

## **APPENDIX 2. Cost Estimates for Deer-, Elk-, and Moose-Vehicle Collisions**

We estimated the cost of the average collision with a deer, elk, or moose (Table 2) based on a review of the literature. Unless indicated otherwise, all cost estimates were expressed as US\$ as reported in the cited work. For our analyses we converted all costs to 2007 US\$ using the U.S. Consumer Price Index (U.S. Department of Labor 2008). The components included in our cost estimate were vehicle repair costs, costs associated with human injuries and fatalities (see also e.g. Bissonette et al. 2008), towing, accident attendance and investigation, the monetary value to hunters of the animal that was killed in the collision, and the cost of disposal of the animal carcass. Passive use costs (see main text of the paper) were not included in our cost estimate.

### *Vehicle repair costs*

In Nova Scotia, the percentage of collisions involving white-tailed deer which resulted in property damage was estimated at 90.2% – 3,524 collisions with property damage out of 3,905 collisions (Tardif & Associates Inc. 2003). In Utah this percentage was estimated at 94% (Romin and Bissonette 1996). There were no similar data available for elk and moose. For these analyses the percentage of collisions resulting in property damage was assumed to be 92% for collisions with deer and 100% for collisions with elk or moose. Current data from a major auto insurance company in the United States showed that in 2006-2007 the average vehicle repair costs were about US\$2,900 for all species combined (Personal communication Dick Luedke, State Farm Insurance). The species specific costs were US\$2,850 for deer ( $n = \pm 178,500$ ), US\$4,550 for elk ( $n = \pm 900$ ), and US\$5,600 (moose;  $n = \pm 550$ ) in 2006-2007 (Personal communication Dick Luedke, State Farm Insurance). Combined with the percentage of chance that a collision results in property damage, the average vehicle repair costs per collision were estimated at US\$2,622 (deer), US\$4,550 (elk), and US\$5,600 (moose) (all in 2007 US\$).

### *Human injuries*

The percentage of white-tailed deer-vehicle collisions resulting in human injuries was estimated at 2.8% in Michigan (12 injuries from 60,875 collisions) (SEMCOG 2007), 3.8% in the US Midwest (4,724 injuries from 125,608 collisions) (Knapp et al. 2004); 4% in Ohio (review in Schwabe et al. 2002), 4% (review in Conover et al. 1995), 7.7% in Ohio (10,983 injuries from 143,016 collisions) (Schwabe et al. 2002); and 9.7% in Nova Scotia (378 injuries from 3,905 collisions) (Tardif & Associates Inc. 2003). Similar data could not be retrieved for elk. The percentage of moose-vehicle collisions resulting in human injuries was estimated at 18% in Newfoundland and Labrador (Government of Newfoundland and Labrador 1997); 21.8% in Newfoundland (363 injuries from 1,662 collisions) (Tardif & Associates Inc. 2003); 20% in rural Alaska (Thomas 1995); 23% in Maine (Huijser et al. 2007a); and, 23% in Anchorage, Alaska (158 injuries from 519 collisions) (Garrett and Conway 1999). The ratio of moose-vehicle collisions to human injuries was estimated at 1:0.201 in Newfoundland (Rathey and Turner 1991) and 1:0.304 in Anchorage, Alaska (Garrett and Conway 1999). The ratios are higher than the percentages because more than one person may be present in a car, and multiple people may be injured as a result of one collision. Based on the data presented above, it was assumed that an animal-vehicle collision resulted in an average of 0.05 human injuries for deer, 0.10 for elk, and 0.20 for moose. When these proportions are combined with the relative frequency for each of the three injury categories distinguished in the General Estimates System for animal-vehicle collisions, (51.4% for possible human injuries, 38.4% for evident human injuries, and 10.3 % for

incapacitating or severe human injuries (Huijser et al. 2007a)) and the standard costs associated with each injury category, (US\$24,418 for possible human injuries, US\$46,266 for evident human injuries, and US\$231,332 for incapacitating or severe human injuries (U.S. Department of Transportation 1994, Huijser et al. 2007a)), it results in species specific cost estimates for human injuries (Table A2.1). The average costs of human injuries per collision are US\$2,702 for deer, US\$5,403 for elk, and US\$10,807 for moose (all in 2007 US\$) and these costs include lost earnings, lost household production, medical costs, emergency services, travel delay, vocational rehabilitation, workplace costs, administrative, legal, and pain and lost quality of life (U.S. Department of Transportation 1994).

Table A2.1: Estimated costs (in 2007 US\$) per type of human injury for the average deer-, elk-, and moose-vehicle collision.

Type of human injury	Deer (US\$)	Elk (US\$)	Moose (US\$)
Possible	\$627	\$1,254	\$2,508
Evident	\$887	\$1,775	\$3,550
Incapacitating/severe	\$1,187	\$2,374	\$4,749
Total	\$2,702	\$5,403	\$10,807

#### *Human fatalities*

The percentage of white-tailed deer-vehicle collisions resulting in human fatalities was estimated at 0.009% in Ohio (14 collisions with human fatalities from 143,016 collisions) (Schwabe et al. 2002); 0.020% (12 fatalities from 60,875 collisions) (SEMCOG 2007); 0.029% in North America (review in Schwabe et al. 2002); 0.03% in the US Midwest (33 collisions with human fatalities from 125,608 collisions) (Knapp et al. 2004); and 0.05% in Nova Scotia (2 collisions with human fatalities from 3,905 collisions) (Tardif & Associates Inc. 2003). Similar data could not be retrieved for elk. The percentage of moose-vehicle collisions resulting in human fatalities was estimated at 0% in Anchorage, Alaska (0 fatalities from 519 collisions) (Garrett and Conway 1999); 0.26% in Newfoundland (14 fatalities from 5,422 collisions) (Joyce and Mahoney 2001), 0.36% in Newfoundland (6 collisions with human fatalities from 1662 collisions) (Tardif & Associates Inc. 2003), 0.45% in Newfoundland (3 fatalities from 661 collisions) (Rathey and Turner 1991); 0.43% in Maine (Huijser et al. 2007a); and 0.50% in rural Alaska (Thomas 1995). Based on the data presented above, it was assumed that an animal-vehicle collision resulted in an average of 0.0003 (deer), 0.0020 (elk), and 0.0040 (moose) human fatalities. When these proportions are combined with the costs associated with a human fatality (US\$3,341,468 (U.S. Department of Transportation 1994, Huijser et al. 2007a)), it results in a cost estimate for human fatalities of US\$1,002 (deer), US\$6,683 (elk), and US\$13,366 (moose) for each collision (all in 2007 US\$).

#### *Towing, accident attendance and investigation*

Not all wildlife-vehicle collisions require the towing of a vehicle, and attendance or investigation by medical personnel, fire department personnel, or police. When they do, the cost for these efforts was estimated to vary between Can\$100 and Can\$550 (Clayton Resources Ltd. & Glen

Smith Wildlife Consultants 1989). Note that the cost for the actual medical assistance is included in the cost estimates for human injuries calculated earlier. Based on the data presented above, it was assumed that the cost of towing, and accident attendance or investigation is US\$500, but these services are only required or provided in 25% (deer), 75% (elk) and 100% (moose) of the collisions. These assumptions result in an average cost for towing, accident attendance and investigation of US\$125 (deer), US\$375 (elk), and US\$500 (moose) for each collision (all in 2007 US\$).

#### *Monetary value of animals*

The monetary value of animals can include benefits associated with hunting or viewing the animal or with the passive use values for the existence of the given animal. Passive use values are likely to be location and population specific, and the literature on wildlife viewing values is not extensive. Therefore we only included hunting-related values in our analyses. These values are measured by what the hunter would be willing to pay over and above the costs of the hunt, for example to access a hunting area. For the U.S. and Canada access for hunting on most private and public lands is free. However, what the maximum amount the hunter would be willing to pay for access if necessary is a measure of the net benefit or hunter "willingness-to-pay" for the hunt (Ward and Duffield 1992).

These net benefits are also referred to as "consumer surplus". For the application to collisions, the foregone expected value related to hunting would be the hunting value per animal times the probability that it would have been harvested. The hunting value per animal can be derived from the hunter willingness to pay for a season of hunting divided by the success rate per hunt. There is extensive literature on net economic values for hunting, usually based on travel cost or contingent valuation methods (for example, see Ward and Duffield 1992), but most of these are location (e.g. hunt district or perhaps state) specific. The most comprehensive hunting value estimates have been developed by the U.S. Fish and Wildlife Service in their periodic national fishing and hunting surveys. The most recent values available for hunter willingness to pay for a season of hunting are for 2001 (U.S. Fish and Wildlife Service 2003), and in 2001 dollars averaged US\$377 for deer, US\$579 for moose (just Alaska) and for elk hunting (CO, ID, MT, OR, WY) were US\$380 for resident hunters and US\$556 for nonresident hunters or a weighted average (based on the number of resident and nonresident big game hunters for these states (U.S. Fish and Wildlife Service 2002)) of US\$424. Corrected to 2007 price levels, these values are US\$441 for deer, US\$496 for elk, and US\$678 for moose. Success rates for these species are not reported in each survey year, but were estimated by U.S. Fish and Wildlife Service (1998) for 1996 at 0.61 for deer, 0.20 for elk, and 0.14 for moose. This implies the value of a successful hunting season for these species, respectively, as US\$723, US\$2,480, and US\$4,843. Crête and Daigle (1999) provide estimates of 1995-1996 hunting harvest as a share of pre-harvest populations for these species in North America as 0.16 for deer (whitetail and mule deer combined) and elk, and 0.08 for moose. Given this probability that a given animal will be harvested by a hunter, the implied foregone hunting value associated with the average collision is US\$116 for deer, US\$397 for elk, and US\$387 for moose (Table 2).

#### *Removal and disposal costs of deer carcasses*

In Canada, the clean-up, removal and disposal costs for animal carcasses were estimated at Can\$100 for deer and Can\$350 for moose (Sielecki 2004). In Pennsylvania, the average for deer

carcass removal and disposal in a certified facility was US\$30.50 per deer for contractors and US\$52.46 per deer for the Pennsylvania Department of Transportation in 2003-2004 (Personal communication Jon Fleming, Pennsylvania Department of Transportation). Based on the data presented above, it was assumed that the removal and disposal costs of animal carcasses were US\$50 (deer), US\$75 (elk) and US\$100 (moose) (all in 2007 US\$).