# QUARANTINE RISK POSED TO FORESTRY BY FULL CONTAINER LOADS, AND EFFICIENCY OF FCL DOOR INSPECTIONS

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## ABSTRACT

A survey of 9001 full-container-load (FCL) consignments imported into Auckland (a 10% sample, based on perceived risk) was undertaken to examine the incidence of interceptions of material that may affect trees and wood products, and to compare the rate of interceptions with those found in an earlier study of part-container-load (LCL) cargo (100% inspection). Interceptions in FCL cargo (4.2%) were less than half those in LCL cargo (9.1%). Bark was found in 3.5% of the consignments, insect damage in 1.5%, insects in 0.7%, and fungi in 0.3%. Stone and slate, sawn timber, and general goods had the highest rate of contamination, along with any cargo from Africa and North Asia. Cargo packed in crates, skids, and cases contained more prohibited material than packages or cargo packed in cartons or bales. A log-linear model was used to predict contamination rates for various combinations of origin, goods, and packaging. Nearly half the combinations had a 2%, or less, probability of carrying contaminated material.

A further study of 501 "high risk" FCLs was carried out by examining the cargo as it was unpacked at its final destination, after the containers had been inspected via the open door of the FCL on the wharf. Contamination by insects or fungi, or the presence of bark, was recorded. Of the 501 containers examined, 191 (38.1%) contained insects, insect damage, bark, fungi, or some combination of the four. Door inspections identified 115 (23%) contaminated containers, and during the follow-up inspections, 76 (15%) containers previously cleared during the door inspections were found to be contaminated. The majority (81%) of contaminants found during the door inspections were of such significance that treatment was recommended. Only 30% of contaminated containers found during the follow-up inspections warranted treatment. Quarantine interceptions were most common for stone and slate, machinery, and general goods packed in crates and cases. The study showed that door inspections are generally efficient for detecting significant contaminants in imported cargo, but some contaminated containers slip through quarantine undetected.

**Keywords**: quarantine; containerised cargo.

## INTRODUCTION

Most cargo is imported as full container loads (FCLs), less-than-full container loads (LCLs), or as "bulk" non-containerised cargo. In 1993, bulk cargo and LCLs were 100% inspected, and a minimum 10% sample of FCLs was selected for door inspection (Ministry

of Forestry 1994). The inspection rate for FCLs increased to 14.8% in 1996, and to 15.6% in 1997–98 (K. Glassey pers. comm.). The sample selection for FCLs is not random, but is based on perceived risk. Quarantine officers sample high risk cargo in preference to other cargo, "high risk" is defined by the officer's training and experience.

In 1990, the Forest Health Advisory Committee formed a quarantine sub-committee to examine the risk associated with various cargo types. In a major study data from 2547 consignments of LCL cargo were examined, and the incidence of intercepted material with the potential to damage trees or wood was analysed (Bulman 1992). Contamination rates as indicated by the number of interceptions varied significantly, depending on the origin and type of cargo. To establish if the proportion of prohibited material in FCLs differed from that in LCLs, a survey of consignments of FCL cargo was carried out and the results were compared with those from the LCL survey.

Carrying on from the FCL cargo study, the efficiency of FCL door inspections was tested by following 501 FCLs that were door-inspected on the wharf to their final destination. As the cargo was unloaded it was examined for contamination by insects or fungi, and for the presence of bark. Results of the FCL cargo study and the FCL follow-up study are discussed here.

## METHODS

### FCL Cargo Study

Results of all FCL container inspections carried out by Ministry of Forestry Quarantine Officers at Auckland from May to December 1993 were analysed. Since only 10% of FCLs were inspected during that period the sample was biased towards "high risk" cargo types, but some cargo considered to have lower risk was also inspected. Information on cargo type and origin, and on quarantine interceptions was extracted. A forestry quarantine interception is defined as the discovery in imported material of any organism with the potential to damage trees or wood products. Bark is considered of quarantine significance because of its likelihood of hosting potentially damaging bark-boring insects.

Altogether 9001 consignments were examined. Information was collected on the ship's name and voyage number, country of origin, port of loading, packaging and goods types, and type of interception (insect, insect damage, bark, fungi). Cargo description (packaging and goods type) was categorised to simplify the analysis. Packaging and goods categories are shown in Table 1. Dunnage was excluded from this study.

The numbers of interceptions from each goods and package type, and the country of origin were tabulated. Individual countries were grouped into geographical regions. To avoid multiple counting, intercepted material (insect, insect damage, bark, fungi) was grouped into one combined category. Overseas trade statistics for the year November 1995 to October 1996 were used to quantify tonnage of cargo imported into New Zealand by country of origin and goods type. The data were fitted to a log-linear model (McCullagh & Nelder 1989) to predict the percentage of total contamination as a function of three factors (goods type, packaging type, region of origin) using the statistical package Genstat 5 (1990). The model was also used to make allowances for the interaction effect of one factor on another. For example, all cargo packed in cartons had a very low interception rate, regardless of the type of goods or their origin. The distribution of material packed in cartons was not even

TABLE 1–Packaging and goods types defined for the study

| Packaging | Goods |
|---|---|
| Bales | Chemicals |
| Cases | Food |
| Cartons | General goods |
| Crates | Glass |
| Other | Machinery |
| Packages | Paper |
| Pallets | Personal effects |
| Pieces | Sawn timber |
| Rolls | Stone and slate |
| Skids | Textiles, clothing |
| Unknown | Unknown |

throughout all goods types and origins; therefore, the predicted contamination rate of goods and origins with a higher-than-average proportion of material packed in cartons was increased to allow for that influence. Actual and predicted means are given in the results section.

## FCL Follow-up Study

In all, 501 containers were examined, 239 of them at Auckland and 262 at Lyttelton. Ministry of Forestry quarantine officers carried out all the follow-up inspections. As the sample size is dependent on the estimated percentage of contaminated containers in the total container population (the higher the percentage of contaminated containers, the lower the sample size), only extreme "high risk" cargo (Table 2) was inspected. Containers carrying "high risk" cargo were selected from manifests and targeted for inspection, based on predicted contamination rates developed from results of the FCL cargo study for combinations of goods type, origin, and packaging. All containers selected had a door inspection, including lines of two or more containers from the same consignor. Any contamination found during the wharf door inspection was recorded and the appropriate quarantine treatment applied. Only those containers considered free of contamination and cleared for release at the wharf were followed to their destination where the cargo was inspected after it had been unpacked.

TABLE 2–Selected high risk cargo types to be inspected

| Region | Goods type | Packaging type |
|---|---|---|
| Africa | All goods apart from chemicals | All types |
| Central Asia (India, Pakistan, Sri Lanka) | Stone and slate, sawn timber | All types |
| Central Asia (India, Pakistan, Sri Lanka) | General goods, food | Skids |
| Europe | Stone and slate | All types |
| North America | Machinery | Skids |
| North America | Stone and slate | All types |
| North Asia (Japan, China, Korea, Taiwan) | Stone and slate | All types |
| North Asia (Japan, China, Korea, Taiwan) | Sawn timber, food | Skids, crates, cases, others |
| North Asia (Japan, China, Korea, Taiwan) | General goods, machinery | Skids |
| South-east Asia | Stone and slate, sawn timber | All types |
| South-east Asia | General goods, food, machinery | Skids |

The following information was recorded:

Manifest description: Cargo origin, consignee and consignor, ship's name and voyage number, type of goods, type of packaging (if listed), container number.

Inspection findings Date inspected, goods type, packaging type, contamination type (insects, insect damage, bark, fungi), severity of attack, any information differing from the manifest description.

Follow-up findings Date inspected, contamination type (insects, insect damage, bark, fungi), severity of attack (trace, medium, treated).

## RESULTS

### FCL Cargo Study

Bark and insect damage were the most common quarantine interceptions, respectively found in 3.5% and 1.5% of the consignments inspected. Insects were found in 0.7% of the consignments and fungal interceptions in 0.3%. A total of 376 consignments (4.2%) contained prohibited quarantine material. This rate was lower than that for LCL consignments where 9.1% were contaminated. The type of interception was of the same order for FCLs and LCLs, bark and insect damage being most commonly intercepted, followed by insects and fungi.

Quarantine interceptions were most common in consignments of stone and slate, sawn timber, and general goods, and fewest in paper, glass, and textiles. The goods to have markedly different adjusted interception rates for FCLs and LCLs were machinery (6.2% for FCLs and 14.2% for LCLs), glass (3.8% and 10.9%), paper (2.5% and 16.2%), and food (6.8% and 0.2%) (Table 3).

TABLE 3–Interceptions by goods type

| Goods type | No. of consignments | Material intercepted (%) | | | | Average contaminated consignments (%) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Bark | Insects | Insect damage | Fungi | Actual FCL | Predicted FCL | Actual LCL | Predicted LCL |
| Stone, slate | 604 | 9.4 | 2.0 | 4.3 | 0.5 | 10.6 | 11.7a | 26.3 | 21.3 |
| Sawn timber | 129 | 4.7 | 1.6 | 1.6 | 0.8 | 6.2 | 9.6a | 6.3 | 7.4 |
| General goods | 2649 | 4.5 | 0.9 | 1.8 | 0.3 | 5.5 | 7.3 b | 7.0 | 10.3 |
| Food | 186 | 4.3 | 0.0 | 0.5 | 0.0 | 4.3 | 6.8 b | 0.0 | 0.2 |
| Machinery | 1566 | 3.4 | 0.7 | 1.7 | 0.1 | 4.1 | 6.2 b | 13.5 | 14.2 |
| Personal effects | 19 | 0.0 | 0.0 | 5.3 | 0.0 | 5.3 | 6.1 bc | 11.6 | 11.6 |
| Textiles | 105 | 1.9 | 0.0 | 1.0 | 0.0 | 2.9 | 4.5 bc | 4.0 | 8.3 |
| Chemicals | 1131 | 3.1 | 0.5 | 1.3 | 0.2 | 3.6 | 3.8 c | 4.9 | 5.5 |
| Glass | 720 | 1.7 | 0.3 | 0.8 | 0.1 | 2.2 | 3.8 c | 11.5 | 10.9 |
| Paper | 1890 | 1.0 | 0.2 | 0.2 | 0.5 | 1.3 | 2.5 c | 12.9 | 16.2 |
| Unknown | 2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1* | 35.0 | 39.9 |
| Total | 9001 | 3.5 | 0.7 | 1.5 | 0.3 | 4.2 | | 9.1 | |

Adjusted means with the same letter are not significantly different at the 5% level. Goods types are regarded as significantly different if the difference of the means exceeds twice the standard error of the means.

* Too few observations for valid comparison

Of the 9001 consignments inspected, 78% were packed on pallets. Crates, skids, other packaging (bundles, coils, drums), and cases contained significantly more prohibited material than bales, pallets, packages, or cartons. The proportion of quarantined items in FCL packaging was broadly similar to that found for LCLs. However, in FCLs 4.6% of pallets were predicted to contain prohibited material compared with 15.3% in LCLs (Table 4). Cargo originating in Africa, Central Asia (the Indian sub-continent), and North Asia (China, Japan, and Korea) had more quarantine interceptions than Australia, other regions (Pacific Islands, Middle East, South America), North America, and Europe. Regions with significantly different FCL contamination rates from the LCL rates were South-east Asia (6.9% for FCLs and 16.9% for LCLs) and United Kingdom (0.9% and 8.8%) (Table 5).

TABLE 4–Interceptions by packaging type

| Packaging type | No. of consignments | Material intercepted (%) | | | | Average contaminated consignments (%) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Bark | Insects | Insect damage | Fungi | Actual FCL | Predicted FCL | Actual LCL | Predicted LCL |
| Skids | 129 | 12.4 | 0.8 | 5.4 | 3.1 | 14.0 | 15.6a | 9.8 | 13.2 |
| Crates | 374 | 11.8 | 5.1 | 8.3 | 0.3 | 14.7 | 13.6a | 20.6 | 22.3 |
| Cases | 430 | 5.8 | 1.2 | 2.6 | 0.5 | 7.7 | 10.5 b | 13.7 | 16.3 |
| Others | 315 | 9.2 | 2.2 | 4.1 | 1.3 | 11.1 | 10.1 b | 10.0 | 12.8 |
| Pallets | 6983 | 2.7 | 0.4 | 0.9 | 0.2 | 3.2 | 4.6 c | 12.2 | 15.3 |
| Bales | 28 | 0.0 | 0.0 | 3.6 | 0.0 | 3.6 | 3.2 c | 8.0 | 9.8 |
| Packages | 288 | 2.1 | 0.0 | 1.4 | 0.7 | 3.1 | 3.1 c | 6.1 | 6.6 |
| Cartons | 153 | 1.3 | 0.0 | 0.0 | 0.0 | 1.3 | 1.1 c | 1.1 | 2.1 |
| Pieces | 255 | 0.4 | 0.0 | 0.4 | 0.0 | 0.4 | 0.7 c | 5.4 | 3.5 |
| Rolls | 46 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 c | 3.1 | 3.7 |
| Total | 9001 | 3.5 | 0.7 | 1.5 | 0.3 | 4.2 | | 9.1 | |

Adjusted means with the same letter are not significantly different at the 5% level. Packaging types are regarded as significantly different if the difference of the means exceeds twice the standard error of the means.

TABLE 5–Interceptions by regional groupings of country of origin

| Region of origin | No. of consignments | Material intercepted (%) | | | | Average contaminated consignments (%) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Bark | Insects | Insect damage | Fungi | Actual FCL | Predicted FCL | Actual LCL | Predicted LCL |
| Africa | 97 | 16.5 | 0.0 | 2.1 | 4.1 | 17.5 | 17.0a | | |
| North Asia | 1228 | 9.7 | 1.4 | 4.9 | 0.6 | 10.5 | 12.5ab | 6.9 | 10.2 |
| Central Asia | 124 | 14.5 | 3.2 | 6.5 | 0.8 | 15.3 | 11.6ab | 15.4 | 25.7 |
| Unknown | 9 | 0.0 | 11.1 | 0.0 | 0.0 | 11.1 | 7.9 bc | 2.6 | 7.7 |
| South-east Asia | 1063 | 4.0 | 1.5 | 2.2 | 0.3 | 5.5 | 6.9 c | 6.3 | 16.9 |
| Europe | 2170 | 2.6 | 0.6 | 1.0 | 0.3 | 3.6 | 5.4 c | 14.4 | 12.6 |
| North America | 1318 | 3.0 | 0.2 | 1.0 | 0.0 | 3.3 | 4.1 cd | 9.1 | 7.0 |
| Others | 271 | 2.2 | 0.4 | 0.4 | 0.7 | 3.3 | 3.2 cd | | |
| Australia | 1954 | 0.6 | 0.2 | 0.2 | 0.1 | 0.8 | 1.2 cd | 8.8 | 7.3 |
| UK | 767 | 0.4 | 0.0 | 0.0 | 0.3 | 0.5 | 0.9 cd | 9.0 | 8.8 |
| Total | 9001 | 3.5 | 0.7 | 1.5 | 0.3 | 4.2 | | 9.1 | |

Adjusted means with the same letter are not significantly different at the 5% level. Regions are regarded as significantly different if the difference of the means exceeds twice the standard error of the means.

The analysis of deviance (Table 6) generated by the log-linear model shows that region of origin had the greatest effect on the contamination rates, followed by packaging and goods types. The major adjustments to actual means were in cargo packed in cases (an increase from 7.7% to 10.5%) and skids (14.0% to 15.6%), sawn timber (6.2% to 9.6%), and cargo originating in Central Asia (a decrease from 15.3% to 11.6%).

TABLE 6–Analysis of deviance for region of origin, goods, and packaging type (FCL survey of 9001 containers)

| | df | Deviance | Mean deviance | Deviance ratio |
|---|---|---|---|---|
| Region | 9 | 268.57 | 29.84 | 22.76 |
| Goods | 10 | 100.32 | 10.03 | 7.65 |
| Packaging | 9 | 91.59 | 10.18 | 7.76 |
| Residual | 298 | 390.70 | 1.31 | |
| Total | 326 | 851.19 | 2.61 | |

Contamination rates for combinations of region of origin, goods, and packaging were predicted using the log-linear model (the full list is available from the author). The highest contamination rates (30% to 59%) were for crates, skids, bundles, and cases of stone, sawn timber, or general goods from Africa and Central or North Asia. Any goods packed in rolls, pieces, or cartons had the lowest values, regardless of origin. Almost half the combinations (48%) had a 2% or less probability, and 9% of the combinations had a 20% or greater probability, of carrying prohibited material. Some of the combinations would not occur operationally—for instance, drums of slate, or rolls of sawn timber.

To assess the real risk associated with cargo types of high predicted interception rates it is necessary to quantify how much of this "high risk" cargo is imported into New Zealand. Data on the quantity of various packaging types imported were not available. Contamination rates for combinations of goods from various origins were predicted, using the log-linear model, for material packed in cases, crates, "other" packaging, pallets, and skids. Contamination rates predicted to be over 20% are presented as combinations of region of origin and goods type, with lowest and highest values given (Table 7).

The tonnage of cargo imported into New Zealand from November 1995 to October 1996 is given in Table 8. Bulk unpacked cargo such as fertiliser, ores, distillates, and other petroleum products were excluded. From Table 7, all goods from Africa and North Asia, goods apart from chemicals and glass from Central Asia, sawn timber and stone from Europe, stone from North America, general goods, sawn timber, and stone from South-east Asia are classified as "high risk". These imports comprise 26%, or 1 584 000 tonnes, of packaged goods imported into New Zealand. It is not known how much of this cargo is packed in "low risk" packaging but of the 9001 FCLs inspected, 742 (8.2%) were packed in cartons, rolls, packages, or individual pieces. In the LCL study, almost 28% of the randomly selected consignments were packed in cartons, although the high proportion of cartons may have been due to the nature of LCL cargo. Since FCL inspections are targeted at "high risk" consignments, the proportion of "low risk" packaging types in all imports is probably higher than 8.2%. If 15% of "high risk" cargo is packed in "low risk" packaging, then about 1 346 000 tonnes (22%) of cargo imported annually would be classified "high risk".

TABLE 7–Cargo types with predicted contamination rates of 20% or greater, packed in cases, crates, "others", pallets, or skids

| Goods | Africa (%) | Central Asia (%) | Europe (%) | North America (%) | North Asia (%) | South-east Asia (%) | Unknown (%) |
|---|---|---|---|---|---|---|---|
| Chemicals | 27.5–27.5 | | | | 20.3–20.3 | | |
| Food | 29.7–42.4 | 20.5–31.0 | | | 22.0–33.0 | | 21.9–21.9 |
| General goods | 31.4–44.4 | 21.9–32.9 | | | 23.5–34.9 | 20.8–20.8 | 23.4–23.4 |
| Glass | 27.2–27.2 | | | | 20.0–20.0 | | |
| Machinery | 27.2–39.5 | 28.5–28.5 | | | 20.1–30.4 | | 20.0–20.0 |
| Personal | 27.0–39.3 | 28.3–28.3 | | | 20.8–30.2 | | |
| Sawn timber | 20.7–52.5 | 27.9–40.3 | 21.8–21.8 | | 29.8–42.5 | 26.6–26.6 | 20.4–29.7 |
| Stone | 25.2–58.8 | 33.4–46.6 | 26.5–26.5 | 21.0–26.5 | 35.4–48.9 | 21.2–31.9 | 23.8–35.3 |
| Textiles | 20.9–31.5 | 21.9–21.9 | | | 23.6–23.6 | | |

Approximately 400 000 tonnes of break bulk, 410 000 tonnes of LCL cargo, and 660 000 tonnes of FCL cargo (1 470 000 tonnes total) were inspected in 1996 (K. Glassey, pers. comm.).

## FCL Follow-up Study

Inspection findings are presented in Table 9. Of the 501 containers examined, 191 (38%) contained insects, insect damage, bark, fungi, or some combination of the four. Door inspections identified 115 (23%) contaminated containers; an additional 76 (15%) containers cleared during the door inspections were found to be contaminated during follow-up inspections, and of these 23 (4.6%) required quarantine treatment.

Quarantine interceptions were most common for stone and slate, machinery, and general goods. Cargo packed in crates and cases contained significantly more prohibited material than pallets. Cargo originating in Central Asia had significantly more intercepted material than any other region. Australian and European cargo was the least contaminated.

Bark was the most common interception followed by insect damage, live insects, and fungi (Table 10), the same ranking being found in both the LCL and FCL studies. In some containers two or more types of contamination were found—for instance, bark and insect damage; therefore the totals in Table 10 differ from those stated previously. The frequency of types of contamination was similar for door and follow-up inspections.

The great majority (81%) of contamination found during the door inspections was of such significance that treatment was carried out, whereas of the 76 contaminated containers missed during the door inspections (Table 11) only 23 (30%) of contaminated containers found during the follow-up inspections warranted treatment. Over 40% of the contaminated containers found during the follow-up inspections had trace contamination (i.e., a small amount of bark or damage), whereas 10% of the contaminated containers found during the door inspections had such damage.

Out of the 501 containers inspected, 116 had contaminants that warranted quarantine treatment. Door inspections found 93 (80%) of these contaminants; the remaining 23 (20%) were not detected.

TABLE 8–Imports to New Zealand November 1995–October 1996 by gross weight (tonnes) and percentage of total. Bulk cargo is excluded.

| Goods | Africa | Australia | Central Asia | Europe | North America | North Asia | Others | South-east Asia | South America | United Kingdom | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Chemicals | 211 048 | 1 245 927 | 3 607 | 184 624 | 517 199 | 285 241 | 211 064 | 658,196 | 18 130 | 25 519 | 3 360 554 |
| | 3.4% | 20.3% | 0.1% | 3.0% | 8.4% | 4.6% | 3.4% | 10.7% | 0.3% | 0.4% | 54.7% |
| Food | 4 084 | 405 220 | 5 043 | 36 888 | 106 001 | 16 270 | 23 826 | 94,948 | 96 870 | 4 611 | 793 761 |
| | 0.1% | 6.6% | 0.1% | 0.6% | 1.7% | 0.3% | 0.4% | 1.5% | 1.6% | 0.1% | 12.9% |
| General | 1 421 | 63 068 | 393 | 65 398 | 51 912 | 288 771 | 30 648 | 14,933 | 536 | 21 800 | 538 880 |
| | 0.0% | 1.0% | 0.0% | 1.1% | 0.8% | 4.7% | 0.5% | 0.2% | 0.0% | 0.4% | 8.8% |
| Glass | 869 | 49 940 | 2 436 | 28 263 | 4 313 | 7 758 | 92 | 18,125 | 2 725 | 4 711 | 119 232 |
| | 0.0% | 0.8% | 0.0% | 0.5% | 0.1% | 0.1% | 0.0% | 0.3% | 0.0% | 0.1% | 1.9% |
| Machinery | 8 | 41 169 | 74 | 18 112 | 4 591 | 7 146 | 0 | 16,819 | 940 | 2 044 | 90 903 |
| | 0.0% | 0.7% | 0.0% | 0.3% | 0.1% | 0.1% | 0.0% | 0.3% | 0.0% | 0.0% | 1.5% |
| Paper | 91 | 13 338 | 115 | 1 991 | 17 429 | 1 146 | 5 385 | 9,876 | 326 | 332 | 50 029 |
| | 0.0% | 0.2% | 0.0% | 0.0% | 0.3% | 0.0% | 0.1% | 0.2% | 0.0% | 0.0% | 0.8% |
| Stone | 29 160 | 144 702 | 11 981 | 109 732 | 150 544 | 228 241 | 2 983 | 107,437 | 15 185 | 45 674 | 845 639 |
| | 0.5% | 2.4% | 0.2% | 1.8% | 2.4% | 3.7% | 0.0% | 1.7% | 0.2% | 0.7% | 13.8% |
| Textiles | 6 784 | 65 647 | 347 | 70 402 | 45 795 | 14 673 | 3 | 18,100 | 9 089 | 13 079 | 243 919 |
| | 0.1% | 1.1% | 0.0% | 1.1% | 0.7% | 0.2% | 0.0% | 0.3% | 0.1% | 0.2% | 4.0% |
| Wood | 1 101 | 21 857 | 16 255 | 6 309 | 8 700 | 28 853 | 821 | 14,301 | 458 | 4 793 | 103 448 |
| | 0.0% | 0.4% | 0.3% | 0.1% | 0.1% | 0.5% | 0.0% | 0.2% | 0.0% | 0.1% | 1.7% |
| Total | 254 566 | 2 050 868 | 40 251 | 521 719 | 906 484 | 878 099 | 274 822 | 952,736 | 144 259 | 122 563 | 6 146 367 |
| | 4.1% | 33.4% | 0.7% | 8.5% | 14.7% | 14.3% | 4.5% | 15.5% | 2.3% | 2.0% | 100.0% |

TABLE 9–Number of containers inspected and the percentage of contamination found during both inspections

| | Number of consignments | Uncontaminated consignments (%) | Contaminated consignments (%) | |
|---|---|---|---|---|
| | | | Door inspections | Follow-up inspections |
| **Region** | | | | |
| Africa | 20 | 60.0 | 20.0 | 20.0 |
| Australia | 73 | 80.8 | 12.3 | 6.9 |
| Central Asia | 44 | 18.2 | 72.7 | 9.1 |
| Europe | 132 | 77.3 | 13.6 | 9.1 |
| North America | 20 | 64.5 | 16.1 | 19.4 |
| North Asia | 99 | 45.5 | 30.3 | 24.2 |
| South America | 6 | 50.0 | 16.7 | 33.3 |
| South-east Asia | 93 | 63.4 | 17.2 | 19.4 |
| Unknown | 3 | 66.7 | 0.0 | 33.3 |
| Total | 501 | 61.9 | 22.9 | 15.2 |
| **Packing type** | | | | |
| Case | 91 | 55.9 | 33.0 | 12.1 |
| Crate | 85 | 41.2 | 43.5 | 15.3 |
| Dunnage | 40 | 67.5 | 20.0 | 12.5 |
| Other | 8 | 87.5 | 0.0 | 12.5 |
| Pallet | 264 | 68.6 | 14.4 | 17.0 |
| Piece | 6 | 83.3 | 16.7 | 0.0 |
| Skid | 7 | 71.4 | 14.3 | 14.3 |
| Total | 501 | 61.9 | 22.9 | 15.2 |
| **Goods type** | | | | |
| Chemical | 17 | 76.5 | 11.8 | 11.7 |
| Food | 11 | 90.9 | 9.1 | 0.0 |
| General | 155 | 66.5 | 17.4 | 16.1 |
| Glass | 52 | 75.0 | 13.5 | 11.5 |
| Machinery | 96 | 56.3 | 25.0 | 18.7 |
| Paper | 50 | 72.0 | 10.0 | 18.0 |
| Sawn Timber | 9 | 66.7 | 22.2 | 11.1 |
| Stone | 100 | 46.0 | 41.0 | 13.0 |
| Textile | 3 | 33.3 | 33.3 | 33.3 |
| Unknown | 8 | 25.0 | 62.5 | 12.5 |
| Total | 501 | 61.9 | 22.9 | 15.2 |

TABLE 10–Type of contamination found during door and follow-up inspections

| | Door | | Follow-up | |
|---|---|---|---|---|
| | No. of containers | Percentage of total | No. of containers | Percentage of total |
| Bark | 72 | 49 | 44 | 49 |
| Fungi | 20 | 13 | 10 | 11 |
| Insect damage | 35 | 24 | 25 | 28 |
| Live insects | 21 | 14 | 11 | 12 |
| Total | 148 | | 90 | |

TABLE 11–Door and follow-up inspection findings from 191 infested containers

| | Trace | Medium | Treated | Total |
|---|---|---|---|---|
| Door inspections | 12 (10.4%) | 10 (8.7%) | 93 (80.9%) | 115 (60.2%) |
| Follow-up inspections | 32 (42.1%) | 21 (27.6%) | 23 (30.3%) | 76 (39.8%) |
| Total | 44 (23.0%) | 31 (16.2%) | 116 (60.7%) | 191 (100.0%) |

Trace = Very small amounts of bark or damage
Medium = Old damage, superficial fungi
Treated = Sufficient bark or damage to warrant treatment, live insects

## DISCUSSION

In general the contamination rates for cargo sampled in the FCL cargo study were similar to those found in the LCL study, although there were some puzzling differences. Glass and paper goods arriving in FCLs had significantly less prohibited material than glass and paper carried in LCLs. Incidence of prohibited material in food and sawn timber was higher in FCLs. Some of the anomalies can be explained by the number of consignments sampled in each category during the LCL study. There were only 16, 55, and 52 LCL consignments of sawn timber, food, and glass, respectively, which could lead to anomalies given the small sample size. The difference in contamination rate between FCL and LCL consignments of paper is unexplained. Cargo packed on skids had the highest incidence of quarantine items in FCLs but ranked fourth in the LCL study; however, only 41 LCL consignments were packed on skids.

Consignments of LCL cargo from South-east Asia, Europe, and the United Kingdom were all ranked higher risk than FCL consignments from those regions—second, third, and fifth highest in the LCL study compared with fourth, fifth, and eighth in the FCL study (disregarding Africa and "Others", which weren't included in the LCL study). Data from the LCL study were received from all major ports, whereas the FCL data were provided by Auckland only. It may be that the type of cargo from Europe and South-east Asia entering Auckland could differ from European and South-east Asian cargo imported via the other ports.

It appears that the difference in interception rates between the LCL (9.1%) and FCL (4.2%) surveys is due to a combination of two factors. Firstly, FCL door inspections do not reveal all contamination—contaminants in 15% of the 501 containers examined in the follow-up study had been missed during door inspections, although when cargo was examined after it was unpacked trace contaminants (for instance small slivers of bark removed with a knife, mould that could be rubbed off the surface of wood) were more likely to be found. Secondly, the severity of contamination was not recorded during the FCL and LCL surveys but it is suspected that all contaminants—regardless of their severity—were recorded during the LCL survey and only those contaminants warranting quarantine treatment were recorded during the FCL survey. It is important to note that not all contamination is subjected to quarantine treatment (fumigation, burning, or burial). Surface moulds, thin slivers of bark able to be removed by a knife, and old insect engravings could be considered contamination, but would not be treated. Insect damage (borer holes and frass), live insects, wood with large pieces of bark attached, and fungal contamination causing wood decay would warrant treatment.

Most containerised cargo entering New Zealand has a very low risk of containing material which poses a threat to forestry interests. Of imported cargo, 22% by weight (1 346 000 tonnes) is identified as "high risk", as defined by goods type, packaging, and origin. Approximately 1 470 000 tonnes were inspected in 1996. The policy of inspecting all "high risk" cargo, and a sample of other cargo, and mandatory fumigation of selected goods (for instance, park benches and cable drums from China and used railway sleepers from Australia—K. Glassey, pers. comm.) appeared to be effective, but there is little margin for error.

The high interception rate found in the follow-up study (23% of all containers door-inspected had some type of contamination and 38% had been found to be contaminated after both inspections were completed) is a result of the policy of selecting only those containers considered extreme "high risk" for scrutiny. Quarantine interceptions from each goods and package type, and region of origin conformed with the previous LCL study (Bulman 1992). In both the follow-up and LCL studies, interceptions were most common for stone and slate, machinery, and unknown goods, and fewest for food and chemicals. Paper had the third highest interception rate in the LCL study but had a very low rate in this study. Most of the containers carrying paper in this study came from Australia or Europe, which probably accounts for the low rate. Crates and cases had the highest interception rates in both studies, as did cargo originating in Central Asia (India, Pakistan, or Sri Lanka).

The data in Table 9 reveal a high rate of contaminated containers missed during door inspections. Of the 501 containers examined, 115 (23%) were identified during door inspections as having some type of contamination, but a further 76 of the 386 let through (20% of the containers cleared) were found to be contaminated to varying degrees when examined at their final destination. However, the high percentage of contaminated containers missed during the door inspection is not as significant as the data suggest because most of the contaminants missed were of little importance. Of the 116 containers with contamination warranting treatment, 80% were discovered during door inspections. It appears that door inspections will reveal a high percentage of infestations of live insects, significant insect damage, or large quantities of bark. Nevertheless, 11 containers infested with live insects slipped through the door inspections without detection, along with another 12 containers having other contaminants requiring treatment.

Forestry quarantine inspection of containerised cargo concentrates almost solely on wood- and bark-boring insects and certain fungi. From 1989 to 1998, approximately 90% of the insects and fungi newly recorded as affecting trees or woody shrubs were organisms that were unlikely to have been introduced via wooden packaging used in FCLs and LCLs (unpubl. data). Obviously, there are other important pathways by which organisms of forestry significance are being introduced into the country—for instance, used imported vehicles and machinery, the external surfaces of containers, and air cargo (which is likely to contain live plant material). These pathways need to be identified and analysed, and appropriate quarantine measures instituted in order to achieve a significant reduction in the numbers of successful establishments of exotic organisms.

## CONCLUSION

The difference in contamination rates found during the LCL and FCL studies is mainly a result of differing interpretations of what constitutes "contamination". In the LCL study,

all contaminants were recorded, regardless of their severity, whereas during the FCL study only those consignments stopped for quarantine treatment (fumigation, burning, or burial) were recorded as contaminated. The follow-up study showed that door inspections do not detect all contaminants. During door inspections almost 40% of all contaminants present were missed, but 80% of the high quarantine risk contaminants were detected. These data suggest that the present policy of inspecting FCL cargo on the wharf through the open door is adequate, but discoveries of exotic organisms present in wooden packaging would be increased if a sample of extreme "high risk" FCLs were followed to their final destination and their cargo inspected as it was unpacked. To establish if such follow-up inspections are cost-effective, much work needs to be undertaken to determine the number of extreme "high risk" containers imported annually, the average cost of follow-up inspections, the potential value loss associated with, and the likelihood of, the establishment of wood- and bark-boring insects in forests or timber. Until these studies are completed it would be premature to recommend changes in current quarantine inspection procedures.

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## REFERENCES

BULMAN, L. S. 1992: Forestry quarantine risk of cargo imported into New Zealand. *New Zealand Journal of Forestry Science 22(1)*: 32–38.

GENSTAT 5 1990: Lawes Agricultural Trust (Rothamsted Experimental Station), United Kingdom.

McCULLAGH, P.; NELDER, J.A. 1989: "Generalized Linear Models". 2nd ed. Chapman and Hall. 511 p.

MINISTRY OF FORESTRY 1994: Annual Report 1994. Wellington, New Zealand.