RESEARCH REPORT
ANIMAL WELFARE

**Title**: Developing Criteria for Timely Euthanasia Decision Making – **NPB #02-175**

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**Objective:** To provide the economic and welfare information necessary to help producers decide whether they should euthanatize a casualty nursery pig or keep it.

**Materials and methods**: We assigned batches of pigs to protocols that required many, some or few casualty pigs to be euthanatized upon entering the nursery. Casualty pigs with conditions not triggering immediate euthanasia were ear-tagged and monitored and costs recorded. Thereafter, pigs were observed daily; adverse welfare status assessed and pigs euthanatized if warranted. Tagged pigs were assigned an economic value based on their weight less the costs incurred.

**Results:** 51,041 nursery age pigs in 47 batches were screened upon entering 5 farms. The mean value ($) for pigs by farm (light euthanasia protocol) ranged from $10.81 for Farm D/5 to $48.99 for Farm B/3. For the heavy euthanasia protocol it ranged from 0 to $46.66. The mean adverse welfare score for pigs, by farm (light protocol) ranged from 73.51 for Farm B/3 to 112.86 for Farm A/1. For the heavy protocol it ranged from 0 to 59.68.

**Implications:**

- After adopting the light euthanasia protocol, pigs that are weak, lame, with 2 or more conditions or prolapses have a low value and high adverse welfare score (indicating poor welfare) and managers can increase farm welfare at least cost by immediately euthanatizing most of these pigs.
- As more pigs are euthanatized (progressing from light, medium, to heavy) the value of casualty pigs decreases 11 fold ($18.44 to $1.61) and adverse welfare improves 7 fold (score 80 to 11)
- Farms vary in the prevalence of casualty conditions and managers need to focus on the conditions on their farms and adjust their protocol accordingly.

**Keywords:** euthanasia, economic, welfare, nursery, and decision-making

Generally, an animal should be culled when it is no longer profitable or euthanatized when it is inhumane to let it live. The difficulty all farm managers encounter is defining when animals become uneconomic and whether to treat or euthanatize the casualty animal. Individual managers usually resort to a very subjective assessment often heavily weighted by the perceived ability of the animal to return a profit. Focus groups of North Carolina farm managers have told us that having clear criteria for when to euthanatize an animal would help reduce some of the job stress they feel. In the companion animal arena, there appears to be much discussion and many suggestions on the appropriate timing of euthanasia[1,2,3,4] Many of the companion animal guidelines are very subjective (e.g., ability to enjoy food,

ability to breathe freely and without difficulty, ability to eat and drink without pain, ability to respond to owner and family), but when taken together are helpful in creating a euthanasia profile. Other guidelines are more objective, evaluating weight loss, weakness, infection, organ failure and injuries.[5] However, these guidelines can be criticized on the basis that they do not comprehensively evaluate all aspects of welfare.

In farm animals, the approach to euthanasia has been to consider aspects of welfare and economics, although few comprehensive guidelines have been created for farmer use. Some farming systems have adopted specific protocols to help managers decide what to euthanatize and what to keep. For example, the “two-strike” system (John Roberts pers. comm.) suggests a weaner pig is euthanatized if it fulfills two criteria: it is underweight (e.g., less that 3.63 kg on a farm with 18 day weaning); and it has a disability such as a rupture, or navel ifection, or lameness, or poor body condition. This introduces a special category of concern for pork producers, the lightweight pig. It has been long accepted that lightweight piglets at birth are lightweight at weaning[6]. Others have established that lightweight pigs at birth have higher mortality, grow slower and so are a significant contributor to the variation in slaughter weight and, as such, a major problem in assembling slaughter loads and a source of financial loss[7]. In 3-site production, where the system rewards nursery managers for moving on more pigs, there tends to be more casualty pigs shipped than there should be. Consequently, finishing managers struggle with the issue of how to handle the underweight/disadvantaged pigs they are shipped.

Industry-specific guidelines for euthanasia, such as the National Pork Producers Council guide “On Farm Euthanasia of Swine” [8] and university-produced extension training materials such as “On-Farm Euthanasia: Better Ways”[9], generally agree closely with AVMA-accepted methods and processes. Unfortunately, these guidelines do not help producers decide if and when any individual animal should be euthanatized to end its suffering. Suffering can be conceptualized as the product of compromised

welfare and its duration. By daily monitoring, farm managers can estimate duration but the difficulty of deciding what is compromised welfare remains. A logical and comprehensive framework for the analysis of welfare of any animal is summarized by the five freedoms[10,11] freedom from hunger and thirst; freedom from physical and thermal discomfort; freedom from pain, injury and disease; freedom to express normal behavior; freedom from fear and distress. However, to be practically useful, these need to be put into the context of day-to-day production systems, and linked to the financial aspects of production.

In this study, a practical guideline to the welfare implications of conditions affecting weaner pigs was constructed, using the '5 freedoms' approach and incorporating SID (severity, incidence and duration) analysis. The objective of this study was to detail the economic consequences and welfare implications managers need to consider when deciding whether nursery pigs should be euthanatized as soon as they are identified or kept and treated as necessary. Our hypothesis was that pigs with conditions adversely affecting their welfare have relatively low economic value and that prompt euthanasia of these animals would improve farm welfare while maintaining optimal economics.

**Materials & Methods:**

**Study Herds**

The study was conducted in 2002-2003 in 5 commercial nursery sites (Farms 1-5) owned by 4 separate entities (A, B, C, and D; two farms were owned by the same entity) in North Carolina. Each farm was part of a 3-site production system and regularly received nursery-aged pigs from their supplier and after growing for about 6 weeks the pigs were shipped to their respective finishing sites. All 5 nurseries were curtain-sided, naturally ventilated, with woven wire floors, concrete alleyways, and nipple drinkers.

**Treatments**

Batches of pigs were assigned to treatment (heavy, medium or light euthanasia regimes based on adverse welfare score) before the pigs arrived on site but at the convenience of the owners. Each owner was requested to complete at least 12 batches (4 heavy, 4 medium and 4 light). Pigs within batches were screened for compromising-conditions upon entering the nursery and either euthanatized, tagged or penned normally depending on their condition and the assigned treatment protocol (Table 1). All pigs in all batches were sized and placed into pens with similarly sized pigs. The heavy protocol triggered euthanasia for welfare conditions that were less severe (compromising) than the medium protocol, and the light protocol triggered euthanasia only for the most compromised pigs (Table 1). Pigs in each treatment group with conditions not severe enough to trigger immediate euthanasia were ear-tagged and monitored daily by farm staff for changes in their condition. The conditions monitored and the levels triggering euthanasia were decided in advance by consensus with the investigators and veterinarians responsible for the health of the pigs studied. Pigs were euthanatized according to standard operating procedures on the study farms and in accordance with current AVMA guidelines[12].

Farms varied in where they housed tagged pigs and the status of porcine reproductive and respiratory disease (PRRS) in the herds supplying the nursery pigs: Farm A/1: Tagged pigs were left in the pens they were found in. The pigs came from herds that were known PRRS positive with clinical signs.
Farm B/2: Tagged pigs were grouped into separate pens if small or lightweight, but were left in the pens they were found if normal weight or heavier. The pigs came from herds that were known to be PRRS positive but not with clinical signs at the time.
Farm B/3: Tagged pigs were grouped into separate pens if small or lightweight, but were left in their original pens if normal weight or heavier. This practice was used to prevent heavier pigs from physically abusing small weak tagged pigs. The pigs came from herds that were known to be PRRS positive but

not with clinical signs at the time. Farm C/4: Tagged pigs were grouped into separate pens. The pigs came from herds where PRRS has never been suspected or diagnosed.

Farm D/5: Tagged pigs were grouped into separate pens. The site was recently depopulated and the pigs came from herds where PRRS has never been suspected or diagnosed.

Any pig requiring veterinary treatment was treated according to standard operating procedures on the study farms. The time taken to administer treatment was recorded as was the amount, type, and cost of drugs administered. If more than one pig was treated at the same time (e.g., injecting 5 pigs with an antibiotic) the time taken to treat the group was averaged and the mean cost in time assigned to individual pigs. Tagged pigs were euthanatized if their condition progressed to a level that triggered euthanasia for their respective treatment group.

When a pig died it was weighed and the date recorded. All tagged pigs were weighed by people standing on bathroom scales (a pig's weight was obtained by subtracting the person's weight) when they were transferred to the finishing barn. In cases where there were no shipping weights they were estimated from the total load out weight of the batch.

**Value of pigs**

The value of each casualty (tagged) pig in each batch was established at shipping by partial budget (additional income + reduced expenses – reduced income – additional expenses). Additional income was calculated as the product of the animal's weight at shipping by the standardized value of $1.78/kg. The cost of euthanasia was not credited as a reduced cost to the tagged pigs because it was by blunt trauma and therefore considered minimal. Individual pig shipping-weights were not available from 7 pigs at farm A1, 1 pig at farm D5, 13 pigs at farms B3, and 74 pigs at farm C4 and so weights were estimated to be the mean of the shipping weights of contemporary pigs in the batch.

The cost of drugs administered was set at a standard value per ml of $0.563 ceftiofur sodium, $0.04 tylosin, $0.03 penicillin G, $0.05 long acting oxytetracycline. Cost of time was set at $10/hour. There were no reduced expenses or reduced income to consider. The value of the batch was the sum of the value of all casualty pigs in the batch.

For tagged pigs that died or were euthanatized, the cost of feed consumed was charged against them and therefore their batch. We assumed a starting pig weight of 2.27kg, feed consumption of 0.9/d, and feed cost of $0.29/kg. We did not include the transfer (purchase price) costs in the economic model because it was assumed to be the same for all pigs.

**Assigning an adverse welfare score**

A list of common conditions in nursery pigs requiring treatment was developed by the authors and the veterinarians of participating farms. A reference notebook was assembled and supplied to each participating farm with pictures illustrating each condition and level of severity.

To determine the status of welfare associated with each condition (e.g., lame, tail bitten, ruptures) and its level of severity [i.e., A (least severe), B, C, or D (most severe)] an expert panel consisting of 3 of the investigators and 4 food animal veterinarians, including 1 beef specialist, 1 swine specialist, 2 laboratory animal specialists, was asked to create a welfare score by ranking each level of each monitored condition from 0 to 10 (0 no effect on welfare, 1 little effect on welfare, to 10 worst possible effect on welfare) (Table 1). In making their rankings panel participants were asked to consider the 5 freedoms as defined by the Farm Animal Welfare Council (FAWC http://www.fawc.org.uk/ accessed 31 July 2004) freedom from hunger and thirst, freedom from physical and thermal discomfort, freedom from pain, injury and disease, freedom to express normal behavior, freedom from fear and distress[10,11].

At the time they were received at the nursery and each day thereafter, farm staff observed the pigs under their care and determined their condition, if they needed treatment, if they changed levels in the physical condition they were experiencing and if euthanasia was warranted. Conditions and levels were recorded for each tagged pig, each day. Pigs that were not tagged were not followed.

When a pig had 2 or more conditions then the welfare scores for each condition were summed to make a final welfare score. For example, if a pig had damaged digits at level B (score 3) and a rupture at level A (score 1) then that pigs total welfare score was 4. The welfare score assigned to pigs was the product of the assigned initial score for their condition and level and the number of days they experienced that condition, that is, until they recovered, died, were euthanatized or left the nursery to go to the finishing stage (e.g., a weak pig, level A, for 30 days would score 90 (3 x 30). Thus, a low welfare score indicated fewer pigs were compromised for less time or less severely compromised. A high score indicated more pigs were compromised for longer, or they were more severely compromised.

**Data analysis**

The model was of hierarchical design. For each dependent variable (value and welfare) we performed an analysis of co-variance (ANCOVA) in the GLM procedure of SAS (Version 8.01 for Windows, 98; Statistical Analysis Systems Institute Inc, Cary North Carolina). The batch (one turn of a nursery room) was the experimental unit. The model included farm, protocol, barn, reason and the level of reason as nominal (class) data. Barn was nested in farm and level nested in reason. The dependent variables were the value ($) or welfare. The PRRS status was not specifically included in the model but accounted for in the variable “farm”.

For sensitivity analysis on the economic value, welfare, cost of treatment etc., a decision tree was constructed using the results from the mixed model ANOVA in Data 4.0, published by TreeAge Software http://www.treeage.com

The decision tree diagram represented in chronological order the alternative states for the pigs for their duration of stay in the nursery. When pigs first entered the nursery they would be allocated to the treatment protocol (light, medium or heavy euthanasia). Then pigs would be examined and determined whether they were in a well or compromised state. If compromised, the reason (state) was determined by clinical examination and a level (state) of severity was assigned. Depending on the protocol, reason, and level then the manager would determine if the pig was either euthanatized immediately or tagged and observed daily.

To construct the tree, the value (utility) of each of the potential outcomes (e.g., no value if euthanatized) and the probability of that outcome occurring was calculated from the farm data. From the constructed tree the expected utility of each decision was calculated by weighting the value of each outcome with the probability that the outcome will occur. Then the weighted values for all outcomes for any branch of the tree was summed (folding or rolling back) giving an estimate for the value of that decision. The branch with the highest expected value ($) or lowest expected value (welfare) is expected to be the most favorable outcome for the population studied. The sensitivity of the results to changing inputs was calculated by varying the cost of treatment, probability of euthanasia, probability of tagged pigs dying/surviving and final value of the pig.

The distribution for the initial reason was set as the same for all protocol (disregarding the chance that some reasons were disproportionally allocated among the protocol).

**Results**

The numbers of pigs processed by each farm was:

Farm A/1: Two batches were processed and mean batch size was 3585 pigs. A total of 200 pigs were euthanatized and 80 tagged.

Farm B/2: 12 batches were processed and mean batch size was 587 pigs.

Farm B/3: Twelve batches were processed and mean batch size was 801 pigs.

Farm C/4: Six batches were processed and mean batch size was 2207 pigs.

Farm D/5: 15 batches were processed and mean batch size was 930 pigs.

A total of 51,041 nursery age pigs in 47 batches were screened upon entering the 5 farms and of those, 819 (1.6%) were immediately euthanatized and 1118 (2.19%) were tagged and followed. Of the tagged pigs, 186 (16.64%) died, 924 (82.65%) were shipped to finishing and 8 were lost to follow up (Table 2). No pigs developed conditions after arrival.

The data from 1904 pigs were used in the decision tree analysis; 1931 were available but the 1 beaten (multiple fight wounds) pig and the 24 pigs with reason “unknown” were deleted from the data set.

For the 7 casualty categories (damaged digits, lame, lightweight, repaired rupture, rupture, weak, or two or more) where more than 10 pigs were tagged the percentage mortality ranged from 5.16% (repaired rupture) to 64.3% (weak). For welfare conditions where more than 10 pigs died, the percentage of deaths numerically increased as the level increased; lame/A 27.27% and lame/B 53.57%, lightweight/B 9.54% and lightweight/C 17.73% (Table 3). There was considerable variation among farms in the reasons for which pigs were compromised, (e.g., 1100 lightweight compared with 41 damaged digits) and the number of conditions reported (farm B/3 had 310 repaired prolapses while other farms had none.

The mean value ($) for pigs, by farm under the light protocol, ranged from $10.81 for Farm D/5 to $48.99 for Farm B/3. For the heavy protocol it ranged from $0 (reflecting all pigs were euthanatized) to $46.66 (reflecting the survival and high value of the 310 pigs with repaired ruptures on that farm)(Table 4) Least squares means analyses were not used because of the lack of variation in both the economic value and

welfare cost for the heavy protocol. In the heavy protocol most study pigs were euthanatized giving a zero value for both welfare and economic value. The mean welfare score for pigs, by farm under the light protocol, ranged from 73.51 for Farm B/3 to 112.86 for Farm A/1. For the heavy protocol it ranged from 0 (reflecting all pigs were euthanatized) to 59.68 again reflecting the survival and daily accumulation of the welfare score of the 310 pigs with repaired ruptures on that farm)(Table 4).
The least squares mean was calculated for all pigs and light and medium protocol pigs (Table 5). Generally, the value ($) numerically decreased and the welfare score increased for the medium compared to the light protocol pigs.

The comparison of economic value ($) and welfare score by protocol and condition is illustrated in the scatterplots, Figures 1A-C. For the light protocol 4 conditions (prolapse, weak, lame, and the presence of two-or-more casualty conditions) are in the top left quadrant indicating a low value/high welfare score. For the medium protocol, the presence of two-or-more casualty conditions is the only condition associated with a low value/high welfare score, with a value of 126 (note the different scale of the y axes for Figure 1A and 1B).

**Sensitivity analysis:** The expected value ($) and welfare score from the decision tree ranged from $18.44 for the light protocol, $11.82 for the medium to $1.61 for the heavy and welfare score of 80 for the light, 44 for the medium to 11 for the heavy. These values are unique to the decision tree and reflect the redistribution of conditions across the protocol. A decision tree for lightweight pigs is is detailed in Figure 2.

If a farm has a different proportion of lightweight pigs than our study farms the effect of changing that proportion is illustrated in Figure 3. Lightweights have a mortality of 12% (level B and C) and as the proportion increases this decreases the economic value of lightweights across all 3 protocol. However,

because lightweights have a low welfare score (level B = 1, level C = 2) as their proportion increases the proportion of pigs with other conditions and higher scores are displaced and welfare improves (welfare score decreases).

**Discussion:**

This study provides economic and welfare-cost guidelines to help producers decide which nursery pigs to euthanatize and when. The advantage to producers of adopting a policy to euthanatize more casualty nursery pigs on arrival is that they can immediately improve the welfare status of their farm without incurring any capital costs. The high mortality for level A weak pigs (66.67%), level B lame pigs (53.57%) and ruptures level A and B combined (38%) indicates that managers should examine the situation in their nursery to determine if the opportunity exists to improve the welfare situation for these categories, by immediately euthanatizing more of those pigs. The cost of the lost feed alone is a major expense when these pigs die and the welfare score improves when these pigs are not on the farm detracting from the overall welfare appearance of the site. Current welfare concerns have focused primarily on issues such as gestation housing, processing (teeth and tail clipping and castration) but have largely ignored endemic health problem and the management of those conditions by the animal caretakers[13]. In our experience, when we take veterinary or animal science students on a teaching tour of pig facilities they are more concerned with the welfare of individual animals that are visibly afflicted with conditions similar to the ones documented in this study. Health problems are much easier to appreciate as welfare problems, and amenable to rectify, because they are usually more recognizable because of the lesions than the less tangible long-term stress tethered sows experience. In addition to a visual assessment, a farm's records may indicate a welfare problem; Hurnik[14] argues that longevity may be a good indicator of welfare as it is logical to assume that premature death is preceded by a period of suffering. However, deciding to euthanatize a casualty pig immediately when it is detected results in forgoing the opportunity to return a profit from that pig.

Welfare and economics are necessarily linked in production animals, and to a large degree, it is the consumer who drives welfare[11]. Only time will tell if welfare requirements will become a cost of doing business with the producer bearing all the cost or if consumers will pay for the added cost and the assurance that the welfare standards were adhered to.

The problems of the accuracy of our welfare score is reflective of the problems with welfare indices generally where it is difficult to decide the relative weightings. We used a simple descriptive scale (SDS) for our welfare index, with relative values assigned by consensus of a group of knowledgeable veterinarians. Pain scales adopted for use in animals include the SDS, the numerical rating scale (NRS)[15], and the visual analog scale (VAS)[16] . Although the SDS is less sensitive than the NRS or the VAS, comparisons of inter-observer variability has shown reasonable agreement between observers using the SDS to assess postoperative pain in dogs[17]. In contrast, the VAS technique proved to have considerable lack of agreement between observers scoring sheep lameness[18]. With using multiple observers, and wanting the assessment system to be as practically applicable as possible, we therefore used a SDS, keeping the categories as unambiguous as possible. In many pain scoring systems in companion animals, no attempt is made to 'weight' different behavioral signs in the scoring system, and such systems have been criticized on this basis[19]. The issue of "weighting" specific conditions in animal welfare is far from resolved[20] but to be meaningful, we believe that any assessment of welfare, or indeed pain, should incorporate some mechanism for allowing for differences in the amount that particular conditions compromise welfare. Our approach attempts to do this and packages welfare assessment into a convenient and meaningful parcel that is more focused and manageable in a farm setting where multiple observers are necessary.

When presented with the picture welfare guidelines produced for this study, managers seem to be able to categorize welfare pigs because few pigs subsequently died in the light protocol, fewer in medium and fewer still in heavy. However, farms vary in the prevalence of the conditions monitored and farm managers need to focus on the conditions on their farms and adjust their protocol accordingly.

The scatterplots in Figures 1A-C provide managers with concise visual representations of the options available to them as they try to optimize the welfare status of their herds while minimizing economic losses. For the light protocol (Figure 1A) the 4 conditions (prolapse, weak, lame, and two-or-more) in the top left quadrant have a comparatively low value/high welfare score. These conditions are therefore prime candidates for immediate euthanasia for managers wanting to improve welfare status. By implementing the medium protocol (Figure1B) the only condition remaining in that quadrant is the presence of two-or-more concurrent conditions which can be removed by adopting the heavy protocol (at least for the two-or-more category).

**Sensitivity analysis**

The expected values of the chosen protocols (light, medium, heavy) are the average values of uncertainties and these are the result of probabilistic calculations enabling comparisons among the options available and with the stated probabilities. They represent the average values obtained if these treatments were repeated many times on similar pigs on similar farms. They are presented to enable managers to estimate the effect of adopting a protocol more suited to their circumstances by better representing the situation on their farms regarding the prevalence of conditions, probabilities of death for the various conditions, and the cost of treatment.

In interpreting these sensitivities remember that the proportions of all conditions must sum to 1 and so if the proportion of lightweight pigs increases then the proportion of other conditions must decrease to accommodate the change.

The sensitivity plots of value and welfare in Figure 3 illustrate that if a nursery has a high proportion of lightweight pigs (0.70, compared to 0.20) and they adopt the heavy protocol then value will decrease much more ($7.59 to -$0.28) than had they adopted a light protocol ($19.47 to $18.11). In addition, welfare will improve less with the heavy protocol (20.13 to 7.65) than with the light (93.45 to 76.03).

The limitations of this study are that, although we screened 51041 pigs and studied nearly 2000 on 5 farms the sample farms were not selected at random, they were convenience samples, and all in isolated nurseries in 3-site production systems. Thus, care must be taken in extrapolating the results from this study to the US or global nursery pig population. In addition, to enable us to compare results across the 5 study farms we mathematically adjusted the age and weight of pigs when they left the nursery to a standard 61 days. Consequently, this adjustment may not reflect the field situation where all pigs were actually shipped to the finisher at exactly 61 days. In addition, we probably overestimated the weight of those tagged pigs that were not weighed at shipping but estimated as the average of their contemporaries. This would slightly overvalue those pigs and the values for their protocol.

This study provides economic and welfare information for nursery farm managers, and their advisors, by which they can begin to make a considered judgement on the impact of their decision as to whether categories of casualty nursery pigs should be immediately euthanatized or kept and cared for until they are ready to move to the finisher.

Because of the high cost of compliance many farmers may find it difficult to access the emerging "welfare" markets[21] However, this paper provides some of the data needed by producers to help them decide how they can improve the welfare status of pigs on their farms at a cost appropriate to their pork enterprise.

**Implications:**

- By euthanatizing more casualty nursery pigs on arrival managers can improve the welfare status of the farm.
- After adopting the light euthanasia protocol, pigs that are weak, lame, with 2 or more conditions or prolapses have a low value and high welfare score and managers can increase farm welfare at least cost by immediately euthanatizing most of these pigs.
- As more pigs are euthanatized (progressing from light, medium, to heavy) the value of casualty pigs decreases 11 fold ($18.44 to $1.61) but welfare improves 7 fold (score 80 to 11)
- Farms vary in the prevalence of casualty conditions and managers need to focus on the conditions on their farms and adjust their protocol accordingly.

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**Table 1. Criteria for euthanasia by treatment protocol.**

| Level | CONDITION | Welfare score | Euthanasia Action (by protocol) | | |
|---|---|---|---|---|---|
| | | | Light | Medium | Heavy |
| | **Weak pig:** | | | | |
| A | Can get to feed and water with difficulty | **3** | **No** | **No** | **Yes** |
| B | Unable to use 2 legs | **10** | **No** | **Yes** | **Yes** |
| C | Unable to use 3 or 4 legs | **10** | **Yes** | **Yes** | **Yes** |
| | | | | | |
| | **Lame: e.g., swollen joint(s)** | | | | |
| A | 1 leg joint swollen and limping on 1 leg | **3** | **No** | **No** | **Yes** |
| B | 2 or more joints swollen and limping on 1 leg | **5** | **No** | **Yes** | **Yes** |
| C | 2 or more joints swollen and limping on 2 or more legs | **8** | **Yes** | **Yes** | **Yes** |
| | | | | | |
| | **Damaged digit** | | | | |
| A | 1 digit mildly damaged (don't tag) | **1** | **No** | **No** | **No** |
| B | 1 digit severely damaged | **3** | **No** | **No** | **Yes** |
| C | 2 digits damaged and with open wounds | **6** | **No** | **Yes** | **Yes** |
| | | | | | |
| | **Recently broken leg** | | | | |
| A | Suspect broken leg | **4** | **No** | **No** | **Yes** |
| B | Leg obviously broken | **10** | **No** | **Yes** | **Yes** |
| C | Compound fracture | **10** | **Yes** | **Yes** | **Yes** |
| | | | | | |
| | **Tail bitten** | | | | |
| A | Tail bitten only (don't tag) | **1** | **No** | **No** | **No** |
| B | Tail end bloody, infected | **3** | **No** | **No** | **Yes** |
| C | Tail end bloody, infected and most of it missing | **5** | **No** | **Yes** | **Yes** |
| D | Tail-head open wound, no tail | **7** | **Yes** | **Yes** | **Yes** |
| | | | | | |
| | **Ear- or flank-bitten:** | | | | |
| A | One or both ears (flanks) bitten, both mild (don't tag) | **1** | **No** | **No** | **No** |
| B | One or both ears (flanks) bitten, one more than mild | **1** | **No** | **No** | **Yes** |
| C | One ear (flank) bloody, infected and necrotic | **5** | **No** | **Yes** | **Yes** |
| D | Both ears (flanks) bloody, infected and necrotic | **6** | **Yes** | **Yes** | **Yes** |
| | | | | | |

| Level | CONDITION | Welfare score | Euthanasia Action (by protocol) | | |
|---|---|---|---|---|---|
| | **Beaten-up pig, numerous superficial skin wounds** | | | | |
| A | Skin wounds on one side only (don't tag) | **2** | **No** | **No** | **No** |
| B | Skin wounds on both sides but not on all 4 quarters (don't tag) | **3** | **No** | **No** | **No** |
| C | Skin wounds on both sides and all 4 quarters affected | **4** | **No** | **No** | **Yes** |
| D | Skin wounds on both sides, all 4 quarters affected and wounds are infected | **6** | **No** | **Yes** | **Yes** |
| | | | | | |
| | **Rectal prolapse** | | | | |
| A | Recent, undamaged and occasionally protruding (don't tag) | **1** | **No** | **No** | **No** |
| B | Recent, damaged and protruding | **4** | **No** | **No** | **Yes** |
| C | Recent, damaged and protruding for 2 or more days | **7** | **No** | **Yes** | **Yes** |
| | | | | | |
| | **Ruptures (scrotal and umbilical)** | | | | |
| A | Rupture is present but small | **1** | **No** | **No** | **Yes** |
| B | Rupture is large but the pig has no problem moving | **3** | **No** | **Yes** | **Yes** |
| C | Rupture is large infected/ulcerated, impedes mobility | **8** | **Yes** | **Yes** | **Yes** |
| | | | | | |
| | **Repaired Ruptures (scrotal and umbilical)** | | | | |
| A | Repaired rupture is healing but has mild swelling | **1** | **No** | **No** | **No** |
| B | Repaired rupture has obvious swelling but is healing | **2** | **No** | **No** | **No** |
| C | Repaired rupture has serious swelling with exudate | **5** | **No** | **No** | **Yes** |
| | | | | | |
| | **Weight compromised (include runts):** | | | | |
| A | Less that 40% under normal barn average weight (don't tag) | **0** | **No** | **No** | **No** |
| B | 40-49% under normal barn average weight | **1** | **No** | **No** | **Yes** |
| C | 50-59% under normal barn average weight | **2** | **No** | **Yes** | **Yes** |

| Level | CONDITION | Welfare score | Euthanasia Action (by protocol) | | |
|---|---|---|---|---|---|
| D | More than 60% under normal barn average weight | **3** | **Yes** | **Yes** | **Yes** |
| | | | | | |
| | **Abscess (including inguinal, scrotal, jowl):** | | | | |
| A | Any abscess, grape to golf ball size | **1** | **No** | **No** | **Yes** |
| B | Any abscess, golf ball to fist size | **2** | **No** | **Yes** | **Yes** |
| C | Any abscess, fist size or bigger | **3** | **Yes** | **Yes** | **Yes** |
| | | | | | |
| | | | | | |
| | **Respiratory:** | | | | |
| A | Just coughing and/or sneezing (don't tag) | **1** | **No** | **No** | **No** |
| B | Difficulty breathing, thumping for 3 days | **7** | **No** | **No** | **Yes** |
| C | Difficulty breathing, thumping for 5 days or more | **8** | **No** | **Yes** | **Yes** |
| D | Severe difficulty breathing, open mouth, thumping for 2 days or more | **10** | **Yes** | **Yes** | **Yes** |
| | | | | | |
| | **Gastrointestinal:** | | | | |
| A | Loose stools (don't tag) | **1** | **No** | **No** | **No** |
| B | Profuse diarrhea | **5** | **No** | **No** | **No** |
| C | Profuse diarrhea with dehydration | **8** | **No** | **No** | **Yes** |
| D | Profuse diarrhea with straining and dehydration | **8** | **No** | **Yes** | **Yes** |
| | | | | | |

**Table 2. Summary information for the Euthanasia trial**

| Farm (Owner/Site) | First batch | Last Batch | Number of batches | Number of hogs screened | Number of pigs euthanatized (%) | Number of pigs tagged (%) | Number of tagged pigs that died. (%) | Number of tagged pigs shipped. (%) |
|---|---|---|---|---|---|---|---|---|
| A/1 | July 2002 | September 2002 | 2 | 7171 | 200 (2.79) | 80 (1.11) | 25 (31.25) | 49 (61.25) |
| B/2 | July 2002 | October 2002 | 12 | 7052 | 17 (0.24) | 125 (1.77) | 31 (24.8) | 92 (73.60) |
| B/3 | July 2002 | September 2002 | 12 | 9618 | 12 (0.12) | 343 (0.12) | 18 (5.25) | 325 (94.75) |
| C/4 | August 2002 | September 2002 | 6 | 13239 | 432 (3.26) | 390 (2.94) | 18 (4.61) | 372 (95.38) |
| D/5 | November 2002 | February 2003 | 15 | 13961 | 158 (1.13) | 180 (1.29) | 94 (52.22) | 86 (47.78) |
| **Total** | | | 47 | 51041 | 819 (1.60) | 1118 (2.19) | 186 (16.64) | 924 (82.65) |

**Table 3. Final disposition and value of pigs by condition and level**

| | | Euthanatized on entry | Tagged Pigs | | | Number/value($) ±SD of euthanatized or tagged pigs | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Level | Number euthanatized | Number tagged | Number died (as % of tagged) | Number shipped | Farm A/1 | Farm B/2 | Farm B/3 | Farm C/4 | Farm D/5 |
| Abscess | A | 1 | 9 | 3 (33.33) | 5 | 2/19.5 ±28.86 | | | 4/45.49±2.56 | 6/21.72 ±29.87 |
| | B | 0 | 3 | | 3 | | | | | |
| Beaten | A | 0 | 1 | 1 (100) | | | | | | 1/-1.26 |
| Damaged Digits | A | 0 | 19 | 1 (4.35) | 18 | 10/16.45±24.09 | | 2/53.97±1.20 | 29/27.02±16.00 | 7/11.17 ±26.66 |
| | B | 8 | 17 | 4 (23.53) | 13 | | | | | |
| | C | 3 | 1 | 1 (100) | | | | | | |
| Lame | A | 37 | 66 | 18 (27.27) | 48 | 31/5.53±17.95 | 7/-0.87±0.86 | 4/54.06±2.06 | 62/19.90±20.04 | 58/10.94±19.95 |
| | B | 16 | 28 | 15 (53.57) | 13 | | | | | |
| | C | 14 | 1 | | 1 | | | | | |
| Lightweight | A | 5 | 14 | | 14 | 172/1.71±7.18 | 70/36.61±11.80 | 26/50.41±15.11 | 658/16.94±20.02 | 161/4.98±13.97 |
| | B | 131 | 325 | 31 (9.54) | 294 | | | | | |
| | C | 304 | 141 | 25 (17.73) | 116 | | | | | |
| | D | 167 | 0 | | | | | | | |
| Prolapse | C | 1 | 1 | 1 (100) | | 1/-7.70 | | | | 1/0 |
| Repaired Rupture | A | 0 | 222 | 13 (5.86) | 209 | | | 310/49.18± 12.38 | | |
| | B | 0 | 88 | 3 (3.41) | 85 | | | | | |
| | C | | | | | | | | | |
| Respiratory | B | 1 | 0 | | | 1/0 | | | | |
| Rupture | A | 26 | 47 | 21 (44.68) | 25 | 47/18.44±22.79 | 24/5.56±20.62 | 1/57.02 | 5/35.71±20.94 | 56/10.43±17.78 |
| | B | 19 | 32 | 9 (28.12) | 23 | | | | | |
| | C | 4 | 1 | | 1 | | | | | |
| | D | 4 | 0 | | | | | | | |
| Unknown | Unknown | 18 | | | | | 4/0/0 | 11/0± 0 | | 3/0±0 |
| Two or more | Any level | 30 | 50 | 11 (13.75) | 39 | 7/7.8± 13.82 | 4/28.88±20.12 | | 60/22.25±20.11 | 9/-0.84±1.28 |
| Weak | A | 2 | 39 | 26 (66.67) | 13 | 3/3.61 ±12.73 | 14/23.02±23.61 | 1/0±0 | 1/0±0 | 32/5.38 ±18.39 |
| | B | 4 | 3 | 1 (33.33) | 2 | | | | | |
| | C | 3 | 0 | | | | | | | |

**Table 4. Mean value ($) and welfare score of pigs by farm and protocol**

| Farm | Protocol | Number | Mean value ($) | Mean welfare score |
|---|---|---|---|---|
| A/1 | Light | 74 | 21.53 | 112.86 |
| | Medium[2] | 0 | 0 | |
| | Heavy[3] | 200 | 0 | 0 |
| B/2 | Light | 65 | 26.98 | 74.52 |
| | Medium | 56 | 24.56 | 69.55 |
| | Heavy | 3 | 0 | 0 |
| B/3 | Light | 165 | 48.99 | 73.51 |
| | Medium | 112 | 46.56 | 79.38 |
| | Heavy | 78 | 46.66 | 59.68 |
| C/4 | Light | 299 | 30.43 | 82.88 |
| | Medium | 268 | 19.22 | 51.58 |
| | Heavy | 254 | 2.15 | 3.87 |
| D/5 | Light | 147 | 10.81 | 95.18 |
| | Medium | 103 | 7.81 | 31.90 |
| | Heavy | 87 | 0.31 | 1.33 |

[1]The negative numbers reflect the feed cost for tagged pigs that died.
[2] Medium protocol not implemented
[3] All pigs euthanatized

**Table 5. Least squares mean and standard error for the value ($) and welfare score for all protocol**

| | All Pigs | | Light Protocol | | Medium protocol | | Heavy Protocol[1] | |
|---|---|---|---|---|---|---|---|---|
| | Value ($) | Welfare | Value ($) | Welfare | Value ($) | Welfare | Value ($) | Welfare |
| Condition | LSMEAN ± SE | LSMEAN ± SE | LSMEAN ± SE | LSMEAN± SE | LSMEAN ± SE | LSMEAN± SE | MEAN ± SE | MEAN± SE |
| Abscess | 38.04±4.62 | 66.82±16.72 | 46.40±6.26 | 100.84±19.86 | 62.80±11.91 | 151.05±41.64 | 0 | 0 |
| Beaten[2] | 21.42±13.95 | 45.78±50.52 | | | | | -1.14 | 2 |
| Damaged Digits | 28.03±2.79 | 95.04±10.10 | 37.70±7.66 | 163.05±24.32 | 23.08±5.82 | 72.75±20.35 | 20.21±17.29 | 36.41±30.25 |
| Lame | 14.12±1.56 | 87.24±5.65 | 19.64±2.79 | 147.73±8.84 | 13.88±2.30 | 72.49±8.03 | -0.12±0.86 | 2.59±17.19 |
| Lightweight | 18.34±0.95 | 16.66±3.38 | 23.37±2.00 | 27.80±6.28 | 19.45±1.42 | 10.57±4.97 | 0 | 0 |
| Prolapse | 4.20±9.70 | 55.70±35.12 | 1.69±15.57 | 128.79±49.42 | 6.49±11.90 | 8.40±41.59 | | |
| Repaired rupture | 29.41±2.20 | 65.65±7.95 | 27.66±3.42 | 64.50±10.84 | 44.17±3.48 | 93.13±12.17 | 49.22±16.38 | 62.9±26.07 |
| Respiratory[3] | 13.85±13.63 | 40.01±49.37 | | | | | 0 | 0 |
| Rupture | 11.26±2.54 | 46.74±9.18 | 31.35±4.89 | 202.04±15.40 | 15.71±3.46 | 31.95±12.09 | 0 | 0 |
| Two or more | 21.04±7.02 | 83.79±25.44 | 24.58±3.06 | 187.77±9.68 | 20.73±2.47 | 126.48±8.87 | 0 | 0 |
| Unknown | -9.49±3.42 | -5.32±12.37 | -9.57±7.27 | -11.72±23.04 | -5.05±5.74 | 2.35±20.07 | | |
| Weak | 10.24±3.27 | 80.26±11.84 | 14.13±4.97 | 165.92±15.75 | 13.43±4.04 | 43.31±14.13 | 0 | 0 |

[1]Least squares means were not calculated because of the lack of variation in both the economic value and welfare cost for the heavy protocol.
[2]Only 1 pig represented. It was tagged and subsequently died.
[3]Only 1 pig represented. It euthanized upon entry.

**Figure 1A. Economic Value and Welfare Costs by Condition (reason) for Light Protocol**
**Least-Squared Means**

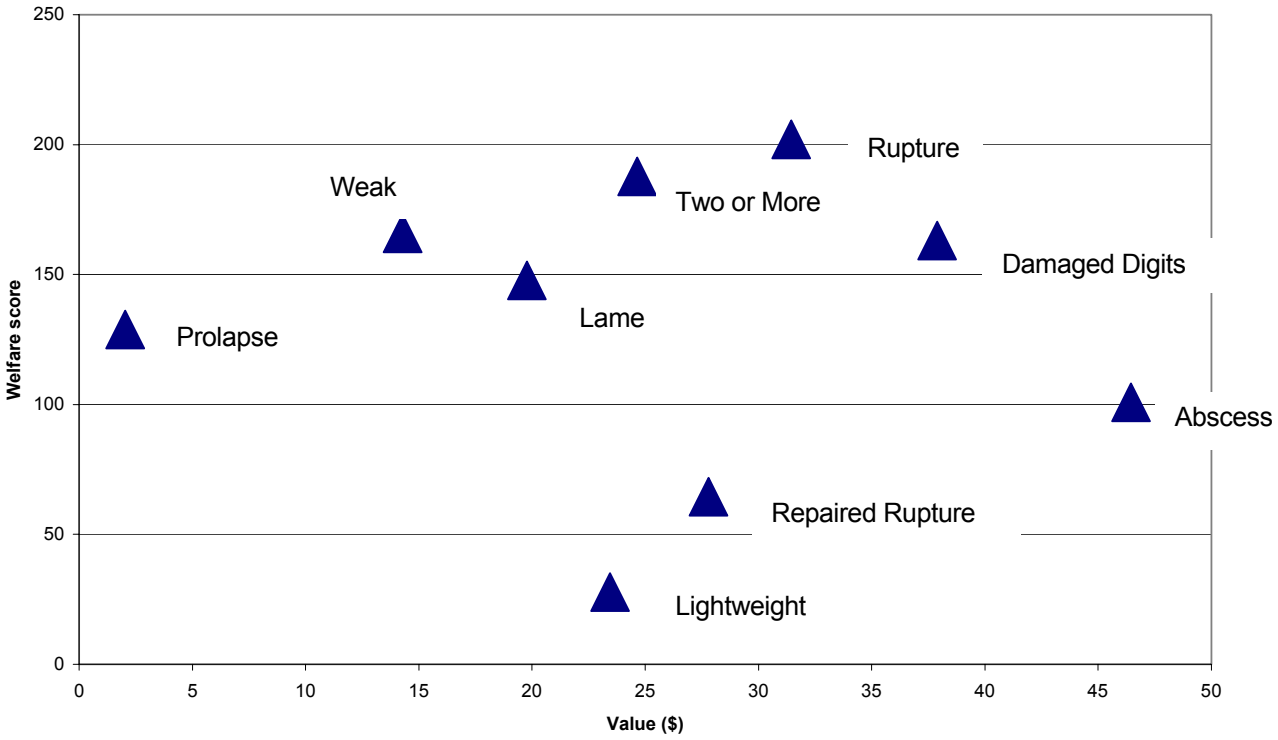


**Figure 1B. Economic Value and Welfare Cost by Condition (reason) for the Medium Protocol**
**Least-Squared Means**

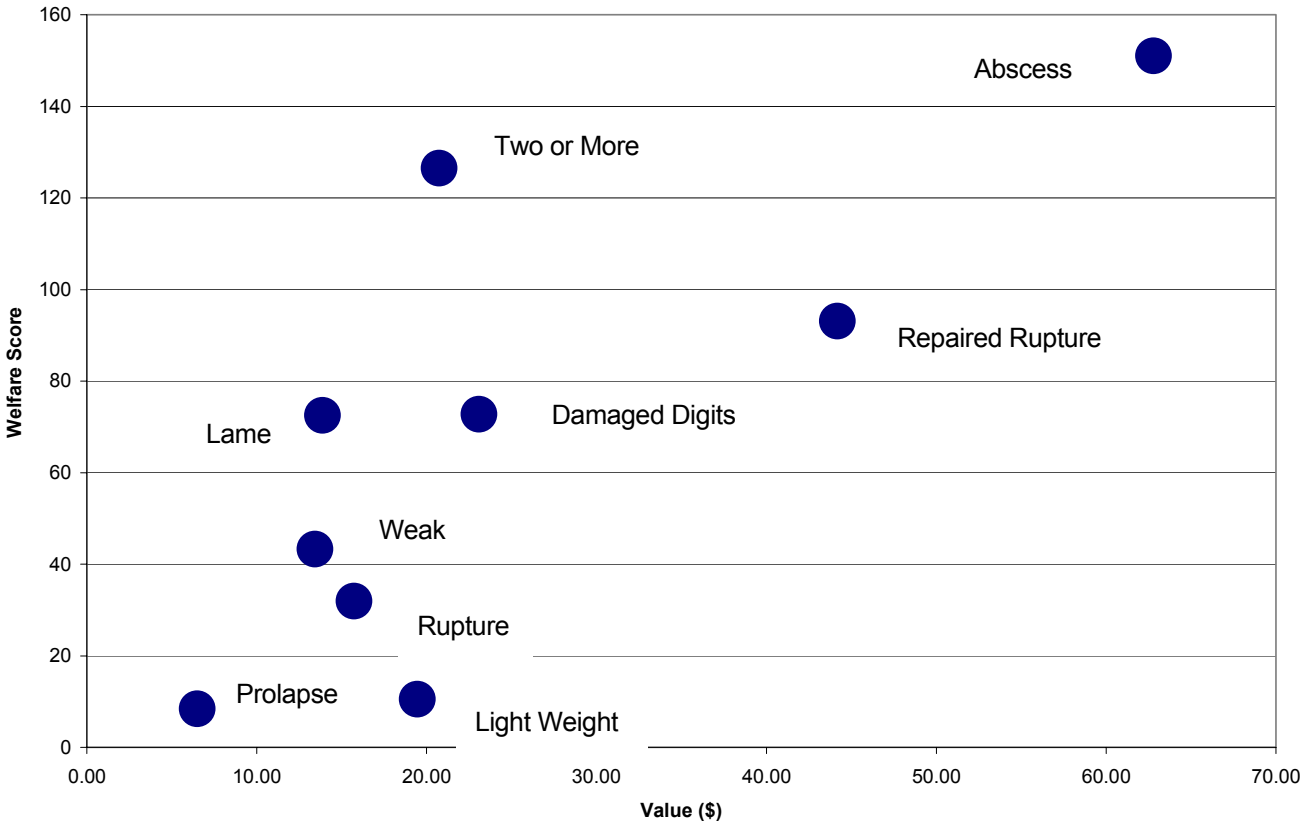


**Figure 1C. Economic Value and Welfare Costs by Condition (reason) for Heavy Protocol**
**Means**

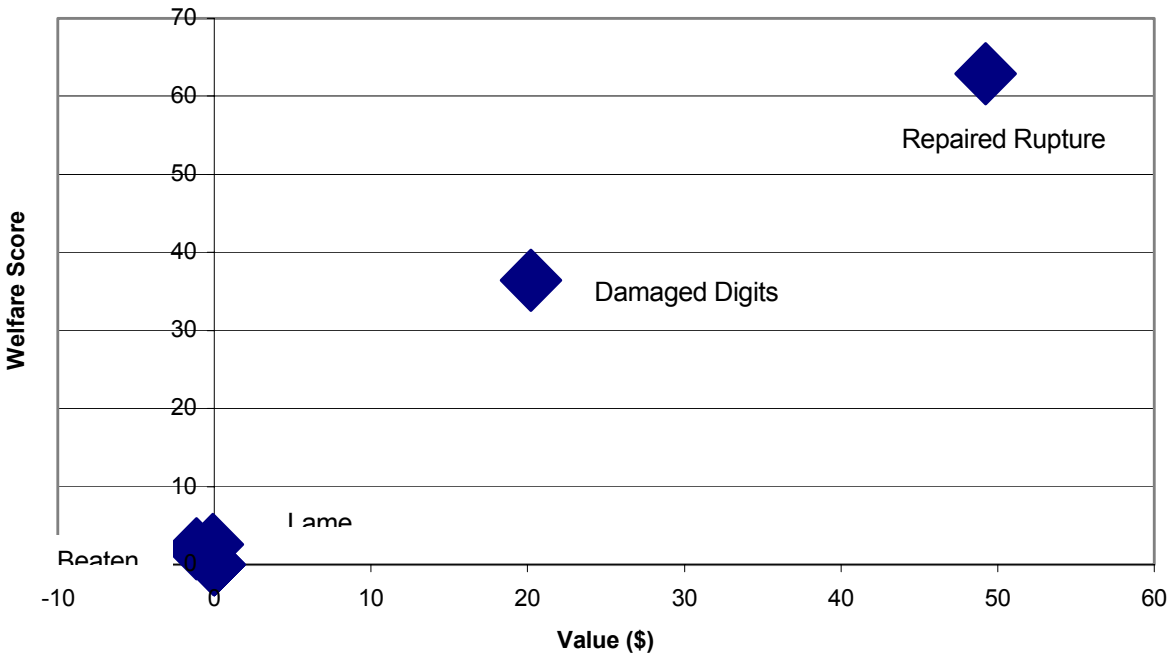


Figure 2. Decision tree for lightweight pigs.

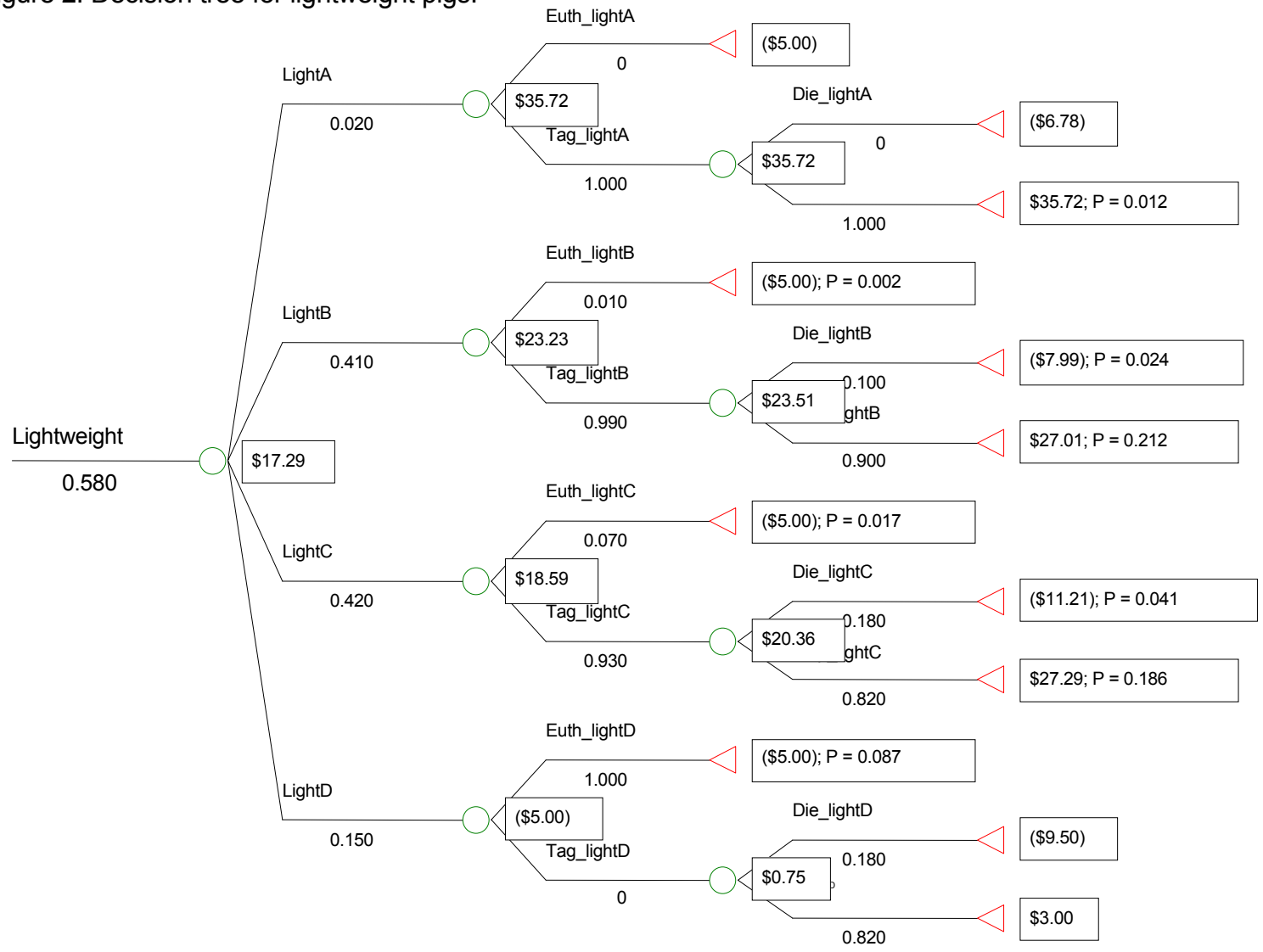


**Figure 3A. Sensitivity of value ($) to the proportion of lightweight pigs**

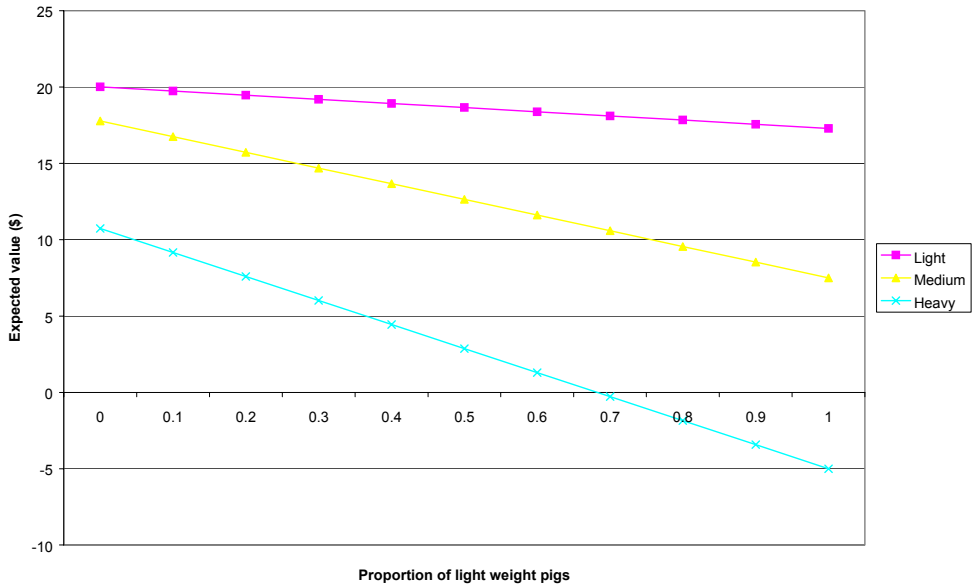
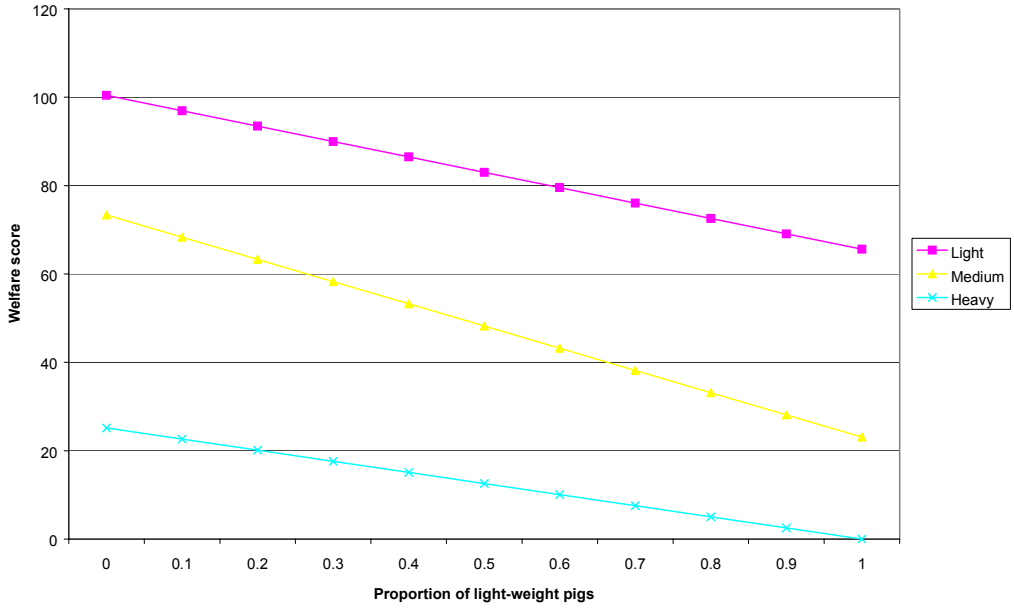



**Figure 3B. Sensitivity of welfare score to the proportion of lightweight pigs**



Legend for Figure 2. Decision tree.

LightA, LightB, LightC, LightD are the probabilities for lightweight pigs in levels A,B,C, and D respectively
Euth_lightA and Tag_lightA are the probabilities for a lightweight pig of level A to be euthanatized or tagged respectively.
Die_LightA is the probability for a tagged lightweight pig of level A to die after it is tagged.
Dollar values in the text boxes represent the value of the pigs at the nodes.