INFORMATION FROM THE CAREFUL EVALUATION OF PACKINGLINE CULLS

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Logic would suggest to us that knowing the cause of fruit injury is the first step in correcting the problem. It also seems to follow good logic that injured fruit that gets to the packinghouse exposes the weaknesses of pest and horticultural management programs. It would then seem to follow that fruit cullage assessments performed in the packinghouse represent valuable information for the grower in planning orchard management programs. However, it has been our experience, and one related to us by many in the industry, that cullage assessment reports received by growers from their packinghouses are not of great value. Why is this the case?

It seems that most packinghouses provide good reports on the size and grade standards of a grower's fruit, but cullage assessments are viewed with suspicion. A review of some cullage assessment recording and reporting forms used by packinghouses sheds some light on the issue. There is no uniform recording or reporting form used by packinghouses. Categories or factors used to identify fruit defects making them culls are often too general for the grower to use in planning a good management program. There are few well-trained personnel in the industry who are dedicated to the process of cullage evaluations. And finally, there are not good aids or training materials available to assist in upgrading cullage assessment systems.

Information can be good or bad but is rarely neutral. An example of how information from a cullage assessment report can seem to be of value but is really misleading is shown by the following not-too-hypothetical example. A grower receives a cullage report from his packinghouse indicating that a high proportion of his culled fruit was attributed to bitter pit. The natural response would be to increase the number of calcium applications the next season and control crop load and tree vigor to reduce the incidence of this physiological disorder. The grower implements an aggressive program to reduce bitter pit, but the cullage report from that year's crop shows even more bitter pit. The following season the grower again follows an aggressive calcium application program and strives to manage tree vigor and crop load. Again his cullage report shows a high incidence of bitter pit. What is the problem? It was not the grower's practice but a misidentification of the cause of cullage. Instead of bitter pit the fruit injury was caused by stink bug feeding, which to the untrained eye looks very much like bitter pit. This example shows the power that misinformation in a cullage report can have on a grower's management efforts.

In 2002 the Washington Tree Fruit Research Commission funded a two-year project on cullage assessment. The objectives were to develop a statistically valid sampling protocol for culled fruit that could be used to identify a key defect factor such as codling moth injury and to develop a standardized form for cull defect recording that could be used by the fruit industry. One of the first things we did was to conduct some preliminary sampling of cullage and generate reports that could be compared to those generated by the packinghouse for the same lot of fruit. By

comparing the results of the two assessments we learned several things. First, the defect categories resulting in cullage were not usually the same, but we were able to make some comparisons of defects for the most important factors. Second, the results were similar for some defects but quite different for others (Figure 1). What were the reasons for the differences? An obvious source of discrepancy would be differences in the two people making determination of what caused the fruit to be culled. However, another difference was probably more important. Most all cullage assessment activities in packinghouses record only one defect per fruit, usually the most obvious or the one the assessor is most sure about. Our cullage assessment took into account every defect, including multiple defects on the same fruit.
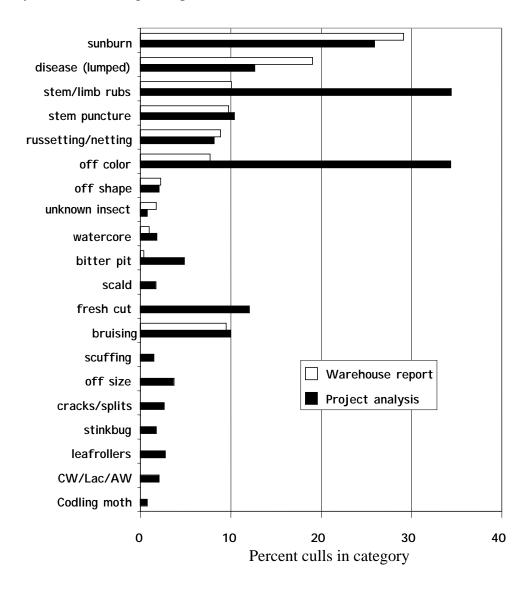

Figure 1. Percentage of culled fruit in defect categories based on assessments by the packinghouse personnel or research project personnel.

What did we discover? For most lots of fruit we sampled, the percentage of fruit with only one defect per fruit was between 40 and 60%. It was common to find two or more defects on the same fruit, as shown in Figure 2. If these defects are ignored in the cullage assessment activity then a large proportion of valuable information about the causes of fruit cullage will not be recorded.
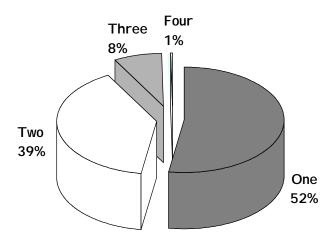

Figure 2. Percentage of fruit with one, two, three or four defects per fruit from one cullage assessment report.

We divided cullage defects into the following five main categories: insect injury defects, disease related defects, horticultural related defects, harvest related defects and storage related defects. The percentage of defects within each major category varies with fruit lot, but generally horticulture defects ("Field" in Figure 3) dominate. Within each main category we identified specific defects that can be identified. These defects within each main category are listed in Table 1. We would appreciate feedback from the industry on these categories and would like to reach an agreement within the industry on which defects to include in a uniform list and what to call each defect. Please contact Wendy Jones by e-mail (wendyej@wsu.edu) or by FAX (509-662-8714) and provide input on this listing and how it compares with the one your packinghouse is currently using.
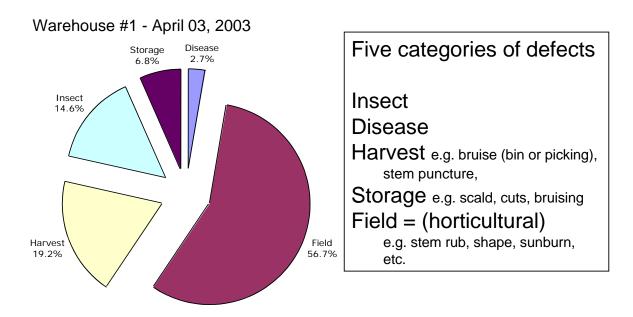
Warehouse #1 - April 03, 2003

Five categories of defects

Insect
Disease
Harvest e.g. bruise (bin or picking), stem puncture,
Storage e.g. scald, cuts, bruising
Field = (horticultural)
e.g. stem rub, shape, sunburn, etc.

Figure 3. Percentage of culls in defect categories from a lot of apple fruit sampled in April 2003.

Table 1. Major categories and specific defects within each category used in assessing apple cullage.

Insect	Hort/Field	Harvest	Disease	Packinghouse
aphids	bird pecks	bin bruise	spongy rot	fresh cut
campylomma	bitter pit	cuts	bull's eye	line bruise
codling moth	cracks/splits	over-ripe	blue mold	line puncture
CW/Lac/AW	other defects	pick bruise	grey mold	chemical burn
leafroller	limb/stem rub	stem pull	Mucor	storage scald
lygus	under color	stem puncture	scab	
mealybugs	off color		other	
scale	off shape			
stink bug	off size			
thrips	frost			
other insect	russeting/net			
	scuffing			
	staining			
	sunburn			
	watercore			

A primary objective of this project is to develop sampling protocols for culls that will provide accurate estimates of the categories that might be identified as critical for certain situations, such as qualifying a lot of fruit for export to a foreign country. It is very important to sample enough

fruit to obtain an accurate estimate of the most critical defect, but it is also important not to over-sample because this results in the inefficient use of valuable resources. We asked questions such as how many total fruits should be sampled from culled fruit from a grower lot? Can one sample be taken or should multiple subsamples be taken? And how many subsamples need to be taken to obtain an accurate estimate of the defect of interest? Based on our data and something that is known as a principle in statistics is that we can reduce error in our estimate of a defect level by taking more samples of smaller numbers of fruit. For example, if you are going to sample 100 fruits from a lot of culled fruit it is better to take 10 samples of 10 fruits than to take two samples of 50 fruits each. It is likely that few packinghouses follow this kind of sampling protocol when selecting fruit from culls to score defects.

In the future a packinghouse will most likely want to sample culls for a specific defect, one that will be important for improving pest control programs or whether a lot of fruit would qualify for export to a particular country. For example, the concern about shipping fruit with codling moth larvae to China is critical for Washington's fruit industry. If a protocol with China is established that includes cullage sampling for codling moth-injured fruit, it will be important to know how best to sample culls and only put as much energy into this activity as is needed in order to use resources efficiently. If a protocol for export to China is established it will include a fixed level of injury of culls that will be acceptable or that, if exceeded, will stimulate a further sampling, possibly of packed fruit, which could be very expensive. If a specific level of defect is established, such as 5% of culled fruit with codling moth injury, it is possible to recommend a sequential sampling program. A sequential sampling program requires that a minimum sized sample be taken and results assessed. Further samples are taken only if the upper or lower threshold lines are not crossed. An example of a sequential sampling activity that might be conducted for codling moth injury in culls is shown in Figure 4. Here the minimum sample size is 10 samples of five fruits each, or 50 total fruits. The "x" shows the number of defects found following this sample. It lies between the two solid lines, which represent an upper and lower threshold, so more samples need to be taken. After each sample is taken, that is each five-fruit sample unit, the total (accumulated) number of defects is plotted. If the number of defects remains between the two threshold lines sampling continues until some upper level is reached. If the sample line crosses the upper threshold, shown in Figure 4 by the dotted line, then sampling is stopped and in this case the decision is that there are too many fruits injured by codling moth to qualify the fruit lot for export to China. In the second example sampling is stopped sooner and after the lower threshold is crossed, which would result in a decision that the lot of fruit had levels of injury below that required by the export protocol so the fruit lot would qualify for export.

Sequential sampling stop line
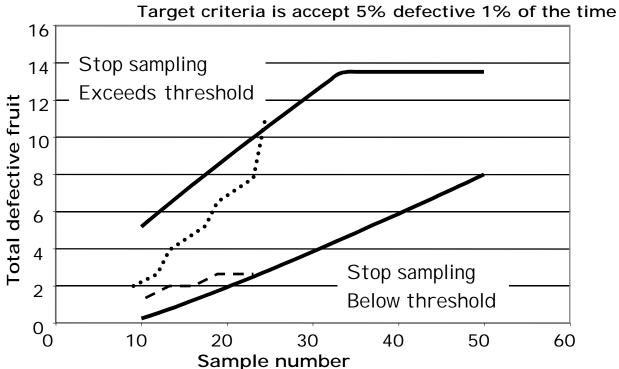### Target criteria is accept 5% defective 1% of the time

Figure 4. Example of a sequential sampling activity based on detecting a cullage factor with a threshold of 5%, such as codling moth damage, at least 1% of the time. Dotted lines show the sampling progress until results cross one of the stop lines.

In the future automated defect sorting, even of internal injury, will most likely become a reality. However, it is unlikely that these defect sorters will be able to differentiate between kinds of injury and the related causes. Therefore, some kind of cullage assessment will still likely be required, especially as foreign markets require more and more evidence of pest-free fruit, and trained personnel using efficient sampling protocols will be needed to carry out these activities. This project can provide the Washington fruit industry with a process and data collection system that would assure foreign markets that we are following statistically valid sampling protocols for assessing factors resulting in culled fruit. We are also gathering many digital photos of the kinds of fruit defects found on different apple varieties. These images could form the basis of defect identification aids and training materials for those conducting cullage assessments. We encourage anyone interested in cooperating on this project to contact any of the authors of this article.