

## RATING KILLING TRAPS AGAINST HUMANE TRAPPING STANDARDS USING COMPUTER SIMULATIONS

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**ABSTRACT:** The Agreement on International Humane Trapping Standards (AIHTS) which applies to wildlife management, vertebrate pest control, and trapping for fur, skin or meat for 19 listed species requires that a trapping method render at least 80% of a minimum of 12 target animals irreversibly insensible within a species-specific time limit. However, the Agreement also allows for the use of other scientifically proven methods as a substitute for testing on live animals. For the past five years, we have been developing computer models and simulation systems to determine whether killing traps meet humane trapping standards. The models were designed to classify the time-to-loss-of-sensibility of furbearing species based on mechanical characteristics of traps and strike location(s). Models were based on data collected from trap testing on marten (*Martes americana*), fisher (*Martes pennanti*) and raccoon (*Procyon lotor*). Models were tested against 15 years of live trap testing data from the Fur Institute of Canada. The models proved to be a valid alternative to trap testing on live animals due to their high levels of safe prediction accuracy (88%, 86%, and 92% for marten, fisher, and raccoon, respectively). If applied to trap testing, these models would dramatically reduce the cost and the need for trap testing on live animals.

**KEY WORDS:** humaneness, trapping standards, killing traps, Canada, furbearers, wildlife management, vertebrate pest control, insensibility, statistical models, computer simulations.

## INTRODUCTION

In Canada, research in the area of humane trapping was initiated in the mid 1970's by the Federal-Provincial Committee on Humane Trapping (1981). Since 1994, the Alberta Research Council (ARC) has been using computer modeling as a tool to evaluate and improve the efficiency and accuracy of the trap testing procedures. The modeling makes use of the data collected from trap testing on furbearing animals accumulated since trap testing research began for the Fur Institute of Canada at ARC's Vegreville facility in 1985 (Nolan and Barrett 1990).

Initially, threshold curves based on the mechanical characteristics of killing traps (momentum and clamping forces at various trap openings) were developed to predict their humaneness (Benn et al. 1980; Benn et al. 1981). Humaneness or effectiveness of killing traps is determined by the irreversible time-to-loss-of-sensibility (TTLS) of the animals trapped. Warburton and Hall (1995) found that momentum and clamping force thresholds developed using anaesthetized animals were predictive of results on unanaesthetized brushtail possums (Trichosurus vulpecula). However, Hiltz and Roy (unpublished data) found that results from trap testing on anaesthetized animals were not predictive of results on unanaesthetized animals for many other species.

In 1997, the Agreement on International Humane Trapping Standards (AIHTS) was signed by the European Union, Canada, and the Russian Federation. The United States signed a similar agreement with the European Union. The trilateral agreement requires that killing and restraining devices for a list of 19 animal species must be certified as meeting the Standards

(AIHTS 1997). For killing traps, the Standard requires that a trapping method render at least 80% of a minimum of 12 target animals irreversibly insensible within a species-specific time limit. Sensibility is determined by monitoring the animal's corneal and palpebral reflexes, i.e., the eyes' blinking response to air pressure and the eyes' blinking response to touch, respectively. An animal is considered irreversibly insensible when all corneal and palpebral reflexes are lost until the heartbeat ceases. Though this standard has proven effective, its major drawbacks are its costs and the requirements for testing on live animals. In an effort to address these two problems, the AIHTS allows substitution of trap testing on live animals by any other scientifically proven suitable substitute parameter.

Consequently, the objective of this study was to evaluate the prediction accuracy of computer simulation techniques for killing trap compliance with the TTLS requirements of the AIHTS. Models used the mechanical characteristics of killing traps and the resulting strike location(s) to predict trap effectiveness on unanaesthetized animals. Simulations of these models were used to predict whether or not a killing trap would meet the TTLS requirements of a trapping standard. If the predictions are accurate, the necessity of trap testing on live animals would be greatly reduced, as testing would only be required for traps whose mechanical design differs significantly from those used to develop the simulation models (straight-jawed; rotating jaw, planar, and mouse trap style traps).

## MATERIALS AND METHODS

### Data Source and Variable Description

Data used to develop and test models were collected over the last 15 years by the Trap Effectiveness Research Team at the Alberta Research Council in Vegreville, Alberta. All traps

were mechanically evaluated using a digital waveform analyzer, an accelerometer, and a load cell (Cook and Proulx 1989). The velocity (m/s) and momentum (kg m/s) of each trap design was determined at the trap's critical jaw displacement, which was at 1/2 displacement for rotating jaw traps, at 2/3 displacement for planar traps, at 1/2 displacement for mouse trap style traps which rotate through 90° and at 3/4 displacement for mouse trap style traps which rotate through 180° (Canadian General Standards Board 1996). The clamping forces (N) at 5 mm increments of jaw openings were also measured. Nonlinear curves were fit to determine the clamping force at the actual jaw opening observed for each trap test. For double strikes, the clamping force at the larger of the two openings was used to represent the test.

Information from 185 animal-trap tests from three furbearing species (marten (Martes americana), fisher (Martes pennanti), and raccoon (Procyon lotor)) using 17 different trap designs were used to build the preliminary computer simulation models (Table 1). Trap tests were done in a simulated natural environment where the animals were free to approach the trap (Proulx et al. 1989, 1990). The tests used in the modeling included only strikes in vital regions, which are defined to be from the back of the eyes to the distal end of the thorax.

A number of mechanical characteristics of each trap design were tested to determine the best predictors of trap effectiveness. These included clamping forces at the trap openings (N), velocity (m/s), striking bar shape (round or square), trap type (rotating jaw, planar, mouse), equivalent mass (kg), momentum (kg m/s), kinetic energy (kg m<sup>2</sup>/s<sup>2</sup>), and trap measurements such as striking bar diameter/width (mm). Other factors which were tested in the model building process were strike type (single or double), strike location (head, atlanto-occipital (relating to the atlas and the occipital bone at back of head), neck, and/or thorax), animal positioning in the trap, animal size, and set type.

### Model Development

Logistic regression models (Hosmer and Lemeshow 1989) were fit to the data, with model selection based on prediction ability,  $R^2$  values, significance of variables in the model, and collinearity diagnostics. The LOGISTIC procedure in SAS was used for model fitting (SAS Institute Inc. 1989). For this application, we modeled the probability that an animal lost sensibility within the species-specific time frame.

A jackknifing approach to cross-validation was used to reduce the bias of classifying the same data from which the classification criterion was originally derived (SAS Institute Inc. 1989). Further model validation was done by running additional compound tests and comparing the results to model predictions.

### Computer Simulation Application

Computer simulations were applied to the resulting predictive models. Ten thousand simulations were run to determine the percentage of passes for a particular trap design on a particular species. Each run consisted of randomly sampling, with replacement, a jaw opening from the original species trap testing database. The jaw opening was then used to estimate the clamping force based on the nonlinear curve fit for the trap design being tested. The probability of a TTLS less than the species-specific time limit was calculated using the clamping force, momentum, velocity, and strike location. The number (or percentage) of passes out of the 10,000 tests was determined by counting the number of tests which had a higher predicted probability of passing than failing. If 80% or more of the 10,000 runs were passes then the trap design was predicted to meet the requirements of the AIHTS.

## RESULTS

### Marten

The model for marten was based on 102 tests using eight different trap designs. To meet the requirements of the AIHTS, at least 80% of a minimum of 12 marten must lose sensibility within 120 seconds. The model was built to predict the probability that a given test would result in a TTLS less than or equal to 120 seconds. The final model contained two predictive factors: the interaction between clamping force (N) and momentum (kg m/s) and an additive velocity term (m/s). The log-likelihood statistic indicated that the model was a good fit (33.612,  $P = 0.0001$ ). The model correctly predicted 74% of the trap test outcomes (Table 2) based on the jackknife cross-validation procedure. We classified error as unacceptable when unsuccessful tests were misclassified as successful; this error occurred for only 12% of the cases resulting in a safe prediction accuracy of 88%.

### Fisher

The TTLS requirements for fisher are different from marten in that at least 80% of a minimum of 12 fisher must lose sensibility within 300 seconds for a trapping method to pass. The fisher model was built using data from 46 tests using seven different trap designs. Although the coefficients differed slightly, the fisher model closely resembled the marten model. It contained terms representing the velocity (m/s) and the interaction between clamping force (N) and momentum (kg m/s). The log-likelihood statistic indicated a good fit to the model (12.545,  $P = 0.0019$ ). Each observation was classified as either  $\text{TTLS} \leq 300$  seconds or  $\text{TTLS} > 300$  seconds depending on which had the higher predicted probability. The fisher model correctly

predicted 84% of the trap test outcomes based on the jackknife cross-validation procedure (Table 3). In 14% of the cases, unsuccessful tests were misclassified as successful leading to a safe prediction accuracy of 86%.

### Raccoon

The TTLS requirements for raccoon are the same as those for fisher, where at least 80% of a minimum of 12 raccoon lose sensibility within 300 seconds for a trapping method to pass. This model was based on 37 tests using four different trap designs. The raccoon model was somewhat different than previous models. It did not contain the additive velocity term. The interaction between clamping force (N) and momentum (kg m/s) continued to be an important factor and an additional term relating to strike location (more specifically, atlanto-occipital strikes) was also included in the raccoon model. The log-likelihood statistic indicated a good fit for the model (12.671,  $P = 0.0018$ ). The raccoon model correctly predicted 84% of the trap test outcomes based on the jackknife cross-validation procedure (Table 4). In 8% of the cases, unsuccessful tests were misclassified as successful leading to a safe prediction accuracy of 92%.

### Rating of Killing Traps Using Computer Simulation

The three models described above allow us to predict whether a single trap test with one animal would pass the TTLS criteria set out in the AIHTS. The computer simulations are applied to predict whether 80% of a series of tests meet the requirements of the AIHTS. Simulation results for a sample of marten traps are presented in Figure 1. The relative placement on the y-axis is the mean of the 10,000 probabilities and although it does not impact the trap rating it is a useful tool for comparing between traps. These results are for all vital strike

locations (head, neck, and thorax). Based on the simulation results, Trap 1 meets the requirements of the AIHTS (82%), while Trap 2 (40%) and Trap 3 (0%) do not.

Since the marten model was the first model completed, three additional compound tests for marten were done during 1998-99 to test the accuracy of the computer simulations. The simulation was run on the three new trap designs prior to compound-based testing to predict whether or not the traps meet the TTLS requirements of the AIHTS. For all three traps, the model correctly predicted whether or not the trap met the requirements of the AIHTS.

## DISCUSSION

Current computer technology and the extensive Trap Effectiveness Project database have made it feasible to develop these computer simulation models to replace trap testing on animals. The cost-savings of the computer simulations compared to compound testing was approximately 85%. This savings, together with the elimination of animal-based testing for traps and species to which the models apply, make the computer simulations an attractive alternative. Furthermore, the simulation models are adaptable to changes in the Standard's TTLS criteria (i.e. drop from 300 seconds to 180 seconds) without the need for further animal-based testing.

The models for marten, fisher, and raccoon classified the TTLS of a trap design with 88%, 86%, and 92% safe prediction accuracy, respectively. We hypothesize that synthesizing the results from many tests into a single model produces a more powerful decision making tool than the traditional compound testing based on a small sample size of 12. A trap manufacturer still has the option of having a compound test run; however the costs associated with it make it impractical.

The models and simulation approach have undergone many forms of scientific scrutiny including in-depth peer reviews. The provincial and territorial governments of Canada have approved the use of the computer simulations as a scientifically valid alternative to compound tests. Once results of the simulations are reported, the traps, which pass, are then subject to Certification by the provincial and territorial governments and those Aboriginal agencies that are sanctioned to regulate the use of traps. As with many areas of research, as more data is collected existing models may be refined and possibly expanded to include other parameters to improve prediction accuracy. The development of new models for other species will expand the tools available for efficient and accurate testing of humane trapping devices.

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## TABLES

Table 1. Number of animal-trap tests by species and trap design completed by the Trap Effectiveness Project in Vegreville, Alberta from 1985 to 1998 used to build the computer simulation models.

Species	Trap Design	Number of Tests
Marten	5" Rotating Jaw	17
	5" Rotating Jaw w/ 160 springs	12
	5" Rotating Jaw w/ clamping bars and 220 springs	20
	Planar Design 1	6
	Planar Design 2	16
	Planar Design 3	14
	Modified Planar Design	3
	5" Rotating Jaw w/ clamping bars	14
Fisher	Mouse Trap Type w/ 7 notches	6
	Mouse Trap Type w/ 8 notches	13
	6" Rotating Jaw	3
	6" Rotating Jaw w/ clamping bars and 280 springs	1
	6" Rotating Jaw w/ clamping bars and 330 springs	5
	6" Rotating Jaw w/ clamping bars and modified 330 springs	6
	8" Rotating Jaw w/ clamping bars	12
	Raccoon	5½" Rotating Jaw
6" Rotating Jaw		12
7" Rotating Jaw w/ clamping bars		7
8" Rotating Jaw w/ clamping bars		6

Table 2. Classification table indicating the percentage of correct and incorrect predictions based on cross-validation of the marten model.

	Model Predictions		Totals
	TTLS ≤ 120 sec.	TTLS > 120 sec.	
Correct	38%	36%	74%
Incorrect	12%	14%	26%
Totals	50%	50%	100%

Table 3. Classification table indicating the percentage of correct and incorrect predictions based on cross-validation of the fisher model.

	Model Predictions		Totals
	TTLS $\leq$ 300 sec.	TTLS $>$ 300 sec.	
Correct	75%	9%	84%
Incorrect	14%	2%	16%
Totals	89%	11%	100%

Table 4. Classification table indicating the percentage of correct and incorrect predictions based on cross-validation of the raccoon model.

	Model Predictions		Totals
	TTLS $\leq$ 300 sec.	TTLS $>$ 300 sec.	
Correct	70%	14%	84%
Incorrect	8%	8%	16%
Totals	78%	22%	100%

FIGURES

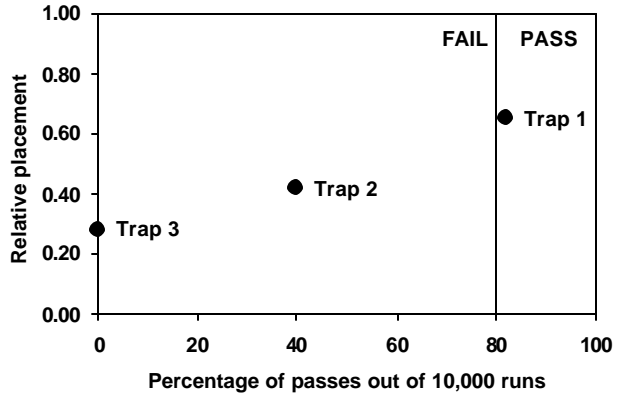


Figure 1. Simulation results for a sample of trap designs tested against the International Humane Trapping Standards for marten. Results are for all vital strike locations.