stratification, monitoring fraction, and clearance number all have an effect on the leakage, and the effects can interact with one another.
- Stratifying by supplier seems to give the best value for simplicity and efficiency
- Given CSP–3 and stratification by supplier, the best strategy seems to be to set the monitoring fraction to 10% and the clearance number to 10, in order to achieve a PIC of 99.95%.

Figure D.12 provides leakage count profiles for all the simulations. It can be used as an alternative means for interpreting the above reasoning.

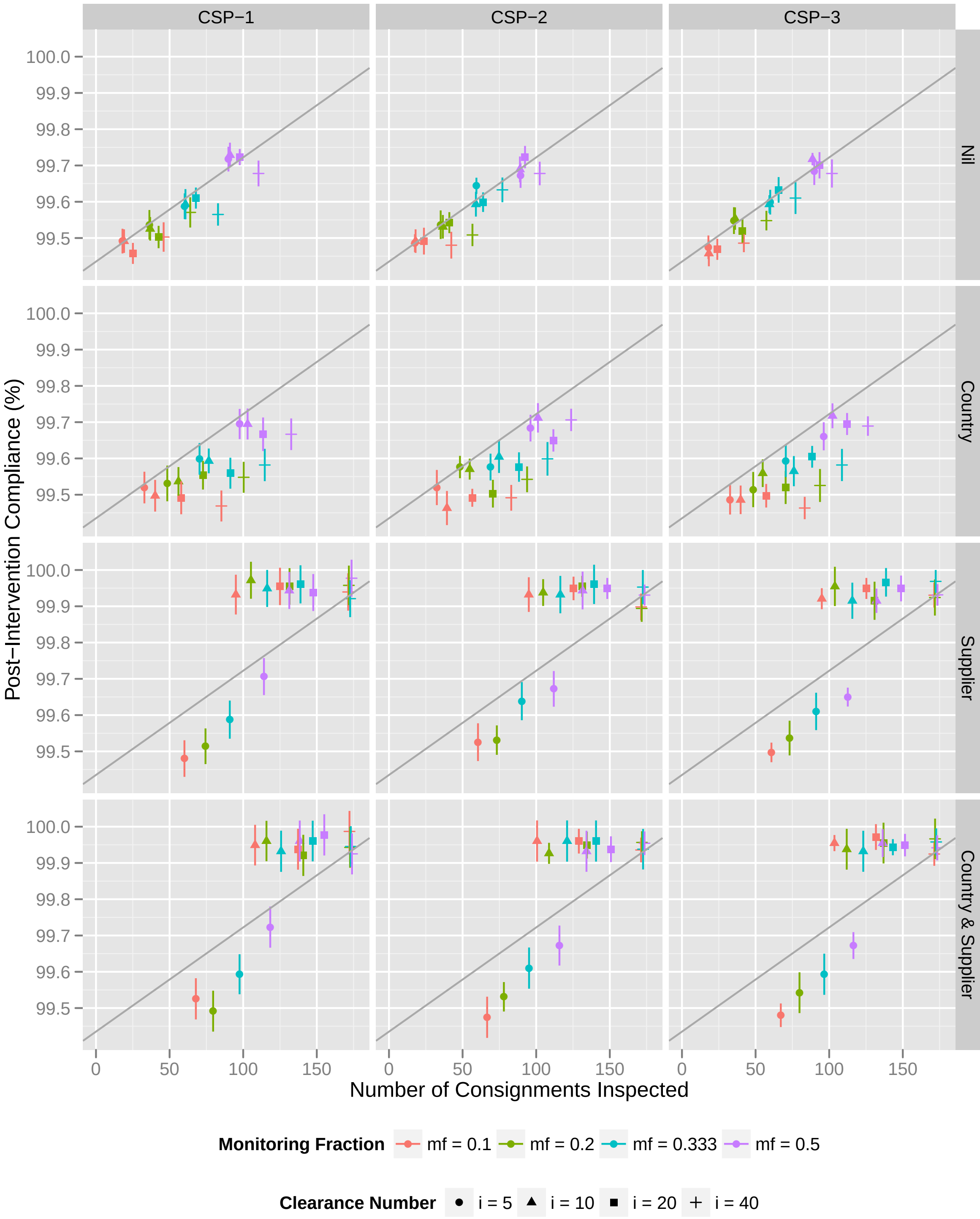

Figure D.11: Simulated Post-Intervention Compliance (PIC) against inspection effort for coir peat inspection history. The inspection strategies are in columns, and the stratification options are in rows. Within each panel, the sampling fraction is delineated by symbol colour, and the clearance number is delineated by the symbol shape. Approximate 95% confidence intervals for the mean of the simulation results are delineated by the vertical line. The grey line represents the expected PIC that would result from random sampling.

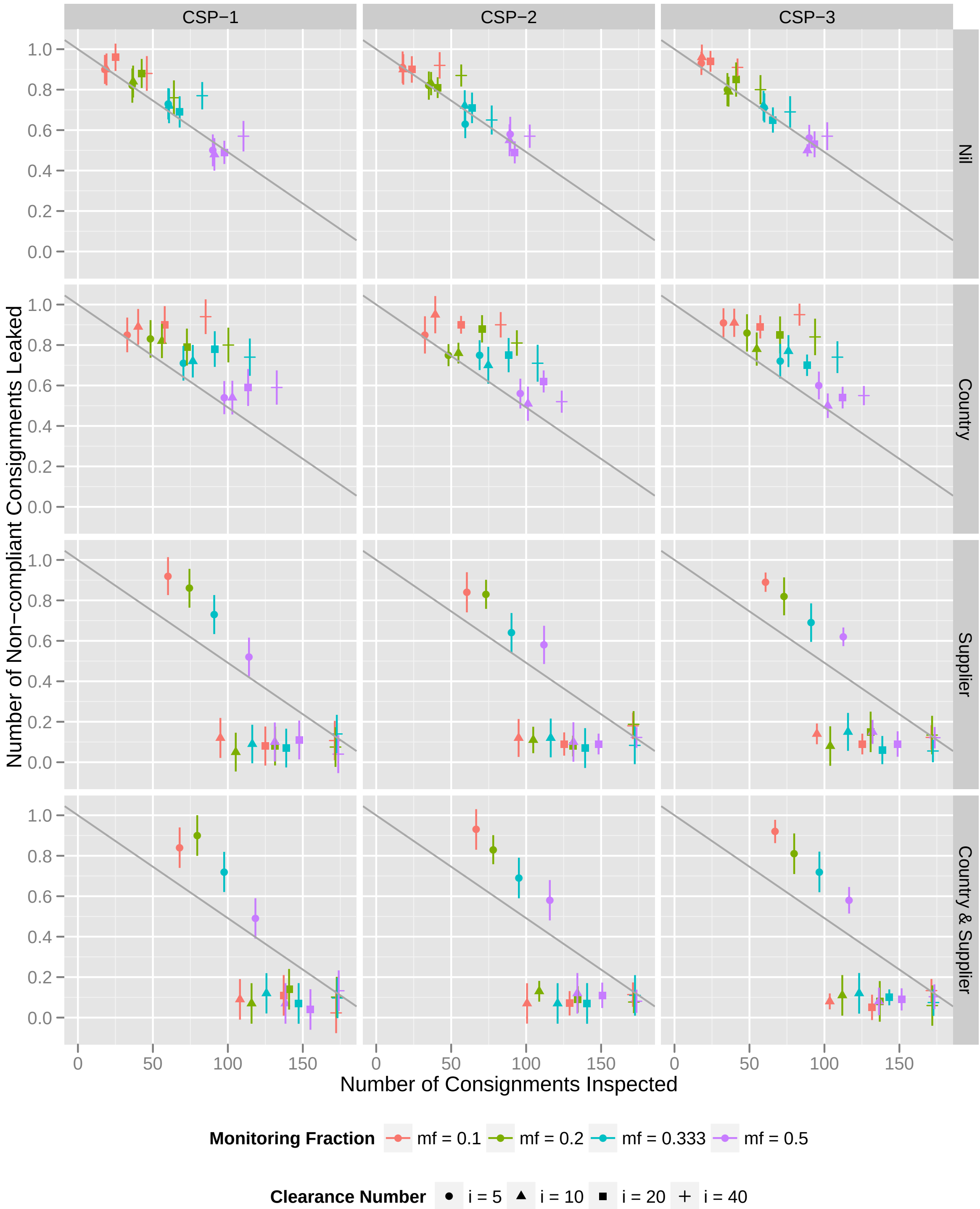

Figure D.12: Simulated leakage count against inspection effort for coir peat inspection history. The inspection strategies are in columns, and the stratification options are in rows. Within each panel, the monitoring fraction is delineated by symbol colour, and the clearance number is delineated by the symbol shape. Approximate 95% confidence intervals for the mean of the simulation results are delineated by the vertical line. The grey line represents the expected leakage that would result from random sampling.

D.4 Dried Dates

For this analysis, 'dried dates' refers to *Phoenix dactylifera* that has been dried. Only dates with a moisture content of 30% or less are considered to be dried dates and are permitted entry. Dates that have a moisture content above 30% are considered fresh dates and are not permitted. Very few of the suppliers in this pathway have sufficiently long inspection histories that a reasonable picture can be constructed of its likely suitability in the scenarios reported herein. However the low pathway failure rate indicates that reduced inspection rates may be implemented as a reward strategy for continued compliance. Of the 8 top suppliers by volume, only one has recorded quarantine failures and this is a positive indication that reduced inspection rates will have a significant risk return for inspection resources on this pathway.

D.4.1 Import Conditions

Dried date import conditions are the same as those listed in the dried apricot case study above.

D.4.2 Pathway Summary

A flowchart of the pathway is presented in Figure D.13.

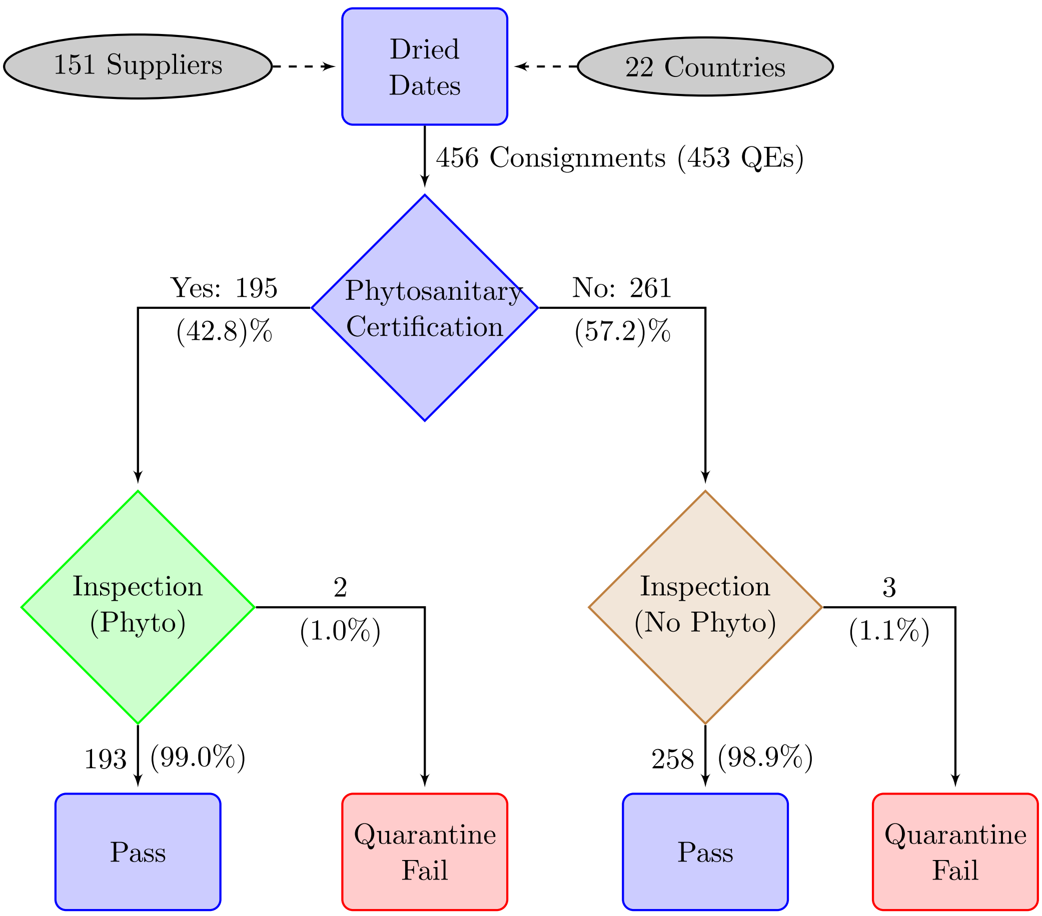

Figure D.13: Dried dates consignments flow chart with statistics for July 2008–December 2010. A quarantine failure was recorded for consignments with a detection of quarantine concern, such as insect, pathogen, or contamination. QEs refers to the number of quarantine entries, which may differ from the number of consignments.

D.4.3 Analysis

This section provides a statistical overview of the data. The full dataset comprises 961 consignments with record creation dates ranging from October 2005 to December 2010, and comprises entries from 27 countries and 284 suppliers.

A smoothed plot of the quarantine failure rate against time is presented in Figure D.14. The figure shows a failure rate descending smoothly from just over 2% to less than 1%. The failure rate for the entire period was 1.46%, and for the analysis period (everything after June 2008) was 1.10%.

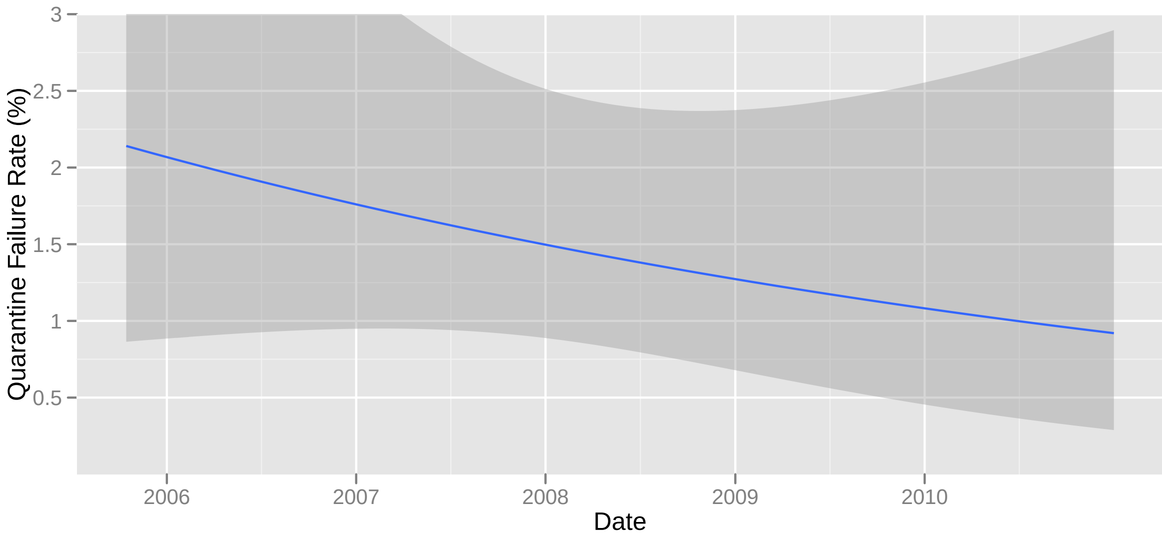

Figure D.14: Quarantine failure rates for dried dates (%) smoothed by date, with a 95% confidence interval (shaded region) added (see the caption of Figure 6.2 on page 24 for an explanation of the interval). The width of the shaded region indicates the uncertainty of the line, which becomes narrower as the number of inspected consignments increases.

Annual inspection statistics are provided in Table D.12. The count of consignments is high in 2006 and 2010, and the tonnage is low in 2008–9. The quarantine failure rate follows the pattern mentioned in the previous paragraph.

Table D.12: Pattern of inspections, pathway failures, and quarantine failure counts for dried dates by year. *Count* is the number of consignments imported during the study period, *PF%* is the percentage of consignments that fail for any contamination or non-commodity failure, *QF %* is the percentage of consignments with contamination of quarantine interest, and *Tonnage* is the total tons of product imported during the study period.

Year	Count	PF %	QF %	Tonnage
2005	49	4.1	4.1	301
2006	209	1.9	1.4	1,081
2007	166	3.6	2.4	1,005
2008	165	4.8	0.6	716
2009	171	1.2	0.0	632
2010	201	2.5	2.0	1,269

Table D.13: Frequency of quarantine failure counts using recent data for dried dates by country and supplier. The data cover all inspections between July 2008 and December 2010.

Failures	Countries	Suppliers
0	17	146
1	5	5

Table D.14: Summary statistics for dried dates by country. See caption of Table D.12 for explanation of column names. *QF* is the count of consignments with contamination of quarantine interest. The *Suppliers* column reports the number of suppliers that have exported from each country during the time period. The data cover all inspections between July 2008 and December 2010. We only include those countries with five or more consignments during the time period.

Country	Count	PF %	QF	QF %	Tonnage	Suppliers
a	179	1.1	0	0.0	249	41
b	58	1.7	1	1.7	703	20
c	42	2.4	1	2.4	467	10
d	25	4.0	0	0.0	6	10
e	24	4.2	0	0.0	25	22
f	18	0.0	0	0.0	16	6
g	18	11.1	1	5.6	129	10
h	18	5.6	0	0.0	37	16
i	17	0.0	0	0.0	175	4
j	16	0.0	0	0.0	160	2
k	12	0.0	0	0.0	148	3
l	8	0.0	0	0.0	108	1
m	7	28.6	1	14.3	6	4

The pattern of quarantine failure counts by country and supplier is presented in Table D.13. The statistics in Table D.14 summarize the inspection data for those countries with at least five consignments during the key time period and Table D.15 summarizes the inspection data for the suppliers with at least ten consignments.

The pathway is very diverse, with a large number of suppliers that have very little activity, and one supplier with a higher number of import records. Revealingly, the top country and the top two suppliers by consignment counts have flawless quarantine inspection records, with only 1 of the top 8 suppliers recording quarantine failure (Table D.15). This is an encouraging pattern for risk–return pathway management. However, Table D.13 shows that no country or supplier has failed more than once during the reference period. This means that there can be no pattern of failures among suppliers or countries. However, the possibility remains for a pattern of non-failures.

Finally, we examined graphical summaries of both the failure rate against consignment size, and at the supplier level, the consignment count and the average quarantine failure rate. Neither summary showed substantial patterns, and they are not included here.

Table D.15: Summary statistics for dried dates by supplier. See caption of Table D.14 for explanation of column names and scope. We include only those suppliers with at least 10 recent consignments. The *Countries* column reports the number of countries that each supplier has exported from during the time period.

Supplier	Count	PF %	QF	QF %	Tonnage	Countries
a	61	0.0	0	0.0	124	2
b	16	0.0	0	0.0	2	2
c	15	6.7	1	6.7	145	1
d	14	0.0	0	0.0	137	2
e	14	0.0	0	0.0	142	1
f	13	0.0	0	0.0	13	2
g	12	0.0	0	0.0	130	1
h	11	0.0	0	0.0	187	1

D.4.4 Simulation Results

The results are presented in Figures D.15 and D.16. Figure D.15 provides the average simulated post-intervention compliance as a function of inspection strategy and total inspection count for a range of options. The x-axis is the amount of effort, and less is preferred. The y-axis is the PIC, and higher is preferred. The grey line shows the expected PIC (or leakage) for random monitoring, and may be used as a baseline to assess the improvement resulting from selecting a CSP strategy. We note the following points, and emphasize that these points are relevant only to the simulated inspection of dates based on existing data.

- All three CSP regimes can improve upon random sampling, in that the average PIC returns are all sometimes higher than the grey line.
- The difference between the different CSP strategies is minimal. However, of the three CSP regimes, CSP–3 seems to provide the best match with the pathway manager's goals of rewarding compliance with reduced inspection rewards, while not allowing unnecessary leakage, or over penalizing random spikes in non-compliance.
- The stratification, monitoring fraction, and clearance number all have an effect on the leakage, and the effects can interact with one another.
- Stratifying by supplier seems to give the best value for simplicity and efficiency.
- Given CSP–3 and stratification by supplier, the best strategy seems to be to set the monitoring fraction to 0.1 and the clearance number to 10, in order to achieve a PIC of 99.7%.

Figure D.16 provides leakage count profiles for all the simulations. It can be used as an alternative means for interpreting the above reasoning.

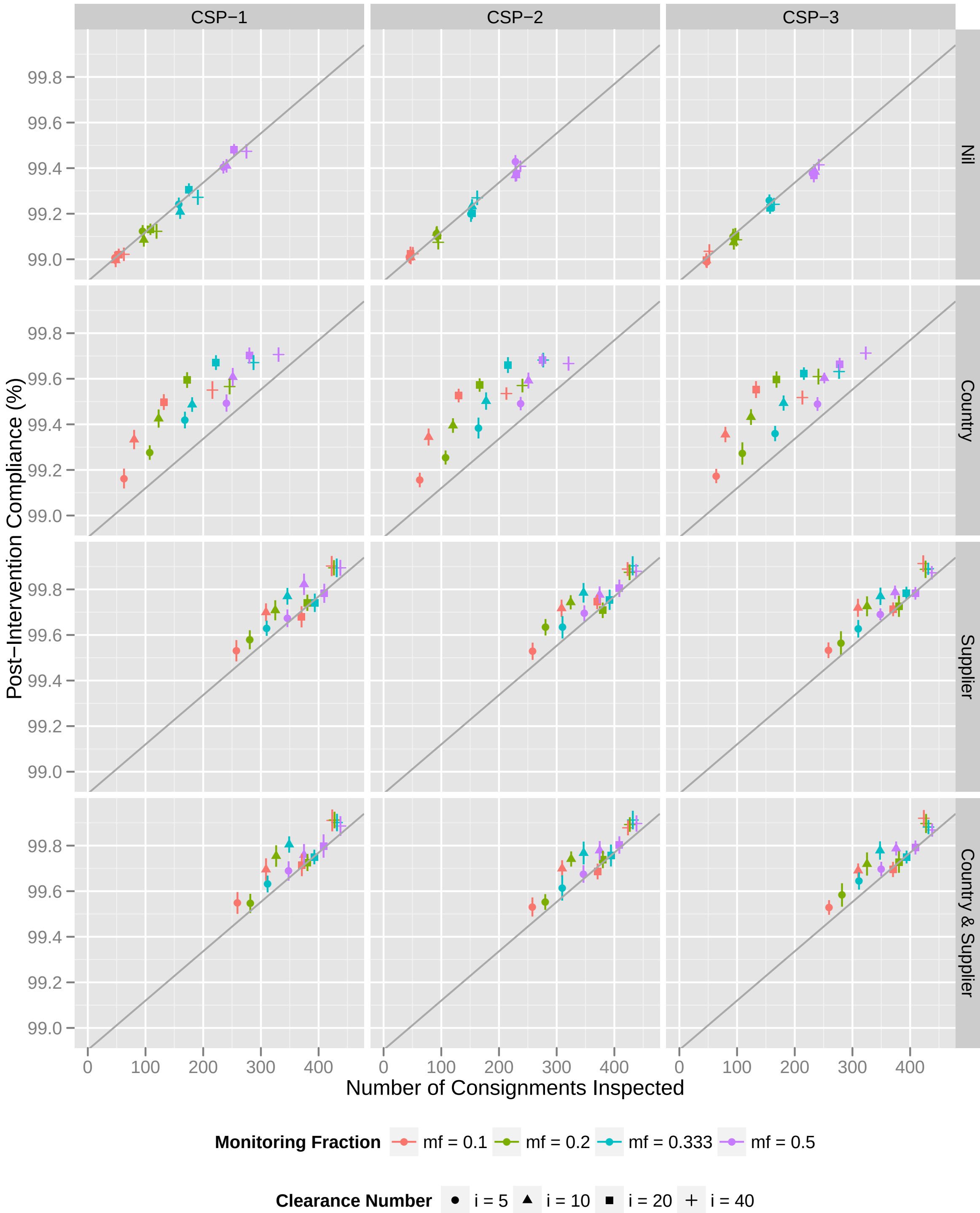

Figure D.15: Simulated Post-Intervention Compliance (PIC) against inspection effort for dried dates inspection history. The inspection strategies are in columns, and the stratification options are in rows. Within each panel, the sampling fraction is delineated by symbol colour, and the clearance number is delineated by the symbol shape. Approximate 95% confidence intervals for the mean of the simulation results are delineated by the vertical line. The grey line represents the expected PIC that would result from random sampling.

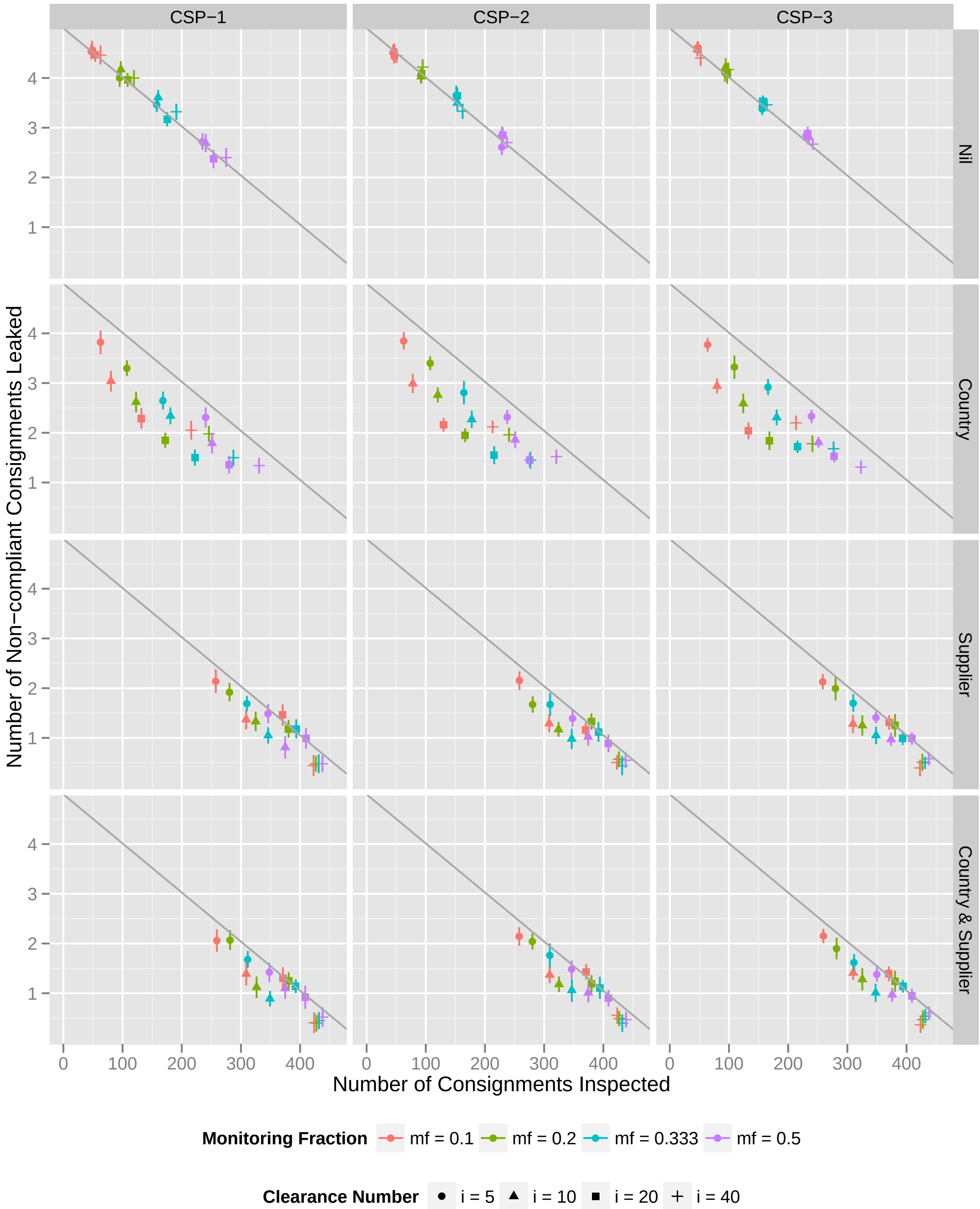

Figure D.16: Simulated leakage count against inspection effort for dried dates inspection history. The inspection strategies are in columns, and the stratification options are in rows. Within each panel, the monitoring fraction is delineated by symbol colour, and the clearance number is delineated by the symbol shape. Approximate 95% confidence intervals for the mean of the simulation results are delineated by the vertical line. The grey line represents the expected leakage that would result from random sampling.

D.5 Dried Seaweed

For this analysis 'dried seaweed' refers to seaweed dried or frozen, other than the prohibited *Caulerpa taxifolia* species. This pathway is sampled, rather than fully inspected and was included as a case study to review if the current reduced regime is still effective. Of the 2435 consignments on the pathway, only 477 were inspected. Very few of the suppliers in this pathway have sufficiently long inspection histories that a reasonable picture can be constructed of its likely suitability for the scenarios reported herein. The results of the simulations are tentative. Alteration of the current regime to incorporate supplier targeting is not considered necessary.

D.5.1 Import Conditions

Dried plant material can consist of a variety of plant matter, including viable seeds that may be prohibited, restricted or diseased. Dried plant material may also be infested with insects, contaminated with soil or carry fungal spores that can introduce serious animal and plant pathogens.

Dried seaweed does not require an import permit. Each consignment must be accompanied by a manufacturer's declaration stating the botanical name, that the consignment is free of QRM, and the seaweed has been dried or frozen. All material in the consignment must be thoroughly dried, or frozen. Documentary evidence must be provided to support the consignment is thoroughly dried or frozen at $-18\,^{\circ}\mathrm{C}$ for 7 days.

Consignments accompanied by valid documentation will be released without inspection. All consignments not accompanied by adequate documentation will undergo a verification inspection. This analysis has been performed on all consignments that have undergone a verification inspection.

A formal IRA has not been undertaken for dried seaweed imports for human consumption, and no specific quarantine risks have been formally identified for this commodity.

D.5.2 Pathway Summary

A flowchart of the pathway is presented in Figure D.17.

D.5.3 Analysis

This section provides a statistical overview of the data. The full dataset comprises 477 inspected consignments with record creation dates ranging from October 2005 to October 2010, and comprises entries from 16 countries and 167 suppliers.

A smoothed plot of the quarantine failure rate against time is presented in Figure D.18. The figure shows a failure rate descending smoothly from over 3% to less than 0.5%. The failure rate for the entire period was 1.47%, and for the analysis period (everything after June 2008) was 0.93%.

Annual inspection statistics are provided in Table D.16. The count of consignments is high in 2006 and 2010, and the tonnage is low in 2008–9. The quarantine failure rate follows the pattern mentioned in the previous paragraph.

The pattern of quarantine failure counts by country and supplier is presented in Table D.17. The statistics in Table D.18 summarize the inspection data for those countries with at least 10 consignments during the key time period and Table D.19 summarizes the inspection data for the suppliers with at least 10 consignments. The major supplying country has recent contamination, as does the largest supplier.

The pathway is very diverse, with a large number of suppliers that have very little activity, and some suppliers with a higher number of import records.

Finally, we examined graphical summaries of both the failure rate against consignment size, and at the supplier level, the consignment count and the average quarantine failure rate. No pattern was detected in these summaries.

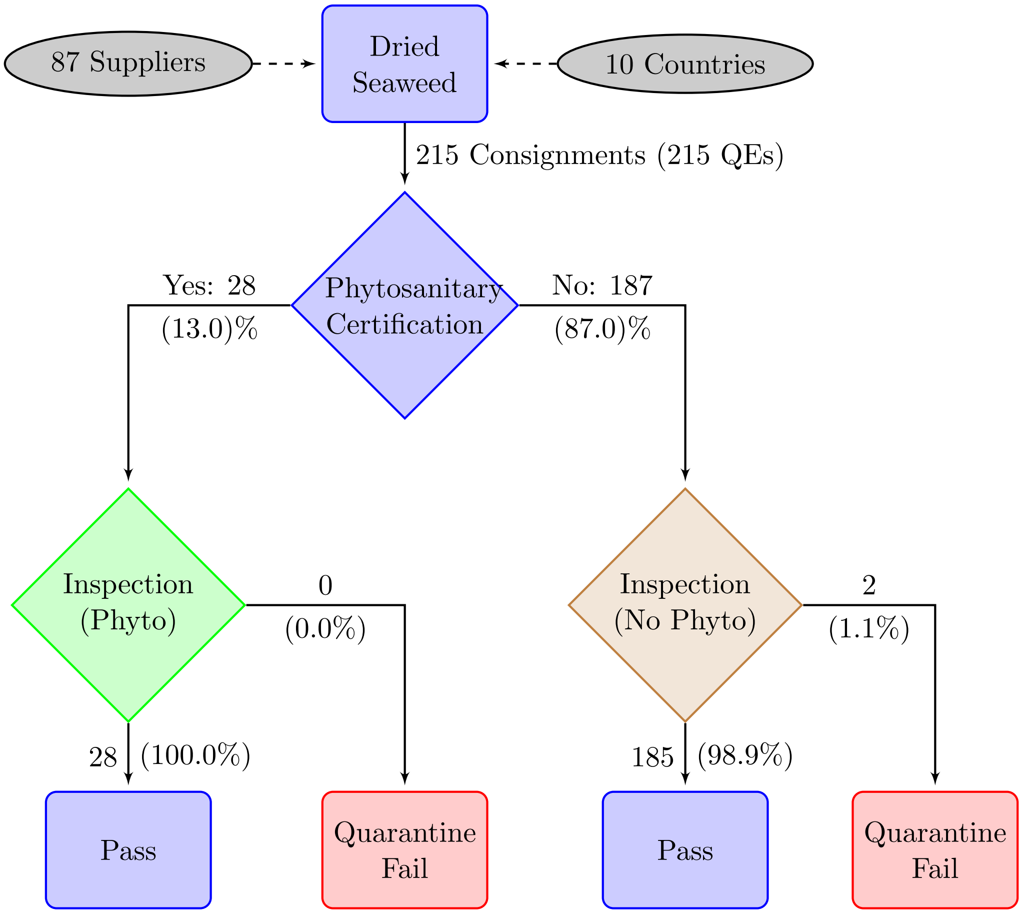

Figure D.17: Dried seaweed consignments flow chart with statistics for July 2008–October 2010. A quarantine failure was recorded for consignments with a detection of quarantine concern, such as insect, pathogen, or contamination. QEs refers to the number of quarantine entries, which may differ from the number of consignments.

Table D.16: Pattern of inspections, pathway failures, and quarantine failure counts for dried seaweed by year. *Count* is the number of consignments imported, *PF* and *PF%* are the count and percentage that fail for any contamination or non-commodity failure, *QF* and *QF%* are the count and percentage with contamination of quarantine interest, and *Tonnage* is the weight of product imported.

Year	Count	PF	PF%	QF	QF%	Tonnage
2005	26	2	7.7	2	7.7	27
2006	91	1	1.1	1	1.1	106
2007	97	2	2.1	2	2.1	141
2008	97	2	2.1	0	0.0	104
2009	85	3	3.5	2	2.4	61
2010	81	0	0.0	0	0.0	388
Total	477	10	2.1	7	1.5	829

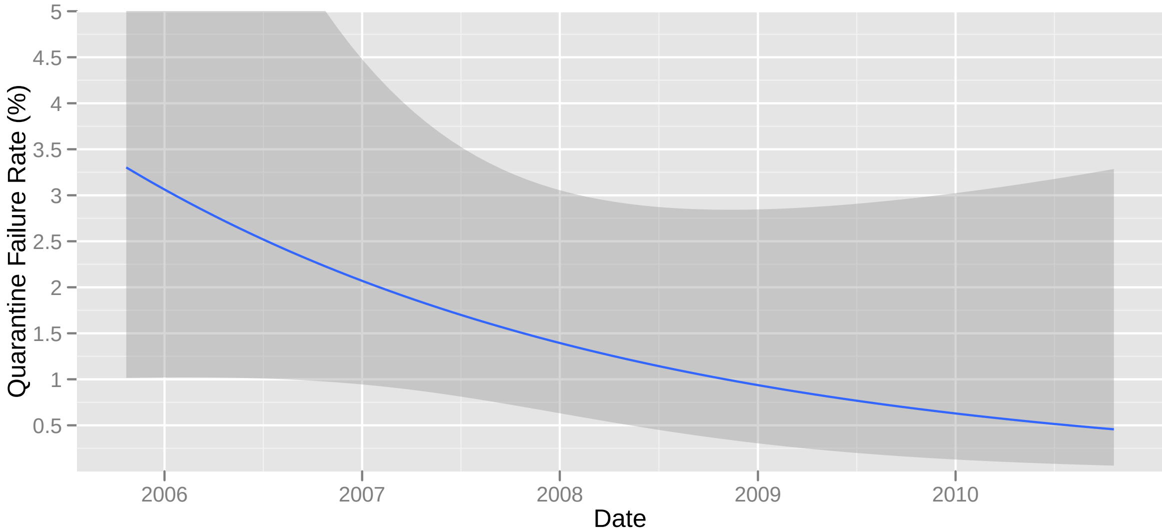

Figure D.18: Quarantine failure rates (%) for dried seaweed smoothed by date, with a 95% confidence interval (shaded region) added (see the caption of Figure 6.2 on page 24 for an explanation of the interval). The width of the shaded region indicates the uncertainty of the line, which becomes narrower as the number of inspected consignments increases.

Table D.17: Frequency of quarantine failure counts using recent data for dried seaweed by country and supplier. The data cover all inspections between July 2008 and October 2010.

Failures	Countries	Suppliers
0	9	85
1	0	2
2	1	0

Table D.18: Summary statistics for dried seaweed by country. See caption of Table D.16 for explanation of column names. The *Suppliers* column reports the number of suppliers that have exported from each country during the time period. The data cover all inspections between July 2008 and October 2010. We only include those countries with 10 or more consignments during the time period.

Country	Count	PF %	QF	QF %	Tonnage	Suppliers
a	118	2.5	2	1.7	76	47
b	55	0.0	0	0.0	14	26
c	16	0.0	0	0.0	<1	6
d	12	0.0	0	0.0	378	1

D.5.4 Simulation Results

The results are presented in Figures D.19 and D.20. Figure D.19 provides the average simulated post-intervention compliance as a function of inspection strategy and total inspection count for a range of options. The x-axis is the amount of effort, and less is preferred. The y-axis is the

Table D.19: Summary statistics for dried seaweed by supplier. See caption of Table D.18 for explanation of column names and scope. We include only those suppliers with at least 10 recent consignments. The *Countries* column reports the number of countries that each supplier has exported from during the time period.

Supplier	Count	PF %	QF	QF %	Tonnage	Countries
a	31	6.5	1	3.2	12	1
b	18	0.0	0	0.0	7	1
c	12	0.0	0	0.0	378	1

PIC, and higher is preferred. The grey line shows the expected PIC (or leakage) for random monitoring, and may be used as a baseline to assess the improvement resulting from selecting a CSP strategy. We note the following points, and emphasize that these points are relevant only to the simulated inspection of seaweed based on existing data.

- None of the three CSP regimes improve upon random sampling, in that none of the average PIC returns are higher than the grey line.
- The difference between the different CSP strategies is minimal.
- The stratification, monitoring fraction, and clearance number all have an effect on the leakage, and the effects can interact with one another.

Figure D.20 provides leakage count profiles for all the simulations. It can be used as an alternative means for interpreting the above reasoning.

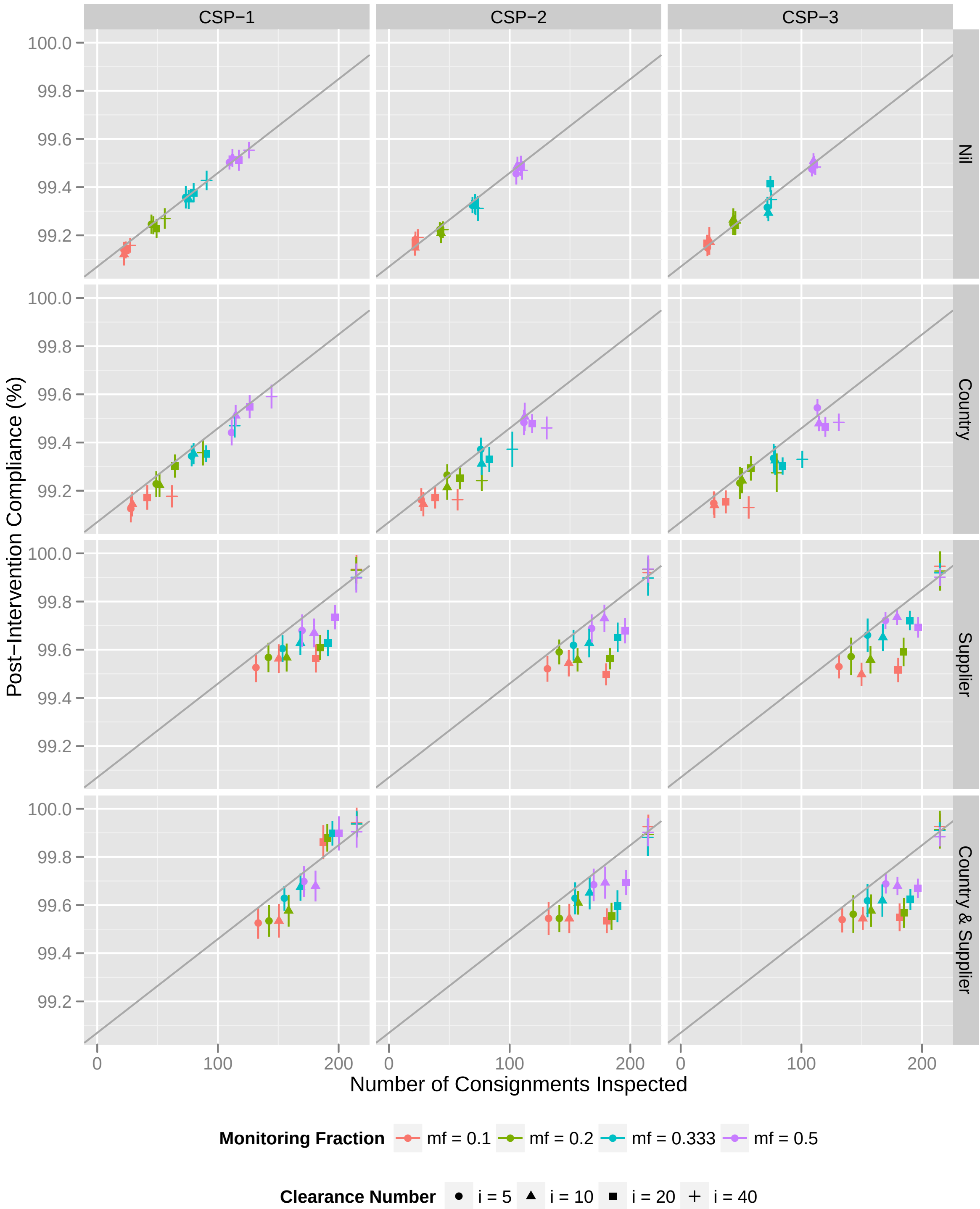

Figure D.19: Simulated Post-Intervention Compliance (PIC) against inspection effort for dried seaweed inspection history. The inspection strategies are in columns, and the stratification options are in rows. Within each panel, the sampling fraction is delineated by symbol colour, and the clearance number is delineated by the symbol shape. Approximate 95% confidence intervals for the mean of the simulation results are delineated by the vertical line. The grey line represents the expected PIC that would result from random sampling.

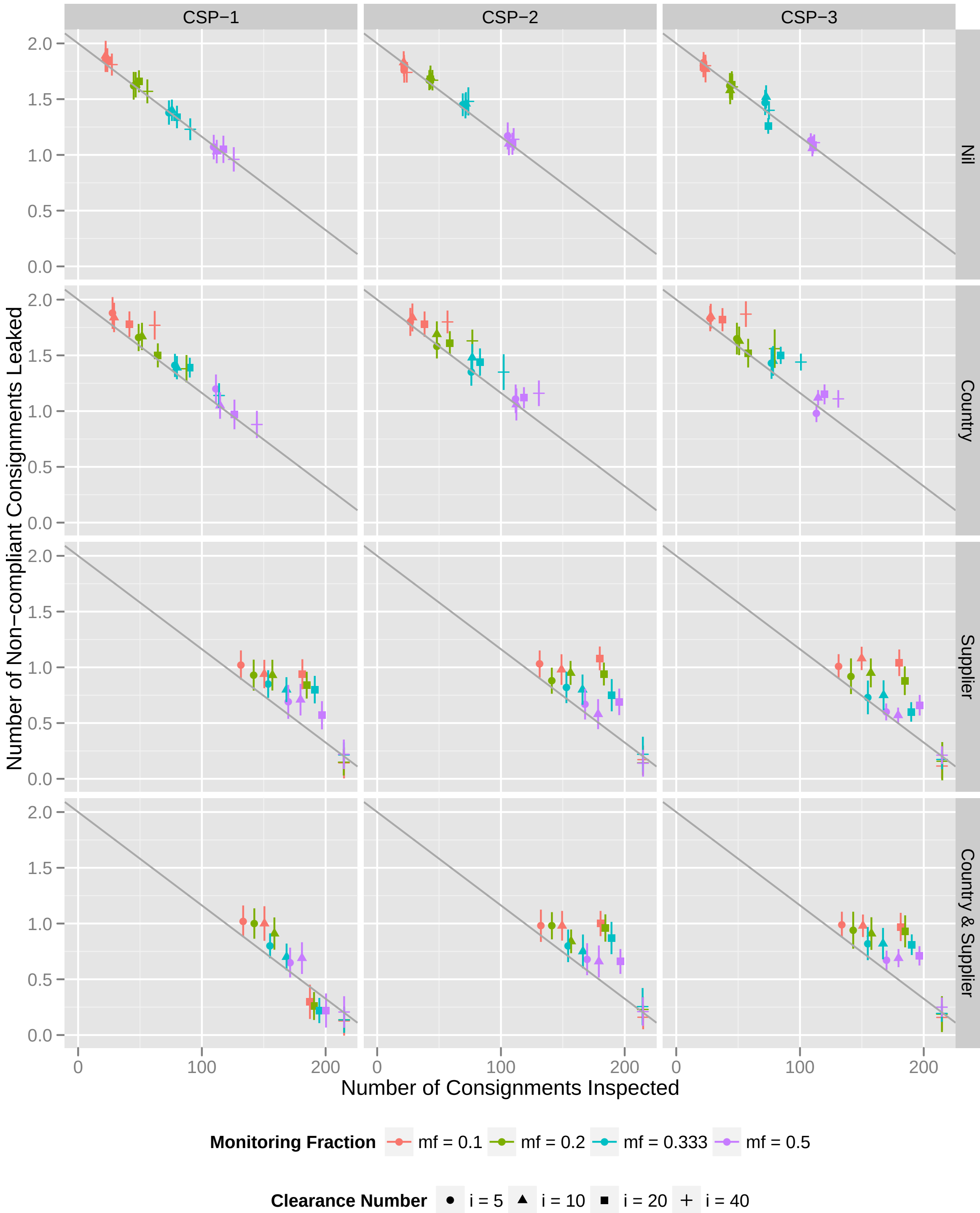

Figure D.20: Simulated leakage count against inspection effort for dried seaweed inspection history. The inspection strategies are in columns, and the stratification options are in rows. Within each panel, the monitoring fraction is delineated by symbol colour, and the clearance number is delineated by the symbol shape. Approximate 95% confidence intervals for the mean of the simulation results are delineated by the vertical line. The grey line represents the expected leakage that would result from random sampling.

D.6 Fresh Garlic

For this analysis, "fresh garlic" refers to *Allium sativum*. The fresh garlic pathway does not show evidence of being a good match for the use of sampling for inspections, as has been recommended for other imported-plant product pathways, because the approach rate of contamination is too high on this pathway.

D.6.1 Import Conditions

Fresh garlic is considered a quarantine risk to Australia because fresh produce and/or the cartons that they are packaged in may contain plant material other than the permitted commodity, and other contaminants such as straw packaging, soil, insects, arthropod eggs, disease symptoms or seeds which add to the quarantine risks. These contaminants also have the potential to harbour microorganisms or fungi, which could have a significant impact if introduced into Australia.

Fresh garlic is only permitted entry into Australia if accompanied by a valid import permit and phytosanitary certificate.

All consignments are subject to AQIS inspection on arrival. A sample of 600 bulbs is selected from a random number of cartons within each consignment and individually inspected for the presence of insects, pests, disease, soil, and other contamination such as weed seeds and plant trash. A further 60 bulbs from the sample must be broken open to examine for fly pupae and larvae.

Fresh garlic from China is known to be periodically infested with *Delia antiqua*. As this pest is most likely to be found inside the garlic clove, and not readily detectable when inspecting the surface area, fresh garlic bulbs (from China only) require each of the bulbs in the 600 unit inspection sample to be broken open to check for live quarantinable flies and/or fly pupae.

A formal Import Risk Analysis (IRA) has not been completed for fresh garlic imports, however, a risk determination has identified a risk of introducing the mite, *Eriophyes tulipae*. For this reason fresh garlic from all countries is subject to mandatory fumigation. All consignments treated prior to export must have a commercial treatment certificate attached referencing the consignment. Any mandatory preshipment treatments carried out must have the treatment details included on the Phytosanitary certificate.

D.6.2 Pathway Summary

A flowchart of the pathway is presented in Figure D.21.

D.6.3 Analysis

This section provides a statistical overview of the data. The full dataset comprises 1145 consignments with record creation dates ranging from October 2005 to early February 2011, and comprises entries from 15 countries and 123 suppliers.

A smoothed plot of the quarantine failure rate against time is presented in Figure D.22. The figure shows a failure rate increasing from below 12% to around 15%. The failure rate for the entire period was 12.05%, and for the analysis period (everything after June 2008) was 13.11%.

Annual inspection statistics are provided in Table D.20. The count of consignments is decreasing gradually across the time period.

The pattern of quarantine failure counts by country and supplier is presented in Table D.21. The statistics in Table D.22 summarize the inspection data for all countries during the key time period and Table D.23 summarizes the inspection data for the suppliers with at least twenty consignments. The inspection history for this pathway is uniformly bad.

Finally, we examined graphical summaries of both the failure rate against consignment size, and at the supplier level, the consignment count and the average quarantine failure rate. Neither summary showed substantial patterns, and they are not included here.

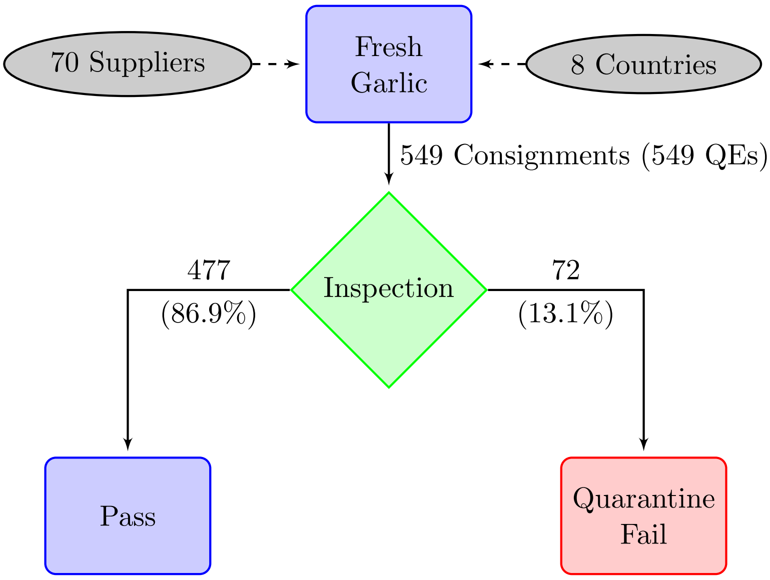

Figure D.21: Fresh garlic consignments flow chart with statistics for July 2008–early February 2011. A quarantine failure was recorded for consignments with a detection of quarantine concern, such as insect, pathogen, or contamination. QEs refers to the number of quarantine entries, which may differ from the number of consignments.

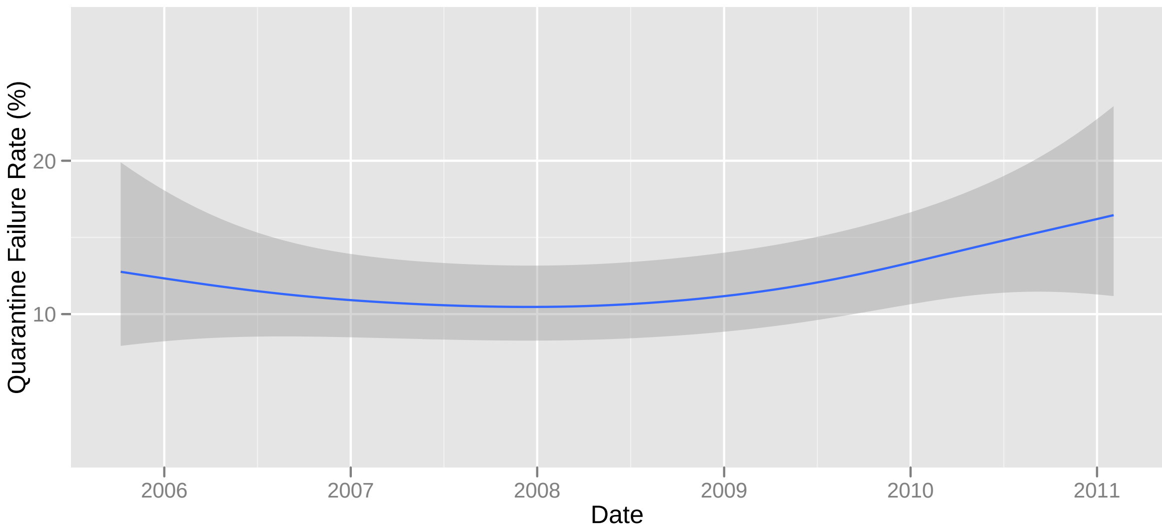

Figure D.22: Quarantine failure rates (%) for fresh garlic smoothed by date, with a 95% confidence interval (shaded region) added (see the caption of Figure 6.2 on page 24 for an explanation of the interval). The width of the shaded region indicates the uncertainty of the line, which becomes narrower as the number of inspected consignments increases.

Table D.20: Pattern of inspections, pathway failures, and quarantine failure counts for fresh garlic by year. *Count* is the number of consignments imported during the study period, *PF%* is the percentage of consignments that fail for any contamination or non-commodity failure, *QF %* is the percentage of consignments with contamination of quarantine interest, and *Tonnage* is the total tons of product imported during the study period.

Year	Count	PF %	QF %	Tonnage
2005	31	25.8	16.1	563
2006	204	14.2	10.8	3,383
2007	216	13.0	11.6	2,763
2008	245	13.1	10.2	3,570
2009	201	9.5	8.5	3,467
2010	235	20.0	17.9	3,652
2011	13	15.4	15.4	256

Table D.21: Frequency of quarantine failure counts using recent data for fresh garlic by country and supplier. The data cover all inspections between July 1 2008 and 2 February 2011.

Failures	Countries	Suppliers
0	2	38
1	1	21
2	1	4
3	0	3
4	0	2
5	1	0
6	1	0
10	0	1
16	0	1
19	1	0
39	1	0

Table D.22: Summary statistics for fresh garlic by country. See caption of Table D.20 for explanation of column names. *QF* is the count of consignments with contamination of quarantine interest. The *Suppliers* column reports the number of suppliers that have exported from each country during the time period. The data cover all inspections between July 2008 and early February 2011.

Country	Count	PF %	QF	QF %	Tonnage	Suppliers
a	365	11.5	39	10.7	6,600	46
b	89	24.7	19	21.3	1,277	5
c	44	18.2	5	11.4	450	8
d	32	21.9	6	18.8	360	9
e	15	13.3	2	13.3	265	4
f	2	0.0	0	0.0	<1	1
g	1	100.0	1	100.0	23	1
h	1	0.0	0	0.0	<1	1

Table D.23: Summary statistics for fresh garlic by supplier. See caption of Table D.22 for explanation of column names and scope. We include only those suppliers with at least 20 recent consignments. The *Countries* column reports the number of countries that each supplier has exported from during the time period.

Supplier	Count	PF %	QF	QF %	Tonnage	Countries
a	93	20.4	16	17.2	1,104	3
b	60	6.7	4	6.7	1,423	1
c	38	2.6	1	2.6	788	1
d	29	17.2	4	13.8	519	2
e	29	17.2	3	10.3	434	1
f	21	47.6	10	47.6	328	1
g	21	14.3	2	9.5	403	1

D.6.4 Simulation Results

The results are presented in Figures D.23 and D.24. Figure D.23 provides the average simulated post-intervention compliance as a function of inspection strategy and total inspection count for a range of options. The x-axis is the amount of effort, and less is preferred. The y-axis is the PIC, and higher is preferred. The grey line shows the expected PIC (or leakage) for random monitoring, and may be used as a baseline to assess the improvement resulting from selecting a CSP strategy. We note the following points, and emphasize that these points are relevant only to the simulated inspection of fresh garlic based on existing data.

- The failure rate of the pathway is quite high.
- All three CSP regimes improve upon random sampling, in that the average PIC returns are all substantially higher than the grey line.
- The difference between the different CSP strategies is minimal.
- The stratification, monitoring fraction, and clearance number all have an effect on the leakage, and the effects can interact with one another.
- Stratifying by supplier seems to give the best value for simplicity and efficiency.

Figure D.24 provides leakage count profiles for all the simulations. It can be used as an alternative means for interpreting the above reasoning.

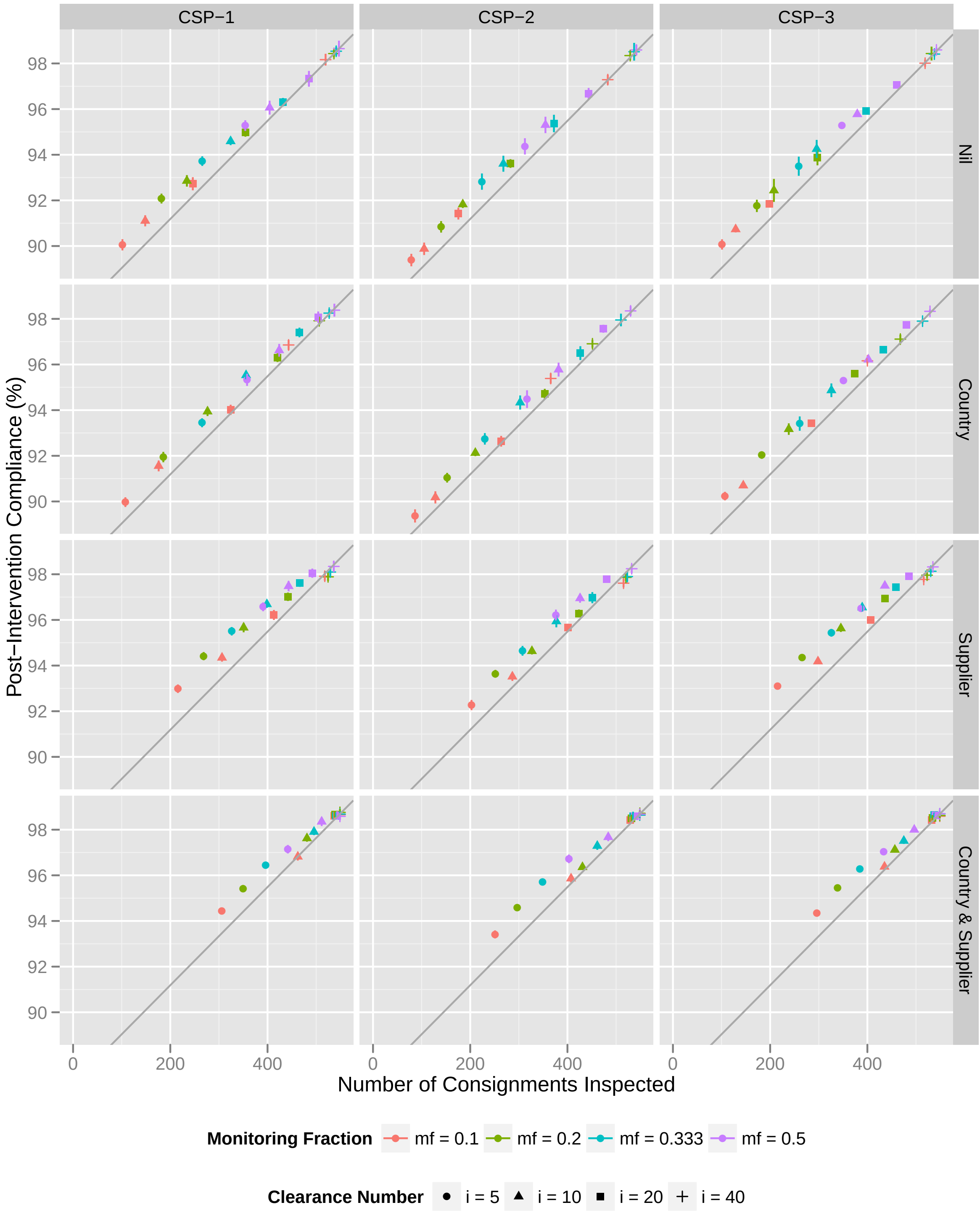

Figure D.23: Simulated Post-Intervention Compliance (PIC) against inspection effort for fresh garlic inspection history. The inspection strategies are in columns, and the stratification options are in rows. Within each panel, the sampling fraction is delineated by symbol colour, and the clearance number is delineated by the symbol shape. Approximate 95% confidence intervals for the mean of the simulation results are delineated by the vertical line. The grey line represents the expected PIC that would result from random sampling.

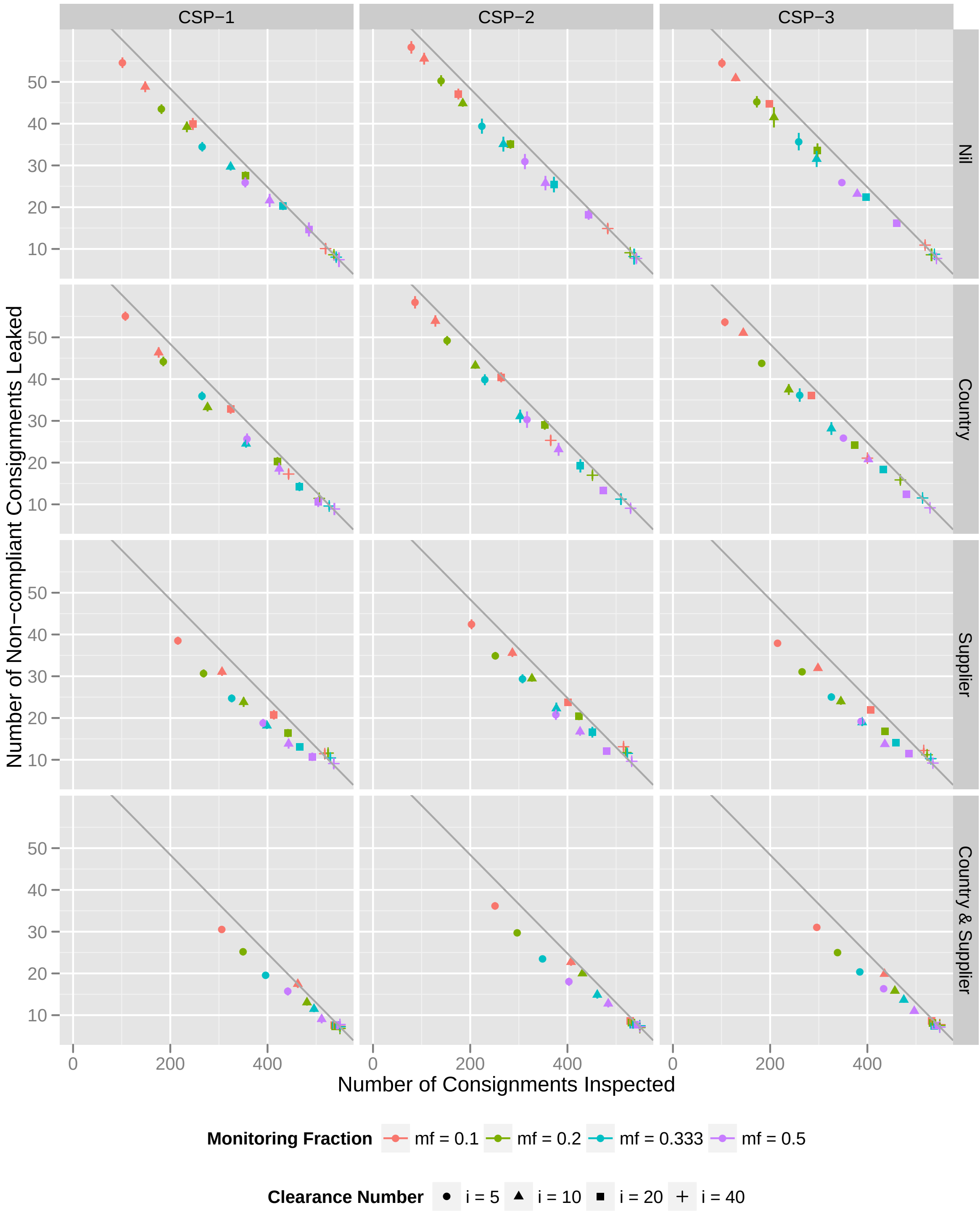

Figure D.24: Simulated leakage count against inspection effort for fresh garlic inspection history. The inspection strategies are in columns, and the stratification options are in rows. Within each panel, the monitoring fraction is delineated by symbol colour, and the clearance number is delineated by the symbol shape. Approximate 95% confidence intervals for the mean of the simulation results are delineated by the vertical line. The grey line represents the expected leakage that would result from random sampling.

D.7 Green Coffee Beans

Green coffee beans refers to *Coffea* spp. seeds which have had the fruit pulp and seed coat (parchment) removed by chemical or mechanical methods. This pathway has a moderately low approach rate but the consequences of leakage are considered low-risk because the post-import treatment involves roasting the beans. Hence, it is recommended for a supplier targeted reduced inspection regime.

D.7.1 Import Conditions

Green coffee beans are considered a quarantine risk to Australia due to the potential to be infested with insect pests, or contaminated with soil, plant material, and weed seeds, and are only permitted entry into Australia if accompanied by a valid import permit. Import permits are granted under the condition that consignments are for processing only.

Prior to release from quarantine, all coffee consignments are subject to inspection by AQIS officers. Samples are collected from the consignment at the rates outlined in Table D.24.

Table D.24: Sampling rates for green coffee beans by consignment size.

Shipment Size (kg)	Sample size inspected (Litres)
<2	All
2–999	0.5
1000–14,999	1.0
14,999+	1.0 per 15 000Kg

The sample is taken from a number of points/bags randomly selected within the consignment using a sampling trier.[1]

Once collected the sample is visually inspected by the officer for insects or contaminants.

A formal Import Risk Analysis (IRA) has not been completed for green coffee bean imports, however a BSG risk determination has identified risks within the green coffee bean pathway are: Coffee Rust (*Hemileia vastatrix*); Coffee bean borer (*Hypothenemus hampei*) and Khapra beetle (*Trogoderma granarium*).

Following a risk review in 2008, parchment is no longer a quarantine concern, however, if the level of parchment within a consignment is considered excessive enough to interfere with the inspection the consignment can be ordered for treatment by the inspecting officer. This decision on parchment levels is made at the officer's discretion.

[1] A sampling trier is a pointed piece of hollow tubular steel that is used to extract a sample from a bag of flow-able material; the trier can be inserted into the bag at any point to collect a sample rather than collecting the sample from the surface of the bag.

D.7.2 Pathway Summary

A flowchart of the pathway is presented in Figure D.25.

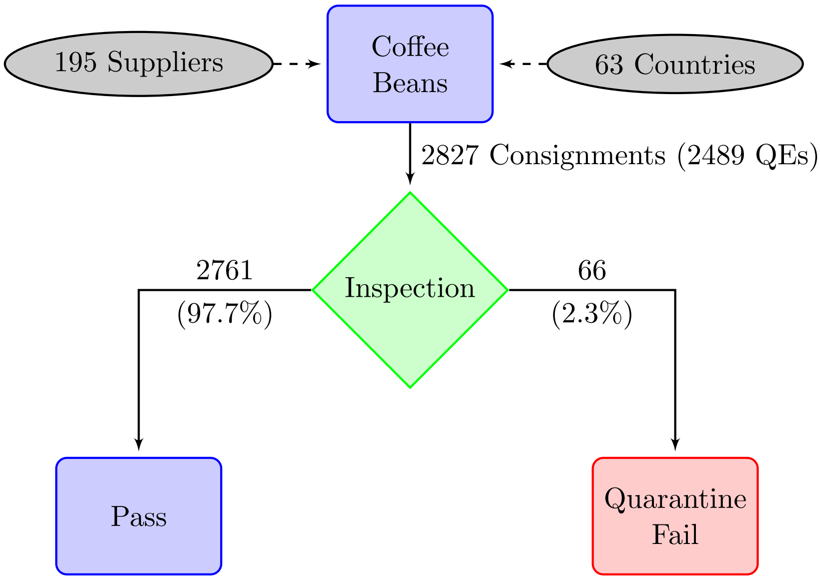

Figure D.25: Green coffee beans consignments flow chart with statistics for July 2008–December 2010. A quarantine failure was recorded for consignments with a detection of quarantine concern, such as insect, pathogen, or contamination. QEs refers to the number of quarantine entries, which may differ from the number of consignments.

D.7.3 Analysis

This section provides a statistical overview of the data. The full dataset comprises 5460 consignments with record creation dates ranging from October 2005 to December 2010, and comprises entries from 70 countries and 248 suppliers.

A smoothed plot of the quarantine failure rate against time is presented in Figure D.26. The figure shows a failure rate hovering around 7.5% for 2006 and 2007, followed by a drop to about 2.5% in 2008, which coincides with a change in import conditions: parchment, the dry skin or husk coating the coffee beans, was no longer considered to be a quarantine risk. The pathway has continued to become cleaner since then. The failure rate for the entire period was 4.45%, and for the analysis period (everything after June 2008) was 2.33%.

Annual inspection statistics are provided in Table D.25. The count of consignments is increasing gradually across the time period, and is on track to stay equally high in 2011.

The pattern of quarantine failure counts by country and supplier is presented in Table D.26. The statistics in Table D.27 summarize the inspection data for those countries with at least fifty consignments during the key time period and Table D.28 summarizes the inspection data for the suppliers with at least fifty consignments. A curious pattern emerges in the latter table: the high-volume suppliers that export from only one country have the lowest quarantine failure rate.

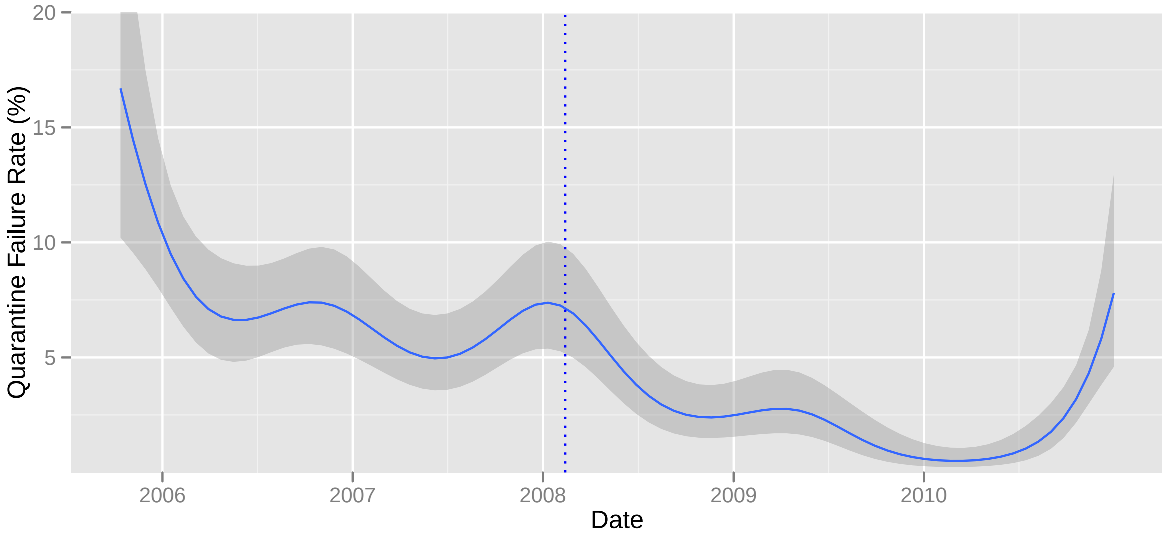

Figure D.26: Quarantine failure rates (%) for green coffee beans smoothed by date, with a 95% confidence interval (shaded region) added (see the caption of Figure 6.2 on page 24 for an explanation of the interval). The width of the shaded region indicates the uncertainty of the line, which becomes narrower as the number of inspected consignments increases. A vertical line is added at 13 Feb 2008 which is when quarantine conditions were changed to exclude parchment as a risk.

Table D.25: Pattern of inspections, pathway failures, and quarantine failure counts for green coffee beans by year. *Count* is the number of consignments imported during the study period, *PF%* is the percentage of consignments that fail for any contamination or non-commodity failure, *QF %* is the percentage of consignments with contamination of quarantine interest, and *Tonnage* is the total tons of product imported during the study period.

Year	Count	PF %	QF %	Tonnage
2005	145	16.6	11.7	6,990
2006	979	10.8	7.9	40,807
2007	1052	10.5	5.3	41,412
2008	932	6.1	4.6	21,858
2009	1021	3.6	1.9	17,116
2010	1331	3.6	2.3	21,132

Table D.26: Frequency of quarantine failure counts using recent data for green coffee beans by country and supplier. The data cover all inspections between July 2008 and December 2010.

Failures	Countries	Suppliers
0	49	172
1	4	10
2	3	6
3	1	2
4	0	1
5	0	2
6	0	0
7	2	0
8	2	0
9	0	0
10	1	0
11	0	1
12	0	0
13	1	1

Table D.27: Summary statistics for green coffee beans by country. See caption of Table D.25 for explanation of column names. *QF* is the count of consignments with contamination of quarantine interest. The *Suppliers* column reports the number of suppliers that have exported from each country during the time period. The data cover all inspections between July 2008 and December 2010. We only include those countries with 50 or more consignments during the time period.

Country	Count	PF %	QF	QF %	Tonnage	Suppliers
a	520	3.1	7	1.3	10,454	36
b	314	5.4	7	2.2	6,691	22
c	310	2.3	2	0.6	4,208	34
d	300	1.7	2	0.7	4,931	21
e	297	5.4	13	4.4	4,813	20
f	135	7.4	10	7.4	2,393	22
g	120	2.5	3	2.5	2,040	10
h	120	10.0	8	6.7	1,774	6
i	95	10.5	8	8.4	3,169	10
j	69	0.0	0	0.0	1,252	11
k	69	0.0	0	0.0	107	11
l	60	1.7	1	1.7	960	11

Table D.28: Summary statistics for green coffee beans by supplier. See caption of Table D.27 for explanation of column names and scope. We include only those suppliers with at least 50 recent consignments. The *Countries* column reports the number of countries that each supplier has exported from during the time period.

Supplier	Count	PF %	QF	QF %	Tonnage	Countries
a	469	4.5	13	2.8	8,097	12
b	432	0.5	1	0.2	12	38
c	426	3.3	11	2.6	9,309	19
d	104	4.8	1	1.0	2,464	5
e	85	0.0	0	0.0	1,583	1
f	72	2.8	2	2.8	1,366	8
g	70	7.1	5	7.1	1,275	15
h	69	1.4	0	0.0	1,274	3
i	68	7.4	5	7.4	1,668	8
j	63	0.0	0	0.0	1,229	1
k	56	12.5	3	5.4	1,653	3
l	56	1.8	1	1.8	1,092	8
m	54	9.3	2	3.7	1,983	5

Finally, we examined graphical summaries of both the failure rate against consignment size, and at the supplier level, the consignment count and the average quarantine failure rate. Neither summary showed substantial patterns, and they are not included here.

D.7.4 Simulation Results

The results are presented in Figures D.27 and D.28. Figure D.27 provides the average simulated post-intervention compliance as a function of inspection strategy and total inspection count for a range of options. The x-axis is the amount of effort, and less is preferred. The y-axis is the PIC, and higher is preferred. The grey line shows the expected PIC (or leakage) for random monitoring, and may be used as a baseline to assess the improvement resulting from selecting a CSP strategy. We note the following points, and emphasize that these points are relevant only to the simulated inspection of coffee beans based on existing data.

- All three CSP regimes improve upon random sampling, in that the average PIC returns are all higher than the grey line.
- The difference between the different CSP strategies is minimal. However, of the three CSP regimes, CSP–3 seems to provide the best match with the pathway manager's goals of rewarding compliance with reduced inspection rewards, while not allowing unnecessary leakage, or over penalizing random spikes in non-compliance.
- The stratification, monitoring fraction, and clearance number all have an effect on the leakage, and the effects can interact with one another.
- Stratifying by supplier seems to give the best value for simplicity and efficiency.
- Given CSP–3 and stratification by supplier, the best strategy seems to be to set the monitoring fraction to 50% and the clearance number to 10, in order to achieve a PIC of 99.0%.

Figure D.28 provides leakage count profiles for all the simulations. It can be used as an alternative means for interpreting the above reasoning.

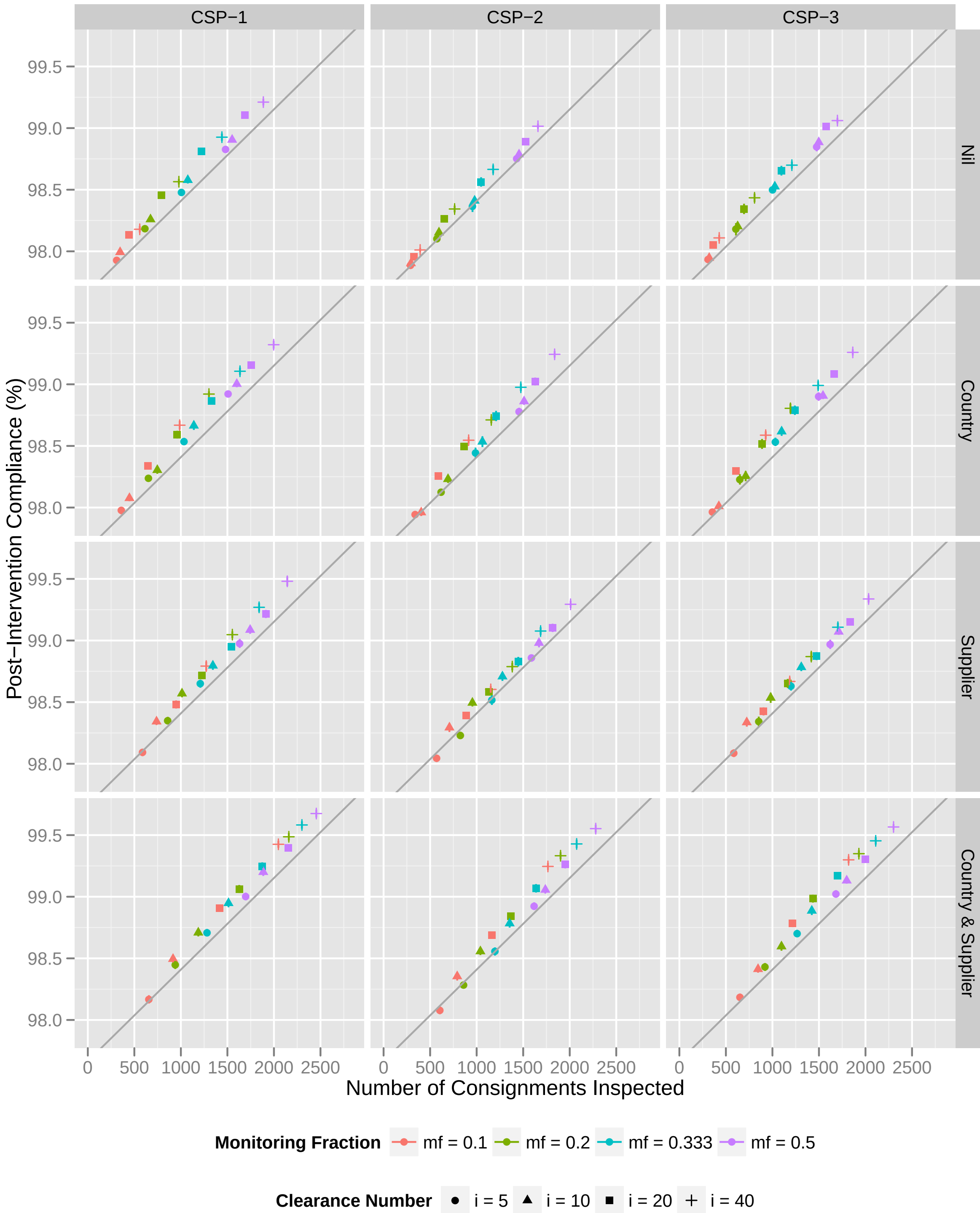

Figure D.27: Simulated Post-Intervention Compliance (PIC) against inspection effort for green coffee beans inspection history. The inspection strategies are in columns, and the stratification options are in rows. Within each panel, the sampling fraction is delineated by symbol colour, and the clearance number is delineated by the symbol shape. Approximate 95% confidence intervals for the mean of the simulation results are delineated by the (almost negligible) vertical line. The grey line represents the expected PIC that would result from random sampling.

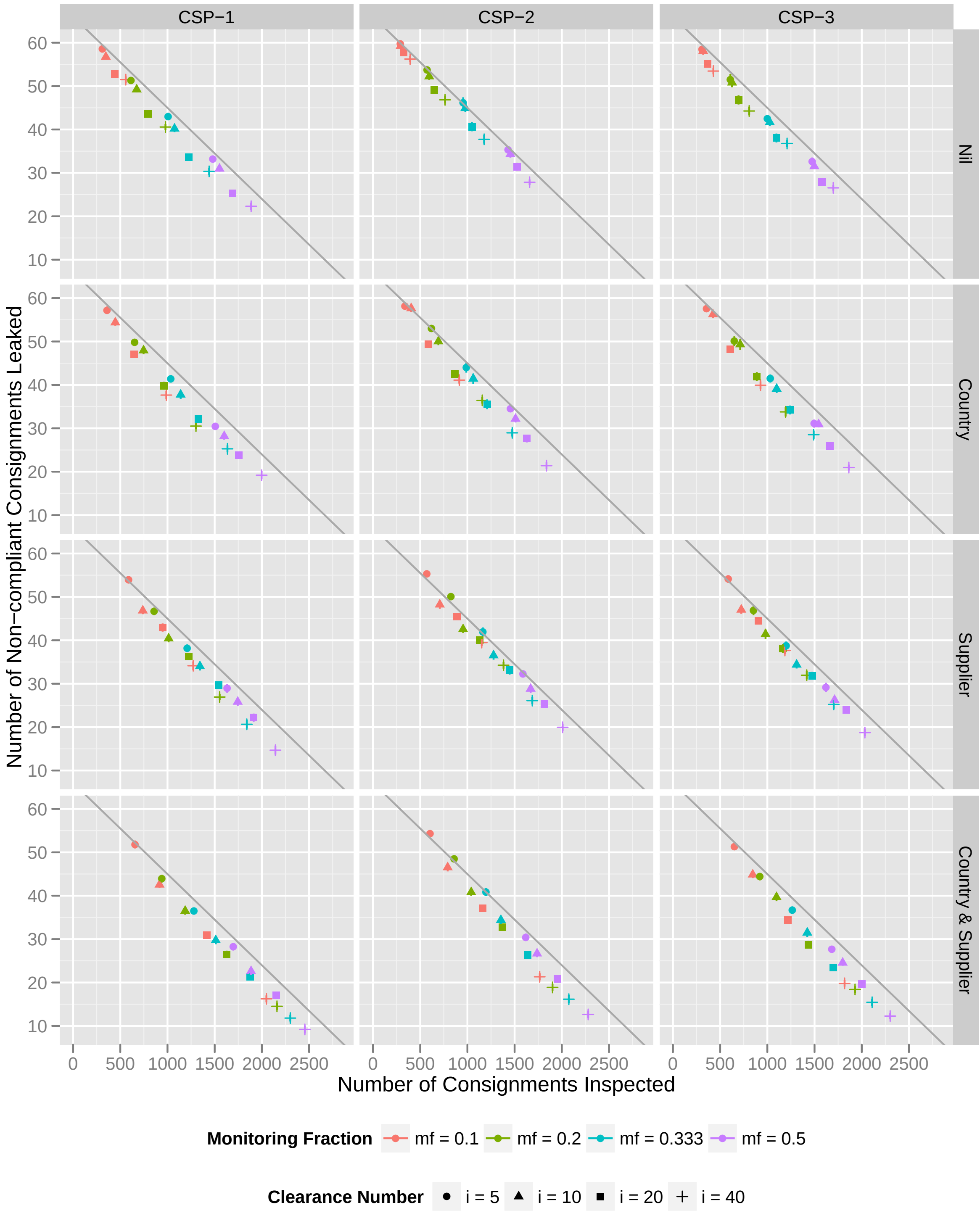

Figure D.28: Simulated leakage count against inspection effort for green coffee beans inspection history. The inspection strategies are in columns, and the stratification options are in rows. Within each panel, the monitoring fraction is delineated by symbol colour, and the clearance number is delineated by the symbol shape. Approximate 95% confidence intervals for the mean of the simulation results are delineated by the (almost negligible) vertical line. The grey line represents the expected leakage that would result from random sampling.

D.8 Hulled Sesame Seeds

For this analysis, 'hulled sesame seed' refers to *Sesamum indicum* syn. *S. orientale* seed for human consumption which has had the seed coat or testa removed. The total number of consignments for this pathway is comparatively small, so the prescription is tentative, however, this pathway seems like a good match for a CSP–3 sampling regime due to low pathway failure rates and a resulting high level of supplier compliance.

D.8.1 Import Conditions

Sesame seed must be hulled when imported for human consumption, if unhulled seeds are found the consignment must undergo a heat treatment to mitigate risks associated with germination.

Hulled sesame seed does not require an import permit for entry into Australia. Phytosanitary certificates are required for all FCL consignments.

Prior to entry into Australia, all consignments must pass an AQIS quarantine inspection on arrival to verify freedom from live insects, contamination with soil, prohibited seeds, other plant material (e.g. leaf, stem material, pod material, etc), animal material (e.g. animal faeces, feathers, etc.), any other extraneous contamination of quarantine concern and to verify that the seed has been hulled.

No formal import risk assessment has been undertaken for sesame seeds, however they are identified as a known regular host of khapra beetle (*Trogoderma granarium*). All commercial consignments from Khapra host countries require mandatory fumigation, either preshipment or on arrival in Australia.

D.8.2 Pathway Summary

A flowchart of the pathway is presented in Figure D.29.

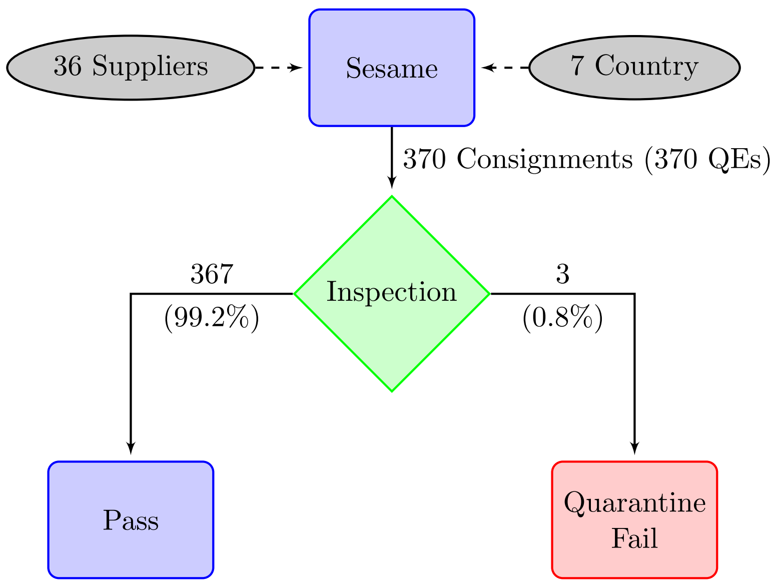

Figure D.29: Hulled sesame seed consignments flow chart with statistics for July 2008–December 2010. A quarantine failure was recorded for consignments with a detection of quarantine concern, such as insect, pathogen, or contamination. QEs refers to the number of quarantine entries, which may differ from the number of consignments.

D.8.3 Analysis

This section provides a statistical overview of the data. The full dataset comprises 843 consignments with record creation dates ranging from October 2005 to December 2010, and comprises entries from 9 countries and 61 suppliers.

A smoothed plot of the quarantine failure rate against time is presented in Figure D.30. The figure shows an initially negligible failure rate ascending to about 1% in 2008 and dropping from there to a low of less than 0.5%. The failure rate for the entire period was 0.36%, and for the analysis period (everything after June 2008) was 0.81%.

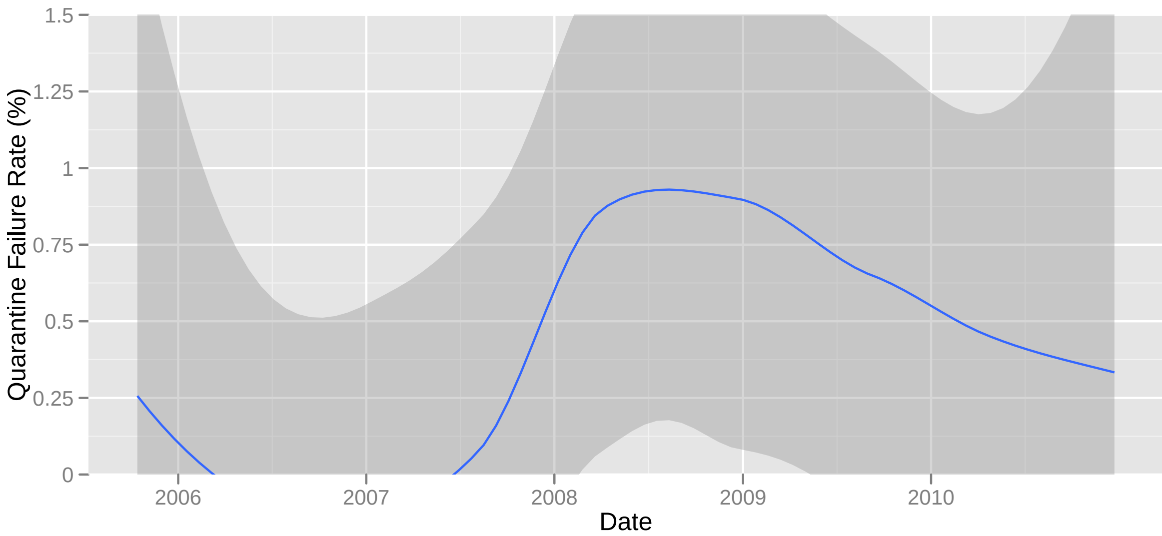

Figure D.30: Quarantine failure rates (%) hulled sesame seeds smoothed by date, with a 95% confidence interval (shaded region) added (see the caption of Figure 6.2 on page 24 for an explanation of the interval). The width of the shaded region indicates the uncertainty of the line, which becomes narrower as the number of inspected consignments increases.

Annual inspection statistics are provided in Table D.29. The count of consignments is stable across the time period, but the tonnage doubles in 2010, and is on track to stay equally high in 2011. The quarantine failure rate follows the pattern mentioned in the previous paragraph.

Table D.29: Pattern of inspections, pathway failures, and quarantine failure counts for hulled sesame seeds by year. *Count* is the number of consignments imported during the study period, *PF%* is the percentage of consignments that fail for any contamination or non-commodity failure, *QF %* is the percentage of consignments with contamination of quarantine interest, and *Tonnage* is the total tons of product imported during the study period.

Year	Count	PF %	QF %	Tonnage
2005	31	0.0	0.0	572
2006	178	1.1	0.0	3,633
2007	160	0.6	0.0	3,449
2008	161	3.7	1.2	3,219
2009	150	1.3	0.0	2,966
2010	163	1.2	0.6	2,926

Table D.30: Frequency of quarantine failure counts using recent data for hulled sesame seeds by country and supplier. The data cover all inspections between July 2008 and December 2010.

Failures	Countries	Suppliers
0	5	33
1	1	3
2	1	0

Table D.31: Summary statistics by country for hulled sesame seeds. See caption of Table D.29 for explanation of column names. *QF* is the count of consignments with contamination of quarantine interest. The *Suppliers* column reports the number of suppliers that have exported from each country during the time period. The data cover all inspections between July 1 2008 and December 2010. We only include those countries with five or more consignments during the time period.

Country	Count	PF %	QF	QF %	Tonnage	Suppliers
a	308	1.9	2	0.6	5,951	24
b	33	3.0	1	3.0	347	8
c	20	0.0	0	0.0	480	2
d	6	16.7	0	0.0	73	1

Table D.32: Summary statistics for hulled sesame seeds by supplier. See caption of Table D.31 for explanation of column names and scope. We include only those suppliers with at least 20 recent consignments. The *Countries* column reports the number of countries that each supplier has exported from during the time period.

Supplier	Count	PF %	QF	QF %	Tonnage	Countries
a	65	4.6	1	1.5	1,261	1
b	61	1.6	0	0.0	1,112	1
c	45	0.0	0	0.0	836	1
d	42	4.8	1	2.4	1,071	1

The pattern of quarantine failure counts by country and supplier is presented in Table D.30. The statistics in Table D.31 summarize the inspection data for those countries with at least five consignments during the key time period and Table D.32 summarizes the inspection data for the suppliers with at least twenty consignments. The top country and some of the top suppliers show evidence of contamination.

Finally, we examined graphical summaries of both the failure rate against consignment size, and at the supplier level, the consignment count and the average quarantine failure rate. Neither summary showed substantial patterns, and they are not included here.

D.8.4 Simulation Results

The results are presented in Figures D.31 and D.32. Figure D.31 provides the average simulated post-intervention compliance as a function of inspection strategy and total inspection count for a range of options. The x-axis is the amount of effort, and less is preferred. The y-axis is the

PIC, and higher is preferred. The grey line shows the expected PIC (or leakage) for random monitoring, and may be used as a baseline to assess the improvement resulting from selecting a CSP strategy. We note the following points, and emphasize that these points are relevant only to the simulated inspection of sesame based on existing data.

- All three CSP regimes improve upon random sampling, in that the average PIC returns are all substantially higher than the grey line.
- The difference between the different CSP strategies is minimal. However, of the three CSP regimes, CSP–3 seems to provide the best match with the pathway manager's goals of rewarding compliance with reduced inspection rewards, while not allowing unnecessary leakage, or over penalizing random spikes in non-compliance.
- The stratification, monitoring fraction, and clearance number all have an effect on the leakage, and the effects can interact with one another.
- Stratifying by supplier seems to give the best value for simplicity and efficiency.
- Given CSP–3 and stratification by supplier, the best strategy seems to be to set the monitoring fraction to 0.5 and the clearance number to 10, in order to achieve a PIC of 99.83%.

Figure D.32 provides leakage count profiles for all the simulations. It can be used as an alternative means for interpreting the above reasoning.

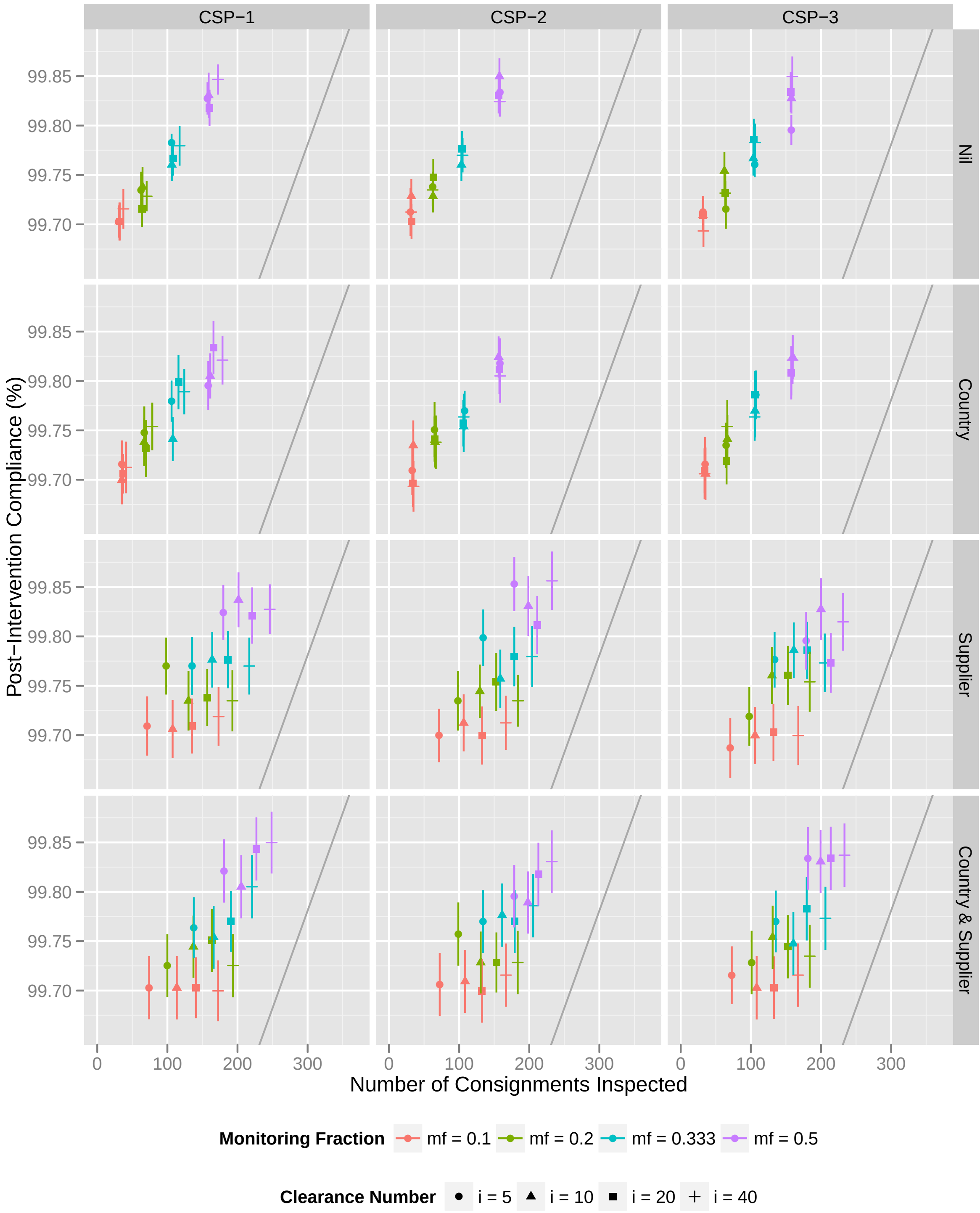

Figure D.31: Simulated Post-Intervention Compliance (PIC) against inspection effort for hulled sesame seed inspection history. The inspection strategies are in columns, and the stratification options are in rows. Within each panel, the monitoring fraction is delineated by symbol colour, and the clearance number is delineated by the symbol shape. Approximate 95% confidence intervals for the mean of the simulation results are delineated by the vertical line. The grey line represents the expected PIC that would result from random sampling.

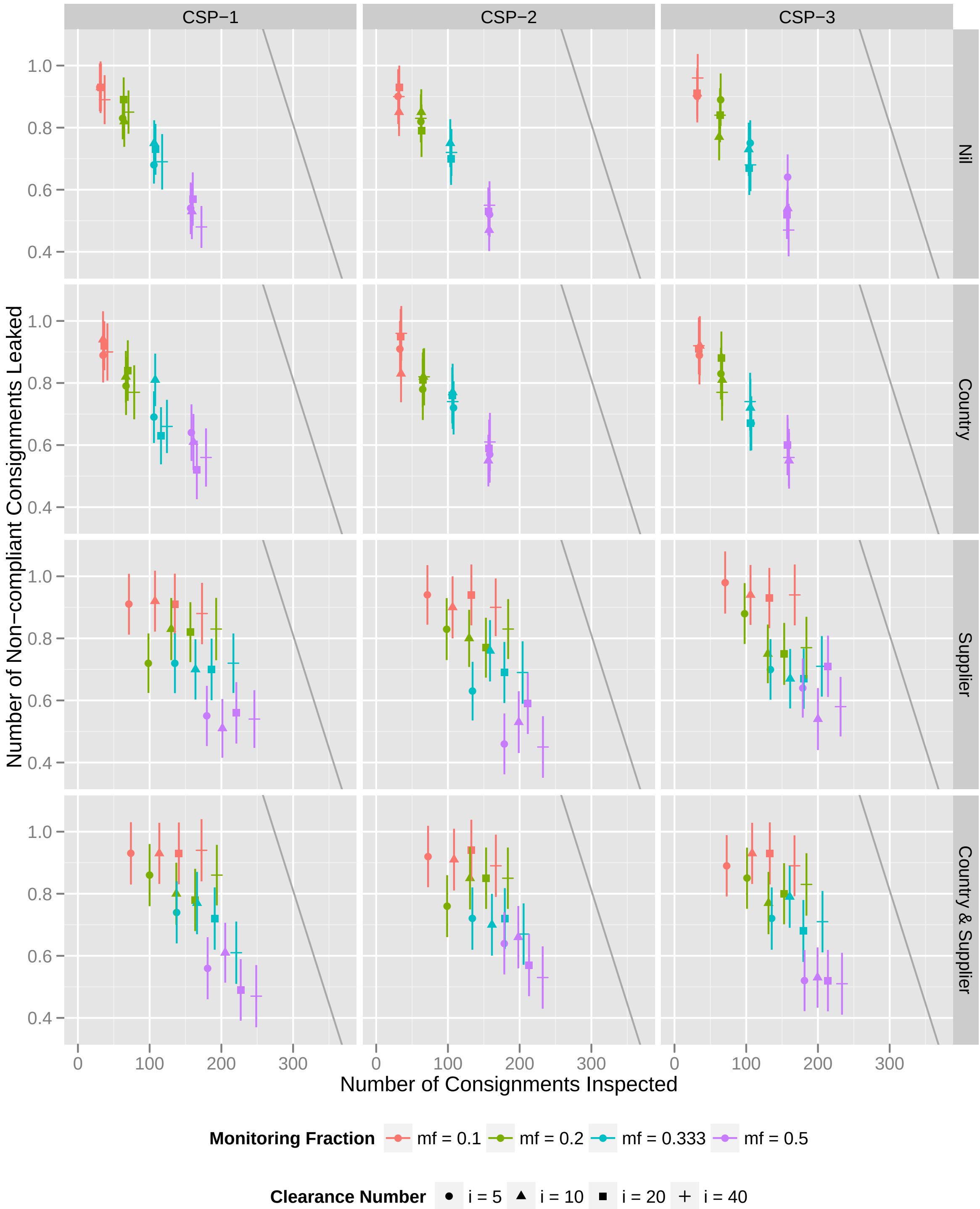

Figure D.32: Simulated leakage count against inspection effort for hulled sesame seed inspection history. The inspection strategies are in columns, and the stratification options are in rows. Within each panel, the monitoring fraction is delineated by symbol colour, and the clearance number is delineated by the symbol shape. Approximate 95% confidence intervals for the mean of the simulation results are delineated by the vertical line. The grey line represents the expected leakage that would result from random sampling.

D.9 Mangosteen exported from *Country B*

For this analysis, 'mangosteen' refers to *Garcinia mangostana*. The mangosteen exported from Country B does not show evidence of being a good match for the supplier-specific sampling prescriptions that have been recommended for other imported-plant product pathways. The reason is that the approach rate of the pathway is very high. Inspection for this pathway should remain at 100%.

D.9.1 Import Conditions

Mangosteen are considered a quarantine risk to Australia because fresh produce and/or the cartons that they are packaged in may contain unidentified or identified plant material other than the permitted commodity, other contaminants such as straw packing, soil, insects, pupae, disease symptoms and seeds which add to the quarantine risks.

Mangosteen are only permitted entry into Australia if accompanied by a valid import permit. A phytosanitary certificate is also required including an additional declaration stating that "The mangosteens in this consignment have been produced in *Country B* in accordance with the conditions governing entry of fresh mangosteen fruits to Australia".

All fresh mangosteen fruit for export to Australia must be sourced from export orchards and packaged in packhouses registered with the Department of Agriculture, *Country B*. All mangosteen fruits are to be individually cleaned of mealybugs and black ants on the surface and underneath the calyx and sepals using physical or mechanical means, such as washing, pressurised air blast, high-pressure water jet blast, or a combination of these methods at registered packhouses only.

Prior to entry into Australia, all consignments must pass an AQIS quarantine inspection to verify that the mangosteen is free from live insects and other QRM. A sample of 600 fruit is selected from a random number of cartons within each consignment and individually inspected for the presence of insects, pests, disease, soil, and other contamination such as weed seeds and plant trash. 60 fruit from the sample is examined further under a dissecting microscope (30X). A further 30 fruit from the sample are cut open to inspect for internal feeders.

A formal IRA has been completed for fresh mangosteen from *Country B*. The arthropod species listed in Table D.33 were identified as quarantine pests of concern for mangosteen from *Country B*.

Table D.33: Quarantine pests of concern for mangosteen from *Country B*.

Scientific name	Common name
Diptera (true flies)	
Bactrocera carambolae (Drew & Hancock)	Carambola fruit fly
Bactrocera dorsalis (Hendel)	Oriental fruit fly
Bactrocera papayae (Drew & Hancock)	Papaya fruit fly
Hemiptera (mealybugs; scales; true bugs)	
Dysmicoccus neobrevipes (Beardsley)	Gray pineapple mealybug
Pseudococcus cryptus (Hempel)	Cryptic mealybug
Hymenoptera (black ants)	
Dolichoderus sp.	Black ant
Technomyrmex butteli (Forel)	Black ant

D.9.2 Pathway Summary

A flowchart of the pathway is presented in Figure D.33.

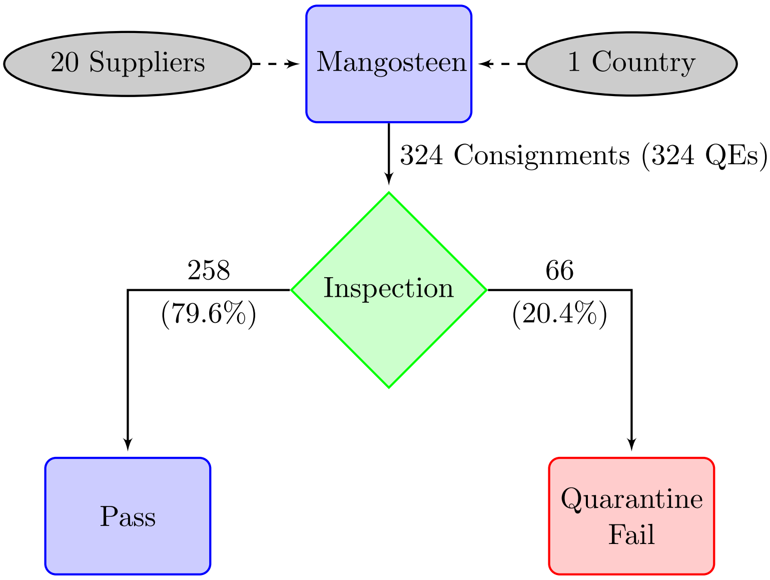

Figure D.33: Mangosteen consignments flow chart with statistics for July 2008–December 2010. A quarantine failure was recorded for consignments with a detection of quarantine concern, such as insect, pathogen, or contamination. QEs refers to the number of quarantine entries, which may differ from the number of consignments.

D.9.3 Analysis

This section provides a statistical overview of the data. The full dataset comprises 644 consignments with record creation dates ranging from October 2005 to December 2010, and comprises entries from 1 country and 33 suppliers.

A smoothed plot of the quarantine failure rate against time is presented in Figure D.34. The figure shows a failure rate increasing from below 50% to around 20% and then increasing. The failure rate for the entire period was 23.29%, and for the analysis period (everything after June 2008) was 20.37%.

Annual inspection statistics are provided in Table D.34. The count of consignments is decreasing gradually across the time period.

Table D.35 summarizes the inspection data for the suppliers with at least twenty consignments.

D.9.4 Simulation Results

The results are presented in Figures D.35 and D.36. Figure D.35 provides the average simulated post-intervention compliance as a function of inspection strategy and total inspection count for a range of options. The x-axis is the amount of effort, and less is preferred. The y-axis is the PIC, and higher is preferred. The grey line shows the expected PIC (or leakage) for random monitoring, and may be used as a baseline to assess the improvement resulting from selecting a CSP strategy. We note the following points, and emphasize that these points are relevant only to the simulated inspection of mangosteen based on existing data.

- No CSP regimes improve upon random sampling, in that the average PIC returns are all no higher than the grey line.

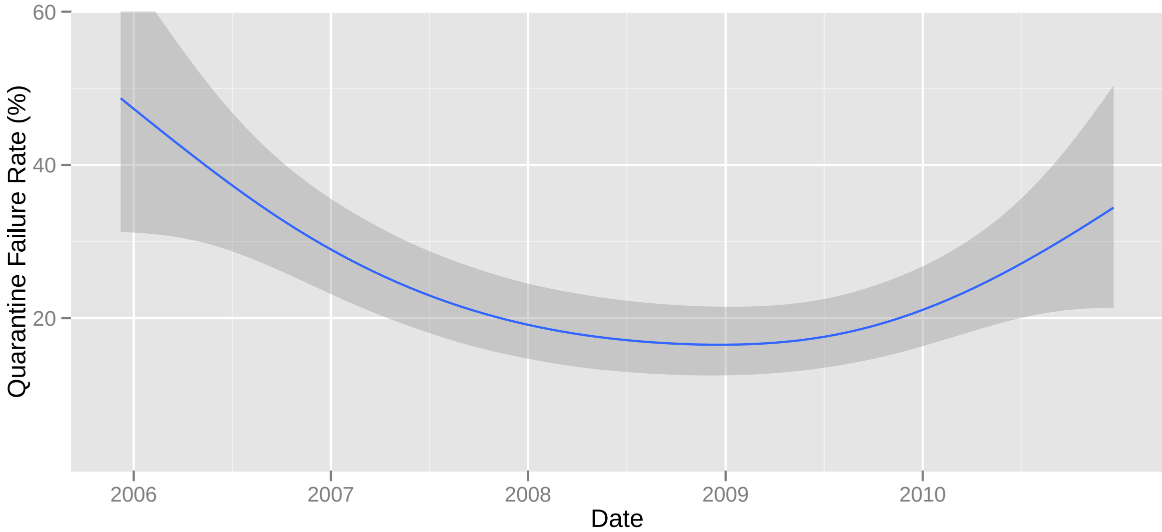

Figure D.34: Quarantine failure rates for mangosteen (%) smoothed by date, with a 95% confidence interval (shaded region) added (see the caption of Figure 6.2 on page 24 for an explanation of the interval). The width of the shaded region indicates the uncertainty of the line, which becomes narrower as the number of inspected consignments increases.

Table D.34: Pattern of inspections, pathway failures, and quarantine failure counts for mangosteen by year. *Count* is the number of consignments imported during the study period, *PF%* is the percentage of consignments that fail for any contamination or non-commodity failure, *QF %* is the percentage of consignments with contamination of quarantine interest, and *Tonnage* is the total tons of product imported during the study period.

Year	Count	PF %	QF %	Tonnage
2005	1	100.0	100.0	2
2006	90	36.7	36.7	119
2007	149	23.5	23.5	245
2008	119	17.6	17.6	239
2009	178	16.3	16.3	389
2010	107	29.9	29.0	212

- The difference between the different CSP strategies is minimal. However, of the three CSP regimes, CSP–3 seems to provide the best match with the pathway manager's goals of rewarding compliance with reduced inspection rewards, while not allowing unnecessary leakage, or over penalizing random spikes in non-compliance.
- The stratification, monitoring fraction, and clearance number all have an effect on the leakage, and the effects can interact with one another.

Figure D.36 provides leakage count profiles for all the simulations. It can be used as an alternative means for interpreting the above reasoning.

Table D.35: Summary statistics for mangosteen by supplier. See caption of Table D.34 for explanation of column names. *QF* is the count of consignments with contamination of quarantine interest. The *Suppliers* column reports the number of suppliers that have exported from each country during the time period. The data cover all inspections between July 1 2008 and 31 December 2010. We include only those suppliers with at least 20 recent consignments. The *Countries* column reports the number of countries that each supplier has exported from during the time period.

Supplier	Count	PF %	QF	QF %	Tonnage	Countries
a	95	13.7	12	12.6	225	1
b	61	32.8	20	32.8	87	1
c	37	27.0	10	27.0	37	1

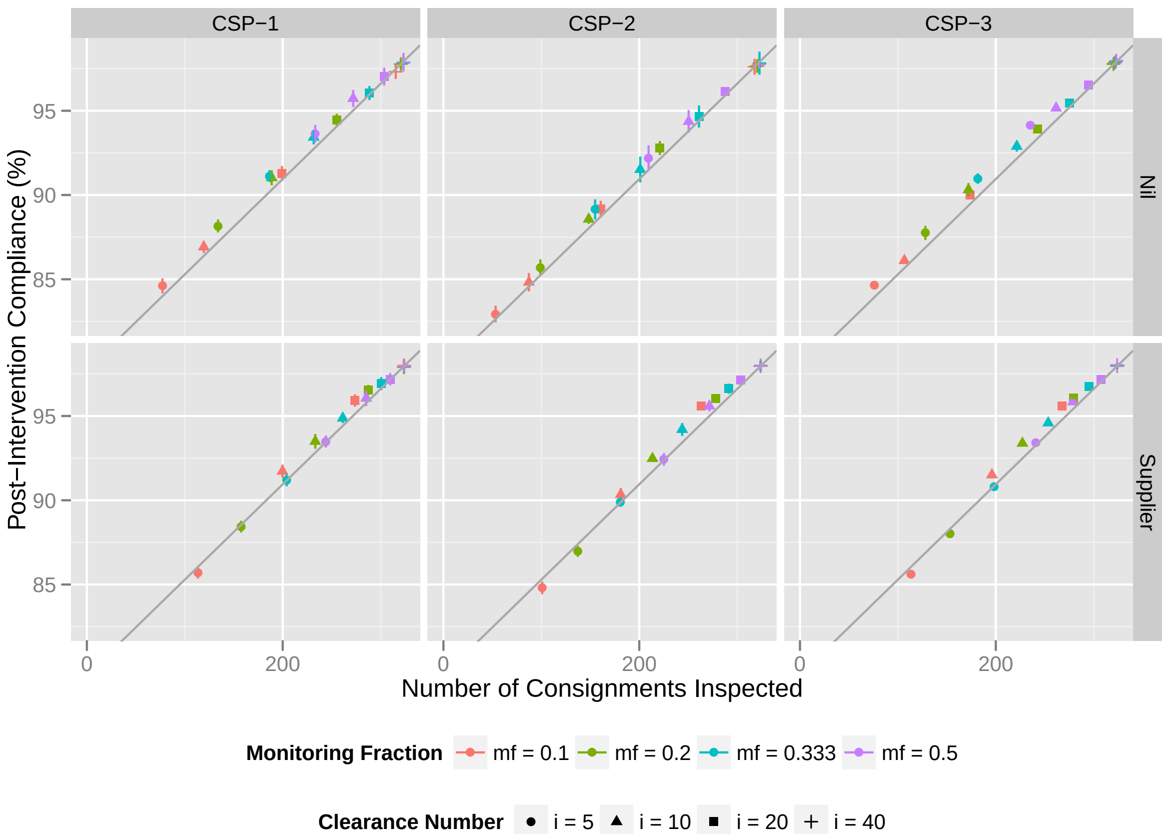

Figure D.35: Simulated Post-Intervention Compliance (PIC) against inspection effort for mangosteen inspection history. The inspection strategies are in columns, and the stratification options are in rows. Within each panel, the sampling fraction is delineated by symbol colour, and the clearance number is delineated by the symbol shape. Approximate 95% confidence intervals for the mean of the simulation results are delineated by the vertical line. The grey line represents the expected PIC that would result from random sampling.

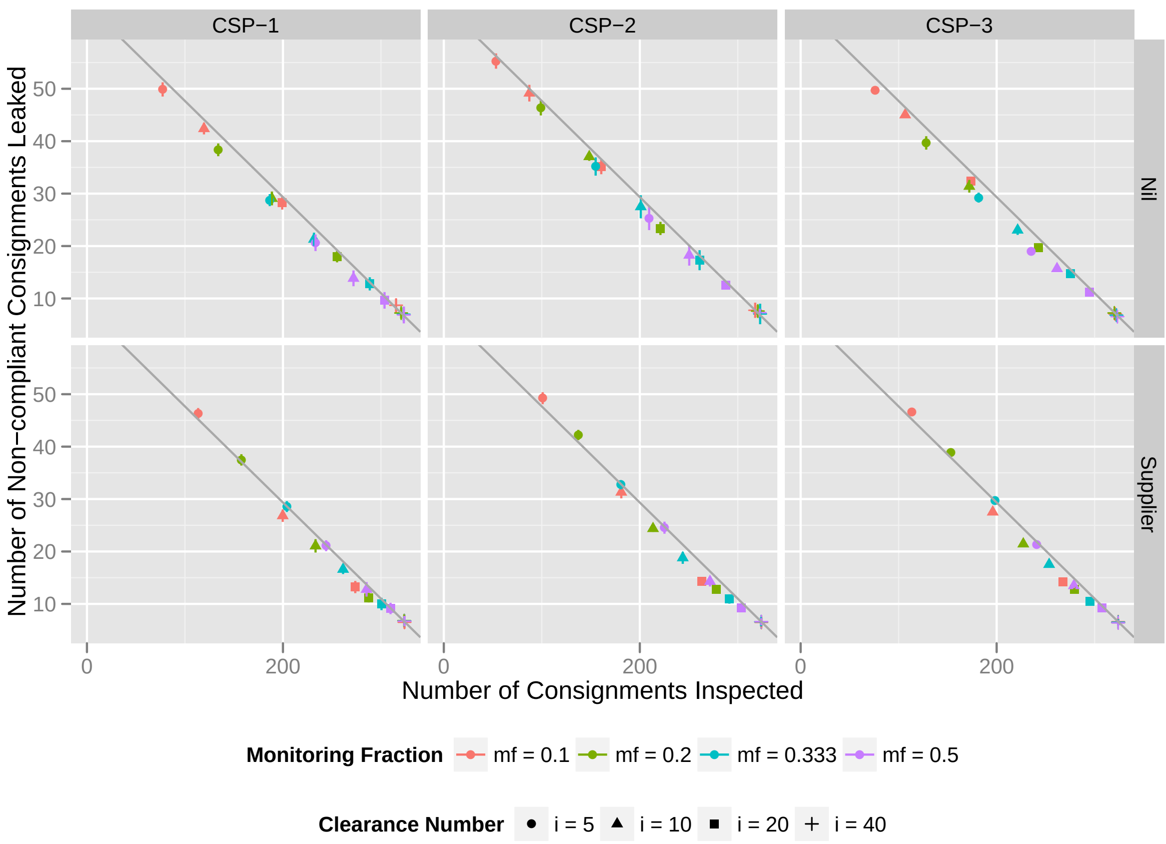

Figure D.36: Simulated leakage count against inspection effort for mangosteen inspection history. The inspection strategies are in columns, and the stratification options are in rows. Within each panel, the monitoring fraction is delineated by symbol colour, and the clearance number is delineated by the symbol shape. Approximate 95% confidence intervals for the mean of the simulation results are delineated by the vertical line. The grey line represents the expected leakage that would result from random sampling.

Appendix E

List of Tables and Figures

List of Tables

List of Figures