UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MONTANA
BILLINGS DIVISION

RANCHERS CATTLEMEN ACTION LEGAL FUND UNITED STOCKGROWERS OF AMERICA, Plaintiff, v. UNITED STATES DEPARTMENT OF AGRICULTURE, ANIMAL AND PLANT HEALTH INSPECTION SERVICE, et al., Defendants	Cause No.CV-05-06-BLG-RFC

SECOND DECLARATION OF LOUIS ANTHONY COX, JR., PH.D IN SUPPORT OF MOTION FOR SUMMARY JUDGMENT

Louis Anthony Cox, Jr., Ph.D. certifies and states as follows:

1. This declaration responds to various comments and critiques that USDA's experts have made of my previous comments on the BSE risk to the United States that would be created by resuming beef imports from Canada. It seems to me that we generally agree about many points, including that the risk is greater than zero; that zero risk is not realistic (at least if imports are allowed); that it is important to consider heterogeneity, that the safety of a whole system of protective measures can be greater than the safety of its individual components, that young cattle usually pose less risk than old cattle, that species barriers probably exist (but are of uncertain magnitude), that exposure assessments and dose-response relations for the probability of vCJD following exposure to BSE prions in meat are uncertain but that human health risks are probably

smaller than was originally predicted at the outset of vCJD discovery that the incidence of vCJD in the UK may have peaked (at least for now), that extrapolating European data and experience to Canada is uncertain (but that relevant Canadian data are missing), and that multiple countermeasures are in place in both the United States and Canada that are intended to reduce BSE risks. Any perceptions that I disagree with these points are mistaken. (I do recognize that perhaps USDA does *not* even acknowledge that importing cattle from Canada creates a non-zero increased risk of introducing BSE into the United States. For example, page 1 of USDA's Motion for Summary Judgment and Paragraph 4, page 2 of Dr. Clifford's declaration both suggest that at least some people within USDA still believe that rules, regulations, and existing measures somehow "preclude" increased risks of introducing BSE into the United States, recent history notwithstanding. However, others of USDA's experts do seem to recognize that importing cattle from BSE-affected countries is not risk-free.)

2. On the other hand, I believe that we differ on some important points, especially about what constitutes adequate risk assessment and responsible risk management given present uncertainties and recent history; the need for quantitative assessment to inform rational risk management decision-making; the likely trustworthiness of "accumulated wisdom" (USDA's term) as a basis for predicting and managing BSE risks; the need to use clearly defined terms (with their usual, generally understood meanings) in stating risk estimates; the appropriate use and limitations of quantitative risk assessment methods and models (including the role of Poisson probability models); the statistical near-certainty that a generally highly reliable system of overlapping protective measures will

fail occasionally if given sufficiently many opportunities (e.g., millions of cattle being processed through it), and other technical points.

3. I believe that a sound risk management policy for the United States should leave no doubts about the answers to the following basic questions:

- Is there *any* level of BSE prevalence among Canadian cattle that would be unacceptable to the United States and that would make resuming imports of Canadian cattle unacceptable? If so, what is that level?
- Given the available data (e.g., 4 BSE-positive cattle of Canadian origin among many fewer than 100,000 Canadian cattle ever tested), *how likely* is it that the BSE prevalence among Canadian cattle that would be imported to the United States (if imports were resumed) would be unacceptably high? *How much confidence* can we have that the prevalence rate would be (and would remain) acceptably small?

I have not found clear answers to these questions in the USDA documents I have read. Nor do I believe that qualitative judgments about risk (e.g., that it is "very small") can provide useful answers to these basic questions. However, based on Canada's own experience and estimates, it seems to me that an estimated three BSE-positive cattle (www.inspection.gc.ca/english/sci/ahra/bseris/bserisc1e.shtml) imported into Canada from BSE-infected countries may have been responsible, years later, for a cluster of new BSE-positive cattle of Canadian origin (of which four have been detected so far.) Assuming that USDA would consider it unacceptable to create a similar situation in the United States by importing BSE-positive Canadian cattle, and that a realistic policy goal is therefore to be highly confident that no more than three BSE-positive cattle will be

imported into the United States over some reasonable amount of time, such as the next five years, I believe that the available data provide a useful basis for putting quantitative bounds on the answers to these questions.

4. Specifically, if the current prevalence rate of detected BSE cases among tested Canadian cattle is only 4 in 100,000 (smaller than the current historical rate) and if the prevalence rate among untested cattle is about $1/20^{th}$ as great (based on European experience), then the prevalence rate among untested cattle would be about (4/100,000) x (1/20) = 2 per million. This is the estimated prevalence rate based on *detected* cases. Of course, the true prevalence rate of BSE prion-contaminated cattle among imported cattle may be higher (e.g., because not all cases are detected, and, indeed, prion contamination in younger animals is currently often undetectable). It might be lower to the extent that only younger animals are imported, with prevalence rates of BSE prion contamination less than in the general herd. (However, since all older animals with BSE were first younger animals with BSE, and since BSE infection is generally thought to occur during an animal's youth, usually during its first year, the prevalence of undetected prion contamination among animals that would be imported is not necessarily smaller than 2 per million and could be larger.) Using 2 per million for purposes of a baseline calculation, it is statistically almost certain (greater than 99% probability) that, at this rate, at least three BSE-positive cattle will be imported into the United States among the first few million cattle imported – presumably within the next few years. (This calculation does *not* require or depend on the assumption of a Poisson process.) This calculation suggests that it is far from certain that the risk of violating specific policy goals will be "negligible", "very small", "minimal", "almost zero", or any of the other qualitative

characterizations that USDA and its experts have used to express their personal convictions that nothing bad is likely to happen to US cattle and citizens as a result of resuming imports. To the contrary, the base case calculation suggests that there may be a greater than 99% probability of exceeding an acceptable level. Until USDA provides a clear statement of what level would be acceptable and until Canada provides data from which to estimate the prevalence of BSE among untested cattle that would be imported into the United States, the preceding calculations are admittedly driven by uncertain assumptions. (However, as discussed in my May 7th declaration, p. 25, the main conclusion, that the quantitative probability of importing BSE cases is *not* low and may well be close to 100%, is robust to several key uncertainties.) Such calculations suffice to show that qualitative assurances that there is not an unacceptable risk here may well be mistaken. USDA has not provided any quantitative demonstration, backed by publicly available data and published models and calculations, that the risks of introducing BSE in Canadian cattle into the United States if imports are resumed are small or acceptable in any usual sense… or even that they are not, in fact, many times larger than other health risks widely regarded as unacceptable.

5. In light of the limited data available from Canada, I believe that rational risk management decisions about BSE risks and Canadian cattle imports can only be based on a *demonstrated safety record* of acceptably low BSE prevalence rates in an adequately large sample of Canadian cattle. That is, before resuming imports can be rationally justified, there should be a clearly stated quantitative criterion for what constitutes an acceptable (to the United States) prevalence rate of BSE among Canadian cattle [e.g., "fewer than 1 BSE case detected per *x* hundred thousand consecutive Canadian cattle

inspected". Here, *x* is a number (perhaps in the range from 2 to 20, based on 2005 OIE Terrestrial Animal Health Code Tables 1 and 2 of Article 3.8.4.4) set statistically based on how much risk is acceptable to the United States]. There should also be a clear record showing that this criterion is satisfied with high statistical confidence. In my opinion, we are not there yet.

6. Approaches to BSE risk management based on *reasonable-looking hopes and projections,* including resuming imports when selected experts and decision-makers (e.g., at USDA and in Canada) have satisfied themselves that well-intended safeguards will probably work well enough in the future to keep risks to cattle and people in the United States acceptably small, appear to me to be untrustworthy. There is a well-known history of confidence and repeated optimistic assurances from agencies in multiple countries (including the United States and Canada) that have been followed by the unpleasant reality that BSE has in fact spread. It seems to me that BSE risk management approaches based on reasonable-appearing hopes and on the high confidence of agencies have repeatedly failed. What works is to *show that current risks are low,* and that current practices are working, not to *predict* that future practices will work and that future risks will be low. (Thus, for example, the Canadian Food Inspection Agency in 2002 and 2003, immediately before the empirical discovery of BSE in Canada, stated based on predictive modeling and assumptions and reasoning noticeably similar to USDA's current ones in this case (http://www.inspection.gc.ca/english/sci/ahra/bseris/bserise.shtml) that "*… the likelihood of establishment of BSE in Canada was negligible*. *The risk was even further reduced by the mitigating measures in place since 1997.* In conclusion, *the measures applied* prior to the 1997 Feed Ban (import policies, disease control measures,

detection system on-farm and at slaughter plants) combined with Canadian feed production and feeding practices, *were effective in preventing the entry of BSE* and its subsequent amplification through the feed system." (Emphases added.) Shortly after these confident predictions and sweeping reassurances that risks were "negligible" and that Canada's multiple risk-reducing measures were successful in "preventing the entry of BSE", it turned out that BSE had in fact entered Canada. The probability turned out empirically to be 100%, not close to zero, as the confident statements based on theoretical predictions had suggested. Other countries have also had histories of confident regulatory statements that BSE risks following imports from BSE-affected countries are small, low, negligible, near zero, etc. – followed by the discovery that BSE has in fact spread to the importing countries. It would be gratifying if the United States could avoid this pattern.

In short, I believe that a decision to resume imports should be based only on an empirical (quality-control type, data-based) demonstration that BSE prevalence rates among cattle that would be imported are *already acceptably low* with high confidence. If this principle is accepted, then quantitative risk assessment becomes important for deciding what prevalence rates among inspected cattle (and what sample sizes) should be considered acceptable. As demonstrated above, the currently observed rate of 4 confirmed BSE cases out of fewer than 100,000 Canadian cattle tested is not reassuring that importing Canadian cattle under current conditions imposes a small or negligible risk to the United States.

7. Theoretical statistical arguments by USDA and its experts that it will be hundreds or thousands of years before the first BSE-positive case is expected to cross the border, or that "we should expect to import one BSE-positive animal every 7 to 110 centuries" (Stark declaration, paragraph 53, p. 12) should be tempered by the reality that *the first detected case of a BSE-positive cow imported into the United States from Canada has already occurred* (in Washington State in 2003.) Before seeking to "correct" my model to produce such reassuring but unrealistic predictions, I believe that USDA and its experts should carefully consider what has actually occurred in the real world and seek to use input assumptions and values that are consistent with recent experience rather than with hopes and intents for the future. Now, a new round of well-intended countermeasures has been put in place, and USDA and Canada are again confident that they will prove effective. Yet, their empirical effectiveness remains to be seen. Meanwhile, prudence requires basing risk management decisions on actual measurements of what is happening now, rather than on optimistic projections of what is theoretically expected to happen in the future if all systems work as intended. Until enough sampling data have been accumulated to show with high confidence that the BSE prevalence rate among Canadian cattle is *already acceptably low* (according to some explicit, well-defined, publicly stated criterion), I believe that it would be irresponsible and would violate precepts of sound and rational risk management to re-open the border based on projections that BSE rates in the near future will be significantly less than they have been in the very recent (January, 2005) past, or based on theoretical predictions that few BSE-contaminated cattle will be imported or that it will not matter much if they are.

8. USDA has found an expert in inverse problems arising in seismology, Dr. Stark, who considers USDA's approach to BSE health risk assessment (essentially, saying "We think it's low") to be a reasonable and appropriate approach, and who believes that my assumptions, models, and conclusions are flawed. Perhaps predictably, I find so many technical errors and misconceptions about sound health risk analysis modeling in Dr. Stark's analysis that I will simply list my responses to some of the main ones briefly, rather than attempting a full response and explanation for all.

9. *"Few risks are exactly zero"* (Stark, p. 1). My main concern is *not* that the BSE risks to the US from importing Canadian cattle are not "exactly zero", but rather that they may well be unacceptably large.

10. While it may be true, as Dr. Stark points out, that "few risks are exactly zero" for natural disasters such as floods, wildfires, and earthquakes, it is not true that few *health risks* created by human actions are exactly zero. Indeed, the risk of an adverse effect being caused by a particular source of risk (i.e., hazard) is zero whenever exposure to that hazard is zero. Unlike Dr. Stark's seismic risks, the risk to the United States of importing BSE in cattle from Canada can easily be kept at exactly zero by not importing Canadian cattle. More generally, the quantitative risks of importing BSE-positive cattle from Canada can be kept as small as desired by not importing Canadian cattle unless and until the prevalence of BSE among Canadian cattle has been shown (by adequate sampling) to have dropped to acceptable levels (and to have stayed there for an appreciable amount of time.)

11. Risk of BSE from imported Canadian cattle is not an act of God that we must learn to live with, but a risk that we can *choose* whether and under what conditions to

accept. Thus, the apparent implicit suggestion in Dr. Stark's first paragraph that BSE in imported Canadian cattle is just another one of life's many risks, along with risks from earthquakes, floods, or wild fire, that we must simply learn to live with as best we can, is altogether inappropriate. It is a risk that we can choose to live with or without. (Indeed, students of health risk analysis are commonly warned to avoid making such facile comparisons between voluntary and involuntary risks.) In this context, rational deliberation based on explicit models and data analysis should be used to decide whether to accept the risk. The risk should not simply be portrayed as if it were an uncontrollable force of nature that the government can only seek to reduce but not eliminate

12. USDA and R-CALF might agree that resuming imports of cattle from Canada at this time would create a *non-zero risk* of importing BSE into the United States. (The significance of this is *not* that incremental risk necessarily should be zero for an action to be acceptable – a generalization that I do not endorse. Rather, it is that there is some risk to be further assessed.) However, it is not clear to me from their statements and press releases whether USDA does acknowledge that there is a non-zero risk of BSE to the United States if imports from Canada are resumed. For example, Paragraph 4, p. 2 of Dr. Clifford's declaration begins "To preclude the introduction of BSE into the United States while resuming imports of Canadian cattle and beef, APHIS has proceeded in measured, incremental steps…." If "preclude" here is used with its normal meaning of "make impossible," then Dr, Clifford's statement suggests that USDA has found a way to make the introduction of BSE into the United States impossible (i.e., to make the risk zero) while resuming imports of Canadian cattle and beef. I believe that such an implication of zero risk is highly inaccurate and misleading. But it seems consistent with many of

USDA's public statements, which appear to deny that there is a significant risk to the United States of BSE and/or to suggest that USDA is confident that it knows how to prevent such risks. For example, as recently as June 9, 2005, Dr. Barbara Masters of USDA concluded her remarks on BSE health risks as follows: "Together, we must continue to rely on science-based solutions to prevent BSE from affecting animal and public health."

http://www.usda.gov/wps/portal/!ut/p/_s.7_0_A/7_0_1OB/.cmd/ad/.ar/sa.retrievecontent/.c/6_2_1UH/.ce/7_2_5JM/.p/5_2_4TQ/.d/0/_th/J_2_9D/_s.7_0_A/7_0_1OB?PC_7_2_5JM_contentid=2005%2F06%2F0203.xml But such statements do not acknowledge that policies and science-based solutions do *not* "prevent BSE from affecting animal and public health". In Dr. Stark's phrase, they "only reduce but do not eliminate risk of foodborne disease". Thus, while Dr. Stark may acknowledge that risks are non-zero, it is not clear to me whether USDA does, at least in its messages to the public. Statements by USDA experts in this case, such as that *"Extensive scientific evidence categorically demonstrates that there is no measurable increased risk to human health or animal health created by the Final Rule"* (USDA, page 6, quoting Dr. Hueston's declaration) contribute to an impression that USDA and its experts may not fully acknowledge that there is a non-zero risk (and possibly a very significant one) to US consumers and cattle from resuming imports at this time. If we agree that the risk to the US from resuming imports *is* indeed non-zero, then the key questions remaining to be addressed are: (a) How large is it? and (b) Is it small enough to be acceptable, i.e., is the public interest better served by accepting or rejecting this particular risk?

13. *"Identifying a risk as low, without further quantification, is reasonable in many situations - because assigning a numerical value may require unreasonable*

assumptions." (Stark, paragraph 4, p. 1). *Response:* This argument is logically fallacious on its face. Even if it were true that assigning a numerical value required unreasonable assumptions, this would not necessarily make it reasonable to state that the risk is low, in any given situation. It also begs the question of what is meant by a "low" risk. (Does USDA consider a 99% probability of importing multiple BSE-positive cattle in the next few years "low"? Does Japan consider it "low"? Does the public? How about a 1% probability? There is simply no way to know what "low" means to USDA and its experts in the absence of a clear, preferably quantitative, definition.) Finally, acting *without* considering numerical risks may itself amount to making an "unreasonable assumption" that the risk is small enough to be ignored or accepted.

14. Dr. Stark's expressed concern that "assigning a numerical value may require unreasonable assumptions" appears to rest on an important misunderstanding of how quantitative health risk assessment works. This concern is addressed in quantitative risk analysis by using bounds and uncertainty and sensitivity analyses to avoid relying on unreasonable assumptions. Thus, risk analysts typically do *not* "assign a numerical value" to such uncertain risks when doing so would require unreasonable assumptions. Instead, we use ranges, bounds, distributions, and uncertainty and sensitivity analyses to discover what conclusions can about drawn that are robust to uncertainties in the assumptions.

15. Much of Dr. Stark's critique of my work and much of USDA's Motion for Summary Judgment dated June 10th, 2005, appear to be based on this mistaken understanding of health risk assessment and of what I have done. For example, as mentioned in my May 7th Declaration (p. 25), my major conclusion that the probability of

importing multiple BSE-positive cattle from Canada in the next few years may be close to 1, given what we know now, is *robust* to (unaffected by) many uncertainties about exactly what the current prevalence rate of BSE in Canada is, how effective current and future mitigation measures will eventually prove to be, the number and location of potential "hot spots" of high BSE risk in the United States and Canada, other aspects of heterogeneity in BSE risks, the use of Poisson models (which Dr. Stark and USDA seem to me to completely misunderstand), and so forth.

16. Rather, the conclusion that the probability of importing multiple BSE-positive cattle from Canada in the next few years is close to 1 follows under a broad range of *alternative* models and assumptions, as long as those models and assumptions reflect current reality: that BSE cases have recently been found in Canada, that one detected case has already crossed the border, that older animals with BSE typically begin as younger animals with BSE (perhaps at undetectable levels), and so forth.

17. Thus, while Dr. Stark and USDA spend pages arguing that I have used "incorrect" numbers, they miss the point, clearly stated on page 23 of my May 7th Declaration, that the example numbers that I used are intended to provide "a rough order-of-magnitude estimate (sufficient for quantitative risk estimation, as discussed below)," not an exactly "correct" number. My main point is that the risk appears to be close to 1, not close to 0.

18. Exactly *how* close to 1 the risk is – whether the "correct" number should be 99.7%, 99.9%, or some other such number – does indeed depend on using "correct" (but currently unknown, in my opinion) numbers. (I strongly question whether USDA or its experts really know the "correct" numbers. This posture seems to me to be only an attempt to suggest, mistakenly, that correct conclusions about risk can only follow if

exactly correct input numbers are used.) But the conclusion that the probability may well be close to 1 (e.g., greater than 99%) rather than close to zero does *not* depend on using (or knowing) the exactly "correct" numbers. Indeed, for a very wide class of uncertain systems, the probability that an undesired event will occur is either close to zero or close to one, except over a relatively narrow transition interval between them. (Some mathematical aspects of such results can be found in Friedgut E, Kalai G. Every monotone graph property has a sharp threshold. Proceedings of the American Mathematical Society Volume 124, Number 10, October 1996). For the case of BSE in Canadian cattle, it seems to me that we are likely to be in the "close to 1" rather than in the "close to 0" range (or in the transition interval between them.) This major conclusion is not at all sensitive to (i.e., would not be changed by) most of the various "corrections" suggested by Dr. Stark and by USDA.

19. Similarly, the conclusion that the probability of importing multiple BSE-positive cattle from Canada in the next few years is close to 100% also does *not* depend on choice of a specific model, as Dr. Stark and USDA mistakenly assert (June 10 Motion for Summary Judgment, p. 13.) Specifically, USDA's assertion that "Dr. Cox's risk estimates rest on the assumption that the occurrence of BSE among Canadian cattle can be described by a 'Poisson distribution,' consisting of statistically independent, random events" is entirely incorrect. (Among other things, a Poisson distribution does not consist of events, does not require statistical independence in the sense that USDA appears to mean it, and is not central to my reasoning or conclusions.) My estimate that the risk of importing BSE-positive cattle is close to 1 under a broad range of alternative models and

assumptions is *illustrated* by the simple Poisson-based calculations, but is not *dependent* on them.

20. Dr. Stark opines that *"I believe that the risk from importing Canadian cattle under the new regulations is extremely small. I think it was reasonable for the Secretary to proceed without a numerical value for the risk."* (Stark June 8 declaration, page 1, paragraph 4.) However, Dr. Stark's opinions notwithstanding, the field of risk analysis teaches that, to make rational decisions, a more quantitative approach is essential. (For example, to compare the expected utility from importing Canadian cattle to the expected utility from waiting until better evidence of a low risk is available, it is necessary to at least consider bounds on the probabilities of different outcomes under each alternative.)

21. Dr. Stark's and USDA's expressed faith "that the risk from importing Canadian cattle under the new regulations is extremely small" does not specify what, if anything, this phrase actually means. (Risk of what, exactly? Could 99% be considered extremely small? How about 10%? Or 1%? Or does "extremely small" have the conventional meaning often used in health risk assessment, of less than 1 in a million chance in 70 years? If so, how is this claim justified?) Nor does the simple statement and repetition of vaguely worded personal beliefs provide any rational, explicit basis that could be used by the public, by trading partners, by R-CALF, or by other stakeholders to examine whether the belief is well founded, based on correctly executed calculations from explicitly stated data and models.

22. Dr. Stark is mistaken in stating (paragraph 7, p. 2) that "Dr. Cox claims that among young Canadian cattle, about 6.25 per million are BSE-positive." I do not claim to know what fraction of young Canadian cattle are BSE-positive. (I also do not believe

that USDA knows.) The required surveillance data have simply not been collected by Canada. While USDA extols Canada's surveillance and sampling efforts, and while these efforts may be praiseworthy in some respects, they are far too limited to provide basic useful information such as BSE rates among young cattle. USDA has suggested that it would be a waste of resources to collect such information, but without it, the correct rate will remain unknown and uninformed by relevant data from Canada. Glowing news releases such as "Canada has surpassed its testing target established for 2005 for bovine spongiform encephalopathy (BSE) surveillance. The target for this year was 30,000 cattle and, as of June 17, there have been 32,363 samples collected and tested… The level and design of BSE testing in Canada is in full accordance with the guidelines recommended by the World Organisation for Animal Health (OIE)." should not distract attention from the reality that *a target level of 30,000 cattle is far too small to do anything other than reveal a high prevalence rate* if it is present (on the order of one in ten-thousand among tested cattle, with 95% confidence). This is exactly what Canada's surveillance program has revealed: two cases of BSE have been found among this year's target sample. Thus, although Canada and the USDA continue to praise Canada's surveillance by citing an OIE guideline designed for a different purpose [to help BSE-free countries verify that they remain free (at least from high rates of BSE)], this seems to overlook the key fact that *the Canadian surveillance program has actually detected BSE cases recently (2005).* Interpreting this result as somehow being reassuring, or as or as evidence that BSE rates in Canada are low because OIE testing procedures were followed, is a complete misinterpretation.

23. Dr. Stark is also mistaken in stating (paragraph 8, p. 2) that "Dr. Cox assumes that BSE-positives are as common in younger cattle as in older cattle." I make no such assumption. Instead, I recognize that Canada has refused to follow the common practice in other BSE-affected countries of systematically collecting data on younger cattle as well as on older cattle, thus preventing any quantification of detected BSE rates among younger cattle based on actual Canadian data. Therefore, I have used European data to estimate that detected BSE-positives may be on average roughly at least $1/60^{th}$ (updated in my most recent calculations to about $1/20^{th}$) as common in the general herd as in cattle targeted for inspection (typically, older cattle). While I acknowledge that BSE positives are often not detectable in younger cattle (even when BSE is present), I consider the possibility (p. 16 of my May Declaration) that risk to the US may only arise when *exceptionally infective* imported cattle (whether young or old) reach exceptionally susceptible locations or "hot spots" in the United States. Thus, I find it unnecessary to make any assumptions about whether BSE-positives are as common in younger cattle as in older cattle: they may be significantly less (or more) common without affecting my main conclusions.

24. Dr. Stark is mistaken again in stating (paragraph 9, p. 2) that "*Even if the rate of BSE-positives among older Canadian cattle is 6.25 per million (it is smaller), the rate in younger Canadian cattle should be three thousand times smaller, i.e., 2 per billion. On this basis, Dr. Cox's calculations imply that the first mad cow is expected to cross the border around 2300 AD.*" First, unlike Dr. Stark, I do not believe that we know whether the rate of BSE-positives among older Canadian cattle is smaller than 6.25 per million. I do believe that it is important for prudent risk management decision-making not to

pretend to know more than we really do. One of the things that we do not know is the rate of BSE-positive cases among Canadian cattle that would be imported into the United States, as Canada has not yet implemented a surveillance program to provide that information.

Second, *essentially all older cattle with BSE start off as younger cattle with BSE,* so that Dr. Stark's claim that "the rate in younger Canadian cattle should be three thousand times smaller" than in older animals is not valid. BSE is thought to be acquired by cattle at a young age (e.g., between 6 months and 12 months old), although typically only becoming manifest years later (e.g., Supervie V, Costagliola D., The unrecognised French BSE epidemic. Vet Res. 2004 May-Jun;35(3):349-62.) Dr. Stark here and in many places evidently confuses *observed* rates (based on detected and confirmed cases) with *actual* rates (detected or not). Actual rates are likely to be greater than detected rates, given the limitations of testing and detection, especially among younger cattle. But it is the actual rates, not the observed rates, that can potentially pose a health risk. Dr. Stark's claim (paragraph 8) that "The rate of BSE-positives among younger cattle is about three thousand times smaller than the rate in older cattle" is not valid, as it is based on observed rather than actual rates.

This fundamental confusion between and inappropriate conflation of detected rates and actual rates pervades much of Dr. Stark's Declaration and USDA's Motion for Summary Judgment. Dr. Stark is mistaken in asserting in his paragraph 30 that "By 'BSE-positive cattle,' [Dr. Cox] means cattle with BSE that can be detected by current surveillance and testing procedures; he does not mean cattle infected with BSE. I follow [this] usage throughout this document." In fact, by "BSE-positive", I generally *do* mean

"infected with BSE." I tried to make this distinction between actual and detected rates of BSE-positives clear and explicit – for example, by explicitly stating at the bottom of page 24 of my May 7 Declaration that "…the 6.25 per million rate was based only on *detected* cases (see Table 2), and thus omits all BSE loads carried at sub-clinical, non-detectable (but not necessarily non-infectious) levels". However, Dr. Stark evidently misunderstood my attempted distinction, and this fundamental misunderstanding runs through and invalidated many of the technical points he attempts to make.

Unfortunately, USDA uncritically accepted and incorporated Dr. Stark's technical analysis (errors, misunderstandings, and all) in their Motion for Summary Judgment, so that many of their points are infected by his misunderstandings and by the fundamental error of conflating detected with actual BSE-positives. In reality, the detected rate will in general be smaller (and possibly many times smaller) than the actual rate, so that this confusion between them invalidates many of Dr. Stark's and USDA's technical points.

25. Third, because Dr. Stark has mistakenly conflated observed and actual rates, it is not true that "*On this basis, Dr. Cox's calculations imply that the first mad cow is expected to cross the border around 2300 AD*". Indeed, the first mad cow has already crossed the border. My calculations, unlike Dr. Stark's proposed "corrections," are consistent with this empirical fact.

26. Finally, while I acknowledge that preventing older cattle from being imported into the United States is an important step toward mitigating risks, it is another measure that only reduces, but does not eliminate, risk. Thus, the same core questions remain now as previously: How large are the remaining risks, and are they risks that the United States should accept? To me, a risk scenario worth considering carefully is that *undetected BSE*

in younger cattle imported into the United States may eventually turn out to lead to detected disease in animals and/or humans. By then, it will be too late to stop the diseases that have already been caused. A second possibility worth assessing in detail is that *some older cattle will be imported into the United States*, due to mistakes, limitations of the method for estimating age, or imperfect compliance. Even if these are not highly likely or frequent events, that does not mean that they should be ignored or dismissed. In risk assessment, it is important to consider what *might* happen (that is not unlikely enough to be ignored), rather than only what is *known* or expected or intended to happen. My main concern is that even occasional (but statistically inevitable) rare combinations of errors in the systems that are intended to prevent BSE cases from being imported into the United States may lead to BSE cases being imported and to severe adverse consequences if there is geographic heterogeneity ("hot spots") in susceptibility to BSE within the United States. I believe this is far from an unlikely possibility. None of the documents I have reviewed presents data showing that occasional imperfections do not occur, perhaps several times a year, or that they will not have severe consequences. Canada's own history suggests that it is more realistic to expect that importing BSE-positive cattle, even in small numbers, can lead to severe consequences in terms of new BSE cases emanating from local hot spots (e.g., Alberta). While the Harvard-Tuskegee risk models suggest that such adverse consequences will probably eventually die out over the next twenty years after imports stop, the near-term damage will already have been done.

27. Dr. Stark is mistaken in stating (paragraph 10, p. 2) that *"Dr. Cox's calculations are based on a particular statistical model for BSE."* This point has already been partly

discussed above, but more discussion may be useful. Dr. Stark's assertions (paragraphs 55, 56, and 58, pages 12-13) that *"Dr. Cox assumes that BSE-positive Canadian cattle can be described by a 'Poisson distribution.' Many of Dr. Cox's risk estimates ride on this assumption… The clustering of BSE cases in Canada is not compatible with the Poisson model. If the Poisson model were correct, there would be far less clustering."* betray a deep misunderstanding and lack of familiarity with how Poisson risk models are used (and justified) in health risk assessment in general and in BSE risk modeling in particular. Apparently, Dr. Stark (and, following his lead, USDA), do not understand that the intensity of a Poisson process can vary from place to place (as well as by age of animal and by calendar year), so that clustering of BSE cases in space and time is not at all inconsistent with Poisson modeling. [See for example Abrial D, Calavas D, Jarrige N, Ducrot C.. Spatial heterogeneity of the risk of BSE in France following the ban of meat and bone meal in cattle feed. Prev Vet Med. 2005 Jan;67(1):69-82; or Sheridan HA, McGrath G, White P, Fallon R, Shoukri MM, Martin SW., A temporal-spatial analysis of bovine spongiform encephalopathy in Irish cattle herds, from 1996 to 2000. Can J Vet Res. 2005 Jan;69(1):19-25.] Dr. Stark's and USDA's comments seem to be directed to *homogeneous* Poisson processes. But my analysis and conclusions allow for *heterogeneous* Poisson processes. Thus, Dr. Stark's and USDA's critiques of my approach appear to be based on a false premise: the mistaken assumption that my main conclusions depend in any way on the assumption of a homogeneous Poisson model. (As suggested in my May 7th declaration, the homogeneous Poisson model does provide a useful way to illustrate more general points with specific, simple numerical results, while

considering heterogeneity can strengthen these results further. But the homogeneous Poisson model is not essential to any of my main conclusions or supporting reasoning.)

28. The main results from applied probability theory that I rely on are *not* based on assuming that a (homogeneous) Poisson process is necessarily justified, as Dr. Stark and USDA seem to mistakenly believe. Rather, they are results showing that, under quite general conditions, the probability that at least one adverse event (e.g., a border-crossing by a BSE-infected cow) occurs will be close to 1 whenever the expected number of such events is sufficiently greater than 1. (Moreover, the time until such an event happens is unlikely to be much greater than its expected value under conditions much more general than those of the homogeneous Poisson model referred to by Dr. Stark.) There are a variety of inequalities and large deviation bounds in applied probability theory that can be used to state and prove precise versions of these results. For practical purposes, the main insight is that if the expected number of BSE-positive cattle is much greater than 1, then the probability that at least one such case occurs is close to 1 (and hence not "minimal", "very small", "negligible", etc. according to any usual meaning of these terms.) This insight does not at all depend on the use of a Poisson model, an assumption of independent events, or on the use of exact numerical input values that Dr. Stark and/or USDA may consider to be "correct" or "incorrect."

29. Dr. Stark is further mistaken in stating that *"That model does not take into account differences in the rate of BSE by age or geography. It does not take into account the feed ban. It does not take into account the fact that cases are linked through contaminated feed. The model does not fit the data for Canada, or the UK, or France, or Switzerland."* This is fine rhetoric but poor statistics. Dr. Stark presents no goodness-of-

fit tests or other analyses to support his claim that "that model" (no specific model is identified) "does not fit the data" (no specific data are presented) "for Canada, or the UK, or France, or Switzerland." Despite the rhetoric, I do not find any solid technical content here. The basis for this claim appears to be Dr. Stark's unsupported opinion.

30. Moreover, it is untrue that my modeling "does not take into account differences in the rate of BSE by age or geography". It is true that Canada has steadfastly refused to collect and report the types of basic surveillance data available in other BSE-affected countries that would allow these sources of heterogeneity to be explicitly quantified using real data. Nonetheless it is still possible to consider how different degrees of heterogeneity in infectivity of cattle and in the vulnerabilities (to BSE-infected cattle) of different locations in the United States would affect risks. Page 16 of my May 7th Declaration illustrates such a calculation with an example that concludes that "The probability that such a rare event (having probability $0.001 \times 0.01 = 0.00001$ for each imported animal) would happen at least once by the time a million cattle have been imported is greater than 99.99%, i.e., it is a statistical near-certainty (given by one minus the probability that no animal causes an epidemic, i.e., $1 - (99999/100000)^{1000000}$.) Yet, a risk assessment that considered only baseline assumptions (e.g., the average infectivity of cattle, perhaps plus or minus two standard deviations to account for uncertainty and/or variability) might well conclude that the risk of a BSE outbreak would be zero, rather than over 99.99%."

Dr. Stark is also incorrect in stating that my analysis "does not take into account the feed ban". Rather, my analysis is predicated on *using actual empirical rates of observed BSE cases after the feed ban*, rather than hopes about possible future rates, to drive calculations. If the feed ban

eventually successfully reduces the actual empirical rate to an acceptably small or zero level, as hoped, then this will automatically be reflected in the calculations I have proposed (via the observed rate of BSE cases per 100,000 cattle tested.) If it proves ineffective, then this will also be taken into account via the observed rate of BSE cases. I believe it would be folly for USDA to base risk management decisions in this case on its hopes for a risk-free future, rather than on a solid demonstration of a low-risk present. The type of solid demonstration that I believe is most appropriate is of the quality control type: Do not re-open the border until at least a sufficiently high number (e.g., hundreds of thousands) of targeted cattle have been successfully inspected without detecting BSE. [From Tables 1 and 2 of the 2005 OIE Terrestrial Animal Health Code, Article 3.8.4.4, at least 300,000/1.6 = 187,500 consecutive targeted cattle (with a BSE risk equal to that in the "Casualty slaughter, age between 4 and 7 years" subpopulation in Table 2), should be tested and found BSE-free to be confident that the BSE prevalence is not more than 1 in 100,000 – even in a country that (unlike Canada) has not identified a*ny* BSE cases. The United States typically discusses and seeks a prevalence of not more than 1 in a million. To achieve this goal, the required number of targeted Canadian cattle that must be tested and found to be BSE-free would be about ten times greater than shown in OIE's Table 1 for the 1/100,000 column, i.e., close to 1.9 million (assuming that OIE's Table 1 is based on the statistical "rule of three" for an upper 95% confidence limit on true prevalence given zero detected cases). Moreover as the OIE document correctly notes, "To monitor the evolution of BSE in a country, *zone* or *compartment* once it is detected, a more intensive sampling method needs to be used to determine disease prevalence." Thus, at a minimum, it appears that the United States should wait until at least 187,500 to 1.9 million consecutive at-risk Canadian cattle have been tested and found to be BSE-free before resuming imports, assuming that cattle

imported from Canada are to be held to the same low acceptable BSE prevalence target (e.g., 1 in a million) as cattle in the United States and that targeted cattle have the BSE risk characteristics described by OIE for "Cattle over 30 months of age that are non-ambulatory, recumbent, unable to rise or to walk without assistance; cattle over 30 months of age sent for emergency slaughter or condemned at ante-mortem inspection (casualty or emergency slaughter, or downer cattle".]

Although USDA (and Canada) often praise Canada's surveillance program as meeting or exceeding OIE guidance (as discussed later specifically for Dr. Hueston's and Dr. Ferguson's declarations), these plaudits appear to be based on a failure to recognize that multiple BSE cases have *already* been found in Canada, so that guidelines for countries with no identified BSE cases do not apply. The above estimates are appropriate if Canada is to be treated as if *no* BSE cases had ever been discovered there, but more stringent surveillance, not yet specified by OIE, seems appropriate in reality. If the feed ban is as effective as we all hope, then such a quality-control limit criterion as "No BSE detected in 187,500 consecutive tested at-risk cattle" should become easy to achieve. If it is not achieved, this sends a strong signal that, despite the wishes and good intentions of those involved, more needs to be done to protect against Canadian BSE risk before resuming imports can be a rationally accepted action that is consistent with acceptable risk levels (e.g., prevalence of less that 1 in a million) for the United States.

31. Dr. Stark claims that "*Dr. Cox plugged the wrong numbers into the wrong statistical model. He used the wrong figures for the number of imports, the number of tested Canadian cattle, the median time to develop BSE in Canada, the ratio of the BSE-positive rate among high-risk animals to the BSE-positive rate among low-risk animals,*

and the ratio of the BSE positive rate among older cattle to the BSE-positive rate among younger cattle. I will show what Dr. Cox's model implies if the right numbers are used…" However, as usual, Dr. Stark mischaracterizes what I have done and draws false conclusions from his own misunderstanding. To begin with, Dr. Stark speaks with great assurance of his own "right numbers" (apparently meaning "What USDA or Dr. Stark assumes") and of my "incorrect" numbers (apparently usually meaning "What someone else assumes".) But in reality, I believe that no one knows the "correct" numbers (meaning "What will turn out to be true.") Acknowledging that the correct values are currently unknown is a first step toward credible risk assessment in the presence of uncertainty.

32. I concede that the number of tested animals in Canada has increased since my 2004 statement (as has the number of BSE-positive animals found), that the estimated number of cattle to be imported in 2005 has decreased as the year passes, that correcting a typo in the Belgian data leads to an estimated ratio of BSE among targeted vs. untargeted cattle of closer to 20 than to 16, and, more generally, that the specific numbers used in my examples are uncertain and can be refined and revised by new information. Such uncertainties and possible revisions were acknowledged and anticipated throughout my modeling. However, by design, *none of these revisions affects my main analyses or conclusions*. The reason is that my analyses were deliberately designed to give an order-of-magnitude estimate that is *robust* to uncertainties in the numerical inputs. [This is discussed on page 25 of my May 7 Declaration, in a paragraph that begins: "The conclusion that imports of some BSE cases into the United States are not very unlikely (probability exceeds 5% per year), if imports from Canada are resumed before their

current prevalence rate declines significantly, has only limited sensitivity to the preceding significant uncertainties."] As explained previously, what matters most is whether the risks of interest are close to 0 or close to 1 (or in the transition interval in between, although this may be unlikely.) The main point of my analysis is that, even in the absence of relevant Canada-specific data (due to Canada's refusal to collect it), it is clear that, for a wide range of plausible assumptions about the approximate values of the various inputs listed by Dr. Stark, the probability of importing BSE cases is close to 100% rather than to 0%. For example, accepting at face values (for purposes of discussion only) Dr. Stark's sub-total conclusion (paragraph 46, p. 11) that "After the corrections, the expected number ranges from just under 1 to just over 4 cases per year", it is *still* statistically almost certain (greater than 99% probability) that at least one case will be imported in the next five years. If there is even a 1% probability that each such case will lead to an unacceptable outcome for the United States, despite USDA's expectations, then the probability of an unacceptable outcome within 5 years would be at least 1% even for the low end of Dr. Stark's range of the "expected number" of BSE cases in Canada (and about 80% if the 4 cases per year figure, which I consider better justified, is used.) I do not believe it is sound policy or consistent with sound risk management practice in the United States for USDA to base its BSE risk management policy on the device of simply calling such risks "low." They may well be unacceptable in a culture that traditionally considers one chance in a million per lifetime (e.g., 70 years) to define an "acceptable" health risk.

33. Dr. Stark asserts (paragraph 47) that *"BSE-positivity is extremely rare in younger cattle."* However, Canada does not collect and report surveillance data on younger cattle

that would be needed to support such an opinion. I believe that the ability to detect BSE in younger cattle is limited; that Dr. Stark is again confusing *detected* with *actual* BSE-positivity (i.e., presence of prions that pose a health threat to other cattle and/or to humans); and that the true rate of (possibly undetected but still hazardous) BSE-positivity in younger cattle is unknown. Less than a year ago, the Japan-United States Working Group issued a statement that concluded that the accumulated abnormal prion proteins in younger cattle is unlikely to be detected using current testing methods and that the relationship of such undetectable levels of prions to consumer's risk is unclear. (Final Report, Japan-United States BSE Working Group, July 22, 2004, p. 4.) Dr. Stark presents no data contradicting that conclusion. In effect, Dr. Stark's analysis seems to be predicated on an implicit assumption that "What you don't see or don't known can't hurt you." I do not believe that it is prudent or that it protects the public interest to make such an assumption. Even if there is only a 1% probability that it will eventually turn out, against Dr. Stark's expectations, that young cattle are *not* safe, this may well be too high a risk to be acceptable. Moreover, Dr. Stark's expressed expectations and judgments seem to be based on something other than objective statistical analysis of available facts and data. For example, he concludes his paragraph 30 with the astonishing statement that "In my judgment, the prevalence of BSE-positives among younger Canadian cattle is now essentially zero." This seems to me to be sheer speculation about something that Dr. Stark cannot possibly know, since Canada has refused to collect the relevant data. USDA may consider such speculation in the absence of data to be a legitimate and important part (or, as far as I can tell, even the whole) of the "overwhelming scientific evidence" and "expertise" that it relies on to conclude that there is essentially no risk to the United

States from importing cattle from a BSE-positive country like Canada. But this does not provide a sound or trustworthy basis for assessing and managing BSE risks.

34. On page 9, paragraph 38, of his Declaration, Dr. Stark argues that "Over 68,000 Canadian cattle have been tested." However, it is inconsistent with quality control principles to keep a running total of all animals ever tested. A rational testing strategy is to require that at least a certain number of cattle be tested and found to be BSE-free *since the last BSE case detected* before it is concluded that the BSE prevalence rate is now satisfactorily low. Each new case found should reset the counter. By this criterion, Canada had tested fewer than 30,000 new cases (as of May, 2005) since the most recently detected BSE case. (By the same reasoning, Dr. Stark's calculations in his paragraph 62, p. 14 are inappropriate, as they look at *cumulative tests* rather than *tests since last case detected*.)

35. Dr. Stark argues (p. 10. paragraph 44) that "Even the ratio of 20 in paragraph 43 is problematic." I agree, and have already stated similar caveats. Still, unless and until Canada starts producing and sharing relevant data, this may be the best surrogate value to use. Fortunately, whether we use 20, 15, 60, or some other value in this range for this parameter makes little or no difference to the main conclusions.

36. Dr. Stark's argument (paragraph 65) that "Not a single case [of vCJD in Canada] has been observed" is specious, as it does not account for the well-known long incubation time of vCJD, nor the known difficulties in accurately diagnosing vCJD.

37. Dr. Stark's assertion (paragraph 66, p. 15) that "There have been 4 BSE-positive Canadian cattle" again confuses the *actual* number of BSE-positive cattle (which is unknown) with the *observed* number. Comparing it to the 180,000 cases of BSE in the

UK is unsound and misleading, as the UK has an aggressive surveillance program that has tested millions of cattle, but Canada does not. Indeed, Canada deliberately sets its testing targets so low (e.g., only 30,000 cattle for 2005, and even smaller in previous years) that it is almost guaranteed *not* to find any BSE cases unless the prevalence rate among tested cattle is far higher (on the order of 1 in ten thousand) than would presumably be acceptable in the United States. Even with this relatively low level (compared to what the United States and other countries affected by BSE use), Canadian surveillance has still found BSE cases, albeit only a small number. It is crucial to recognize that *this small number of cases reflects the relatively tiny sample size* (only 30,000 targeted for 2005 – about what the US samples in one month) that Canada has chosen, rather than a low prevalence rate of BSE among sampled cattle. (Canada's and USDA's frequent argument that Canada's sample size is not so small when expressed as a proportion of its herd size is specious: what matters most for quantitative estimation of prevalence rates is the absolute number of samples, not the sample size expressed as a proportion of herd size.)

38. Dr. Stark's declaration states (paragraph 59, p. 13) that "Dr. Cox claims that if his model is wrong, the true risks are higher than his estimate. There is no technical justification for this claim." This is a further misrepresentation of my statements. What I actually said was: "Specifically, the only underlying technical assumptions required are that (a) BSE cases are rare; and (b) They are sporadic, occurring independently or nearly independently of each other (i.e., no strong animal-to-animal transmission or BSE epidemics are in progress.) (Technically, we assume that the underlying count data are approximately Poisson distributed.) If either assumption is violated, it will strengthen

our conclusions." The technical justification for this claim is straightforward. If assumption (a) is incorrect, then BSE cases in Canada are not rare. This can only strengthen the conclusion that the probability of importing BSE cases is close to 1. If assumption (b) is incorrect, then cases are not merely sporadic, but strong animal-to-animal transmission or BSE epidemics in Canada are in fact in progress. This again increases the risk of importing BSE cases. More generally, the technical justification whose existence Dr. Stark denies is as follows. The actual value of a non-negative random variable (such as number of BSE cases imported into the United States per million Canadian cattle imported) is unlikely to lie many standard deviations above its mean. (Otherwise, the mean would have to be larger than it is.) For a given mean, the standard deviation is *maximized* by assuming a binomial process (i.e., by assuming that all cattle have the same risk). The binomial process is well approximated by a homogeneous Poisson process under the conditions I have stated. Therefore, as stated in my February declaration, we can "use a simple [binomial or Poisson] calculation to obtain lower bounds on the true but unknown risks, realizing that more sophisticated calculations [incorporating heterogeneity] might increase (but not decrease) the risks shown." [If this brief technical justification is still not clear to Dr. Stark, details (e.g., for Hoeffding-type inequalities and the fact that increasing the variability of Bernoulli trial probabilities around their mean decreases the variance of the total number of events given by their sum) can be found in many textbooks on modern applied probability theory.]

39. Less technically, the reason that unmodeled heterogeneity (i.e., differences) in the probabilities that individual imported cattle have BSE *strengthens* my main conclusion (that such imports are statistically almost certain to occur under current conditions) can

be understood intuitively through toy examples such as the following. Suppose that I import two cows per year, one from Alberta and one from the rest of Canada. Suppose for simplicity that the average probability of BSE in each cow is 0.5. Then if the BSE probabilities are modeled as being identical for all cows (0.5 for each) the probability of importing at least one BSE positive cow would be 1 – (0.5 x 0.5) = 0.75 (i.e., at least one BSE-positive cow will be imported unless both are BSE-free.) Now, increase the heterogeneity of individual BSE probabilities as much as possible (consistent with the given average probability of 0.5.) This is accomplished if the probability of BSE is 1 for the Alberta cow and 0 for the non-Alberta cow. Under these conditions, the probability of importing at least one BSE-positive cow *increases* from 0.75 to 1 (since the Alberta cow has a probability of 1.) The idea illustrated in this simple, extreme example holds more generally: increasing heterogeneity in the BSE probabilities for individual cattle around a given average probability *increases* the probability of importing at least some BSE-positive cattle. (Dr. Stark's suggested counter-example, in which age is a source of heterogeneity and importing younger cattle is safer, is of course fallacious: it violates the condition that we consider heterogeneity around a given average probability. Instead, it substitutes an example with a lower average probability value.) My point is that once we have estimated the average probability of BSE per imported animal based on current data, adding consideration of heterogeneity in individual animal BSE probabilities around that average value can *strengthen,* rather than weaken, the conclusion that importing BSE cases is statistically inevitable.

40. Dr. Stark concludes that "I think… the risk that imports from Canada will introduce BSE into the US herd is negligible." He has presented no objective, data-

driven calculation leading to this conclusion, instead explicitly declining to present his own quantitative risk assessment (Stark, paragraph 11). Nor is it clear that what Dr. Stark and USDA call "negligible" is considered negligible by the public, Japan, or any other stakeholders. For example, OIE's 2005 Terrestrial Animal Health Code defines "negligible BSE Risk" for transmitting the BSE agent in cattle commodities from a BSE-affected areas as requiring demonstration of conditions such as that: "there has been no case of BSE, or any case of BSE has been demonstrated to have been imported and has been completely destroyed," or "the last indigenous case of BSE was reported more than 7 years ago". Clearly, Canada does not meet these conditions. Thus, applying the "negligible BSE risk" label to imported Canadian cattle appears to implicitly redefine the meaning of "negligible risk" for Canada (apparently, to mean "whatever the risk in Canada is"), in a way that differs from its meaning for the rest of the world. It is not clear that using risk terms to mean something different for Canada than for other countries serves the public interest or promotes what USDA refers to as "transparency" in its decision-making rationale. Returning to the numbers in Dr. Stark's subtotal in paragraph 46, it is also far from clear that just over 4 cases per year should be considered "negligible", especially in light of the fact that what has been estimated by Canada as perhaps only 3 imported cases (www.inspection.gc.ca/english/sci/ahra/bseris/bserisc1e.shtml) appear to have been sufficient to have caused Canada's current BSE problem. (Perhaps recognizing this, Dr. Stark later suggests reducing this number by a further factor of 2,800 to 10,000 in his paragraph 52. As already explained, this reduction depends on substituting *detected* cases for *actual* ones, and is therefore not valid.)

41. Overall, the main point that I have been trying to get USDA to understand is that, in sufficiently many trials (e.g., millions per year), for the type of imperfect probabilistic system now in place to manage BSE risks, *anything that can go wrong eventually will go wrong, with probability close to 1.* This is not a statement of a pessimistic philosophy, but is a mathematical and statistical certainty based on applied probability analysis of stochastic systems. It is a point that USDA appears not to understand or accept. For example, Dr. Engeljohn's June Declaration mis-paraphrases this ideas as follows: *"It is important to highlight the fact that the overall premise of Dr. Cox's analyses is flawed because it assumes that each control measure alone must totally eliminate the risk of BSE or offer complete protection independent of any other control measure."* This completely inaccurate paraphrase completely misses my point. I adopt no such premise, which would clearly be a ridiculous one. Rather, it is my premise that *even a well-designed conjunction of protective measures*, each with some non-zero probability of failure on each trial, will eventually fail (i.e., *all* of its components will fail, and BSE cases will slip through) on some fraction of trials. *The probability of this occurring approaches 100%* as the number of trials becomes sufficiently large (e.g., for millions of cattle.) Applied probability calculations can help to quantify the failure rate for the whole system based on the failure rates of its components. For the specific case of BSE-positive cattle imported from Canada, it appears that a failure rate of several BSE-positive cattle per year may be quite realistic. USDA and its experts have offered no demonstration (excluding repeated statements of unsupported personal belief) that this will not happen (with probability close to 1) or that it will not have severe consequences for the United States when it does happen.

42. USDA's Motion for Summary Judgment enthusiastically but uncritically adopts the errors, confusions, and misrepresentations in Dr. Stark's declaration, and adds to them. Some quick responses to points on page 1 of USDA's Motion follow.

43. *"The overwhelming scientific evidence indicates that Canadian beef is safe and will stay safe."* RESPONSE: Scientific evidence does not and cannot show what will happen to Canadian beef safety in the future. On the basis of Canadian surveillance sampling to date, it is impossible to know whether the prevalence of BSE in Canadian cattle will eventually reach levels that most people (including members of the public, United States trading partners, or United States policy makers and professional risk analysts outside of USDA) consider "safe". Unless by "The overwhelming scientific evidence indicates" USDA only means "We hope", it is not clear to me how this sweeping statement can be justified by available facts and data.

44. "*The rule reflects a broad consensus of scientists everywhere that the existing risk mitigation measures in Canada and the United States, together with the additional prophylactic measures imposed by the rule, will preclude the introduction of BSE into the United States."* RESPONSE: Dr. Stark states (Stark, paragraph 68) that "The scientific literature seldom speaks with a single voice, even when there is general consensus. The present case is no exception." USDA now claims that there is "a broad consensus of scientists everywhere" that new and existing measures "will preclude the introduction of BSE into the United States." This dramatic claim suffers from the limitations that (a) Consensus is not science. (Consensus, in the sense of "group solidarity in sentiment and belief", while possibly very important to USDA and its experts in this case, often has more to do with politics than with science and in any case is not a substitute for sound

risk assessment as a basis for sound risk management.) (b) At least some responsible scientists do not claim to have foreknowledge of how effective the measures that USDA refers to will ultimately prove to be. (c) Even if there were such a consensus, it would be unjustified. USDA has exhibited no grounds for concluding that there is zero risk, as the phrase "will *preclude* the introduction of BSE into the United States" suggests (emphasis added.) (d) Prudence demands that we wait until there is solid evidence that risks have *already* successfully been reduced to desired levels before assuming that risk reduction measures are as effective as we and USDA hope they will be. It would be folly to start importing cattle now on the basis of theoretical *predictions* that the measures USDA refers to "*will preclude* the introduction of BSE into the United States" (emphasis added) until there is some evidence that they already *have precluded* unacceptable levels of BSE in Canada (based on sample sizes comparable to those in other countries that have successfully demonstrated reductions in their BSE risks). Earlier measures, described with similar enthusiasm and confidence by USDA and Canadian regulators, did *not* preclude the introduction of BSE into the United States in Washington State. Some of the measures, e.g. SRM removal, have been implemented for far too short a time to empirically validate their actual effectiveness. It is prudent to collect empirical data that show that current measures work as intended before assuming that they will.

45. "*Although the risks posed by the importation of Canadian beef are so minuscule as to be essentially hypothetical, plaintiffs [sic] basic objection to the rule is that the risk is not zero.*" This utterly misrepresents our main concern, which is not that "the risk is not zero", but that the risk is probably unacceptably large (e.g., much closer to 1 than to zero.) Adding further qualitative descriptions such as "so miniscule" and "essentially

hypothetical" does not change the concern that the risk of importing BSE-positive cases in the next few years may well exceed 99%.

46. "*Anyone who argues that zero risk is attainable for meat product, vegetable product, baked good or beverage, whether imported or domestically produced, is deluding themselves* [sic]." This is untrue on its face. I have zero risk from drinking tea if I do not drink it. There is zero risk of BSE from imported Canadian cattle if we do not import any.

48 "*And no BSE-positive under-30 month cow has <u>ever</u> been found in Canada.*" Since BSE prion contamination cannot be detected in younger cattle except in rare cases where the levels are exceptionally high, and since Canada does not have any surveillance program in place to look for BSE in younger cattle, the fact that no cases have been *found* tells us little or nothing about what levels of BSE contamination among younger cattle are *present*.

49 "*The Secretary's decision to permit imports of under-30-month Canadian cattle and beef cannot be deemed arbitrary or unreasonable based on a near impossibility.*" RESPONSE: USDA has not shown that importing BSE-contaminated Canadian cattle is a "near-impossibility". To the contrary, it may well be a near-certainty, under the conditions I have discussed. The fact that it has happened already (and frequently enough to detect, although so far perhaps only once, in Washington State) shows the peril of simply assuming that well-intended measures will work as planned.

50 Moving past page 1, USDA's Motion for Summary Judgment states that "*the regulations erect a series of interlocking, overlapping, and sequential barriers that, taken together, virtually eliminate any risk that BSE will be introduced or spread to cattle or*

humans." This statement appears to reflect a belief that USDA and Canada can simply regulate risk away ("virtually eliminate" it.) Sadly, this view is extremely naïve. How well the regulations will work in practice will depend on factors such as the extent of compliance, error rates in implementing it, any errors in its assumptions (e.g., about reservoirs and mechanisms for the spread of BSE), effects of factors that have not yet been modeled (such as geographic heterogeneity, which we all seem to agree now is important), and so forth. For this reason, I believe it is important not to base current risk management decisions (particularly, decisions about whether to resume imports) on the concept that regulations "virtually eliminate" risk (or will do so at some unspecified date in the future.) Rather, the United States should insist on a rigorous quality-control type approach that relies on *extensive surveillance data to* determine when BSE rates in Canada *already* meet desired levels with high confidence. Otherwise, we are gambling that regulations will perform as advertised, i.e., that they really will "erect a series of interlocking, overlapping, and sequential barriers that, taken together, virtually eliminate any risk that BSE will be introduced." So far, this optimistic prediction has not been validated by data and is inconsistent with the experience in other countries with BSE, as well as with Canada's own experience. Moreover, as I have stressed previously, it is the nature of sequential barriers that they do *not* eliminate risk, and that when enough trials are made (e.g., if millions of cattle per year are imported), even highly reliable sequences of barriers have close to a 100% probability of occasionally failing (i.e., letting some BSE cases through.)

51 Among the barriers listed on page 14 of USDA's Motion for Summary Judgment is "*an effective BSE surveillance system*." But I disagree that the system is effective if by

"effective" is meant "providing the basic information needed to confidently assess the approximate extent of BSE contamination among targeted and non-targeted cattle in Canada." (I do agree that the Canadian surveillance system has been adequate to catch three of the four cases detected so far. I believe that it is statistically very unlikely that these were the only four cases of BSE-contaminated cattle to originate in Canada.) A well-designed surveillance system should provide the information needed to (a) confidently quantify the approximate prevalence rate of detectable BSE among targeted cattle; and (b) confidently quantify (or at least place usefully narrow bounds) on the approximate ratio of BSE rates among cattle that would be imported into the United States to BSE rates among targeted cattle. At the moment, Canada is not producing the basic data required for either of these goals.

USDA's Dr. Ferguson (Second Ferguson Declaration, paragraph 13) argues that "Canada's targeted surveillance program is appropriate, effective, and well-suited to making an accurate determination regarding prevalence of BSE in Canada, and we believe that the surveillance results amply support the conclusion that the prevalence is extremely low." To justify this conclusion, Dr. Ferguson reasons as follows: "If it is assumed that 80% of the six cases would be detected in the targeted, high risk population, the prevalence for disease in this targeted population would….00006%. Using a standard statistical formula… a sample size of 37,140 would be needed to detect disease at this level. In a 12-month time frame, from June, 2004 to May, 2005, a total of 49,023 samples have been examined, substantially exceeding the necessary sample size." However, this reasoning appears to neglect the following essential points:

(a) The result of this sampling was that *additional cases of BSE were actually found.* It is not evidence that "the prevalence is extremely low" when a statistical protocol that was designed to find new cases of BSE if the BSE prevalence is at least 1 in a million does in fact find new cases. (This is somewhat analogous to saying that there must be little risk of a fire if a very sensitive fire alarm starts to ring. It is not the sensitivity of the test that should be reassuring, but rather its failure to go off..) A correct interpretation of the discovery of multiple additional cases is that this constitutes strong evidence that the prevalence is *not* less than one in a million. (And even one BSE-positive animal in a million is not self-evidently an "extremely low" prevalence rate, given that many millions of cattle are slaughtered each year.)

(b) Dr. Ferguson's calculation appears to pick key numbers without statistical justification, rather than reflecting real-world data. A key part of her argument is the following *ad hoc* assumption: "If it is assumed that 80% of the six cases would be detected in the targeted, high risk population…". But why would any rational person with a calculator make this assumption? Dr. Ferguson states in the same paragraph that "Canada currently has an adult cattle population of approximately 6 million and it has estimated that approximately 80,000 of these would be in the targeted, high risk population." This means that the "targeted, high-risk population" constitutes a mere 80,000/6,000,000 = 1.3% of the population. Yet, Dr. Ferguson assumes, without apparent justification, that "80% of the six cases would be detected in" this 1.3 percent of the population. Why? Even if the relatively tiny targeted sub-population has a rate of BSE-positives that is twenty times greater than in the non-targeted population, one should still expect to find that most cases (about $1 - [0.013*20]/[(1 - 0.013)*1 + 0.013*20] =$

79% of them) in the much larger non-targeted population. Thus, Dr, Ferguson's supposition beginning "If it is assumed that 80% of the six cases would be detected in the targeted, high risk population…" lacks plausibility for the real-world. More generally the essence of Dr. Ferguson's argument seems to be that *if* Canada had a surveillance system that would detect most cases of BSE and *if* that system had failed to detect any new cases of BSE, *then* we could be reassured that the true prevalence rate of BSE is probably less than 1 case per million. But neither condition holds. Dr. Ferguson and USDA draw their desired conclusion anyway ("we believe that the surveillance results amply support the conclusion that the prevalence is extremely low"), but this conclusion appears to be reached in spite of the data, not because of it.

(c) Dr. Ferguson also states that "Canada's surveillance program has been designed to detect a level of disease equivalent to one case per million adult cattle." But there is no valid statistical method for confidently detecting one case per million adult cattle while testing only a few tens of thousands of animals, not even if one assumes that the tested cattle have twenty times the BSE rate of the general herd. Thus, despite Dr. Ferguson's statement, Canada's surveillance program is *not* adequate to "detect a level of disease equivalent to one case per million adult cattle", unless one is willing to make extreme assumptions (such as that the testing program just happens to be incredibly lucky, e.g., by finding 80 percent of cases despite targeting only 1.3%.) However, the prevalence rate of BSE in Canada is high enough so that multiple cases have been found anyway.

(d) Dr. Ferguson's unsound statistical reasoning is echoed by others at USDA, including Dr. Hueston. Dr. Hueston's Paragraph 11.5 states that "Canada's surveillance program is of equivalent sensitivity to the USA's program when one considers the size of the high-

risk populations." As previously discussed, this is a basic statistical error: it is the *absolute number* of cattle *sampled*, not the relative sizes of the populations being sampled, that determines the sensitivity of the sampling procedure in this application. Dr. Hueston continues: "The number of animals comprising each countries (sic) high-risk population is significantly different (i.e., 450,000 in the USA versus 80,000 in Canada). These data indicate the Canadian surveillance program appropriately targets high-risk animals and is sufficiently sampling enough animals (sic) to strongly demonstrate BSE is rare in Canada." But this is a completely incorrect interpretation of the data, if "rare" means "less than one animal in a million". (As usual, it seems impossible to tell what, specifically, USDA means by terms such as "rare".) All that the data "strongly demonstrate" is that Canada, while sampling far fewer than 50,000 animals in the first part of this year, found new cases of BSE anyway. Even if the detected rate for 2005 were only 2/50,000, and even if this rate were assumed to be twenty times higher than the rate in the general herd, the general herd rate would still be (2/50,000) x (1/20) = 2 per million. It is not clear how Dr. Hueston, Dr. Ferguson, or USDA in general reconcile such rates with their repeated claims that "BSE is rare in Canada", "the prevalence is extremely low", and so forth, unless these undefined terms are interpreted to mean "whatever rate we find in Canada, even if it is well in excess of one per million." But such high rates, no matter what reassuring-sounding qualitative descriptions USDA affixes to them, are plenty high enough to guarantee that, with a probability of almost 100%, some BSE-positive cattle from Canada will be imported into the United States within the first few million cattle.

52. *"Beyond these measures there is a formidable species barrier so that humans may need 10,000 times the level of infective tissue necessary to infect cattle."* (USDA, p. 5). It is my understanding that the size of the species barrier for the most susceptible individuals is currently not known and that the "may" in USDA's statement is speculative. If a goal of risk management is to protect sensitive sub-populations, then the assumption of a "formidable species barrier" is not necessarily justified based on current science. Rational risk assessment requires considering what *might* turn out to be true (and that is plausible enough to affect optimal decisions) as well as what is currently *known* to be true. At present, I believe that it is not known that all consumers are protected by "a formidable species barrier", even though some probably are.

53. "*Extensive scientific evidence categorically demonstrates that there is no measurable increased risk to human health or animal health created by the Final Rule"* (USDA, page 6, quoting Dr. Hueston's declaration.) On its face, this passage appears to claim that USDA can now prove a negative (using scientific evidence to "categorically" demonstrate the absence of an effect). This is traditionally considered impossible by scientists who rely on facts and data to form their conclusions. The claim is even more remarkable because the "increased risk to human health or animal health created by the Final Rule" presumably would not even come into existence until some time in the future, after the rule is implemented. Thus, USDA appears to be claiming to be able to use unspecified "extensive scientific evidence" (perhaps referring to the speculations and personal convictions of its employees and experts in the absence of relevant data) to "demonstrate" (I am not sure how) that some undesired future events (measurable increases in risks to human health or animal health created) will never take place. Such

miraculous powers of foreknowledge and proof seem to me to go well beyond what USDA has actually demonstrated. Finally, it may be that USDA denies the possibility of a measurably increased risk because they mistakenly believe that Canada and the United States have statistically similar BSE risks (consistent with the rhetoric of a "North American BSE problem", although not with available surveillance data.) But this belief would be untrue. For example, even if the United States detects one or a few cases of BSE per million cattle tested, this would still represent a *significantly lower* BSE risk rate than Canada's (as implied by four BSE-positive Canadian-origin cattle from the Alberta cluster detected so far, with fewer than 70,000 cattle tested.)

54. USDA interprets the following quote as providing justification for their conclusion that "the rule provides no measurable increased risk to either animal health or public health": " When *all appropriate measures* to minimize human exposure *are fully implemented and controlled*, meat and meat-based products derived from cattle can be regarded as free from the BSE agent and thus free from any risk of causing vCJD in humans" (emphases added). However, a less optimistic interpretation is that the conditions in this quote requires perfect compliance, zero errors, and full and exhaustive implementation of countermeasures ("all appropriate measures"), none of which is realistic to expect in the near future if imports from Canada are resumed.

55. USDA states (p. 7) that "*R-CALF's arguments are not based on current science, are extrapolations of results beyond what the data supports, and are inconsistent with the accumulated scientific wisdom and international experience regarding BSE in cattle."* These claims are correct in that R-CALF's arguments (and mine) apply techniques from the field known as health risk analysis to consider what might happen and what might be

learned in the future (that is likely enough to affect the optimal current decisions). When current uncertainties are resolved and current conventional wisdom is updated to reflect future information, USDA's "accumulated scientific wisdom" may well have to be revised. Rational risk analysis requires considering this possibility now, when decisions are being made. Assuming that USDA refers largely to its own opinions when it speaks of "accumulated scientific wisdom", our conclusions, based on currently available data and knowledge, about what future risks are likely to be, are indeed inconsistent with USDA's current opinions. However, I strongly disagree that our arguments (mainly, that BSE is likely to spread if cattle are imported from BSE-positive countries before there is very strong evidence, typically based on hundreds of thousands or millions of samples, that the BSE threat there has already been successfully controlled) are in the least "inconsistent… with international experience regarding BSE in cattle." To the contrary, I believe that USDA's repeated denials that importing cattle from a BSE-positive country creates significantly increased risk to the importing country are inconsistent with international experience and history. I believe that USDA's "accumulated wisdom" should be revised to acknowledge the repeated finding that BSE risks said to be "low", "negligible", etc. have in fact turned out to be certainties.

56. USDA states (p. 7) that "*Plaintiff's arguments - and Dr. Cox's opinion - are inconsistent with the scientific evidence in several respects. First, plaintiff predicts a future epidemic because BSE has been found in Canada and 13 additional countries since 2000."* But I do not "predict a future epidemic". Rather, I recognize that some models (including the original Harvard-Tuskegee model) imply the *possibility* of an epidemic under conditions that have not been shown to be impossible or highly unlikely.

The field of health risk analysis teaches that it can be important to consider low-probability, high-consequence events in identifying current prudent (or optimal) risk management strategies, even if those events are considered relatively unlikely. Considering the range of possibilities is not at all the same thing as "predicting a future epidemic." Thus, USDA again mischaracterizes what I have done.

57. USDA states (p. 8) that *"Plaintiff further errs by attempting to identify putative flaws in each risk reduction instead of viewing them as a series of interlocking, overlapping, and sequential barriers whose cumulative effect is to prevent the introduction and spread of BSE. Second Declaration of Daniel L. Engeljohn, Ph. D. ("Engeljohn **II** Dec.")".* Again USDA misrepresents what I have said and vigorously attacks a straw man. The argument here is simple. Suppose that a BSE case will leak through a system of N barriers if and only if the first barrier fails *and* the second barrier fails and… *and* the Nth barrier fails. If each barrier has a positive failure probability (conditioned on the failures of its predecessors), then the probability that *all* of them fail is just the product of these probabilities. If their product, multiplied by the number of trials (e.g., the number of cattle that pass through the sequence of barriers) is much greater than 1, then the occurrence of some *system* failures (i.e., relatively rare events in which all barriers fail and a BSE case gets through) is a statistical near-certainty (probability close to 1.) My argument is that this is probably the situation with imports of Canadian cattle at present, and that USDA has not presented any analyses or data that demonstrate or suggest that the occasional failure (e.g., one time out of ten thousand) of its "series of interlocking, overlapping, and sequential barriers" is either impossible or unlikely. This is sufficient to let some BSE cases through. Dr. Engeljohn's suggestion

that the cumulative effect of a sequence of barriers is "to prevent the introduction and spread of BSE" is inconsistent with the laws of probability, which teach that such a series reliability system *does not prevent* some cases from passing all barriers (unless one or more of them has zero failure probability – something that neither USDA nor R-CALF believes.) All that the sequence of barriers does is to decrease the number, but not the eventual certainty, of some cases getting through.

I declare under penalty of perjury that the foregoing is true and correct. Executed on June 27th , 2005.

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Louis Anthony Cox, Jr., Ph.D.