USING ROAD-KILLS AS AN INDEX TO MOOSE POPULATION CHANGE

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ABSTRACT: Wildlife managers consider moose (*Alces alces*) population size an important contributing factor to the number of moose-vehicle collisions (MVCs), but the value of MVCs as an index to moose numbers is not clear. I review past applications of wildlife-vehicle collisions as a population index and identify the potential for using MVCs to indicate changes in moose population densities.

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Interest in using road-kills as indices to the relative size of wildlife populations dates back at least to the 1950's (Jahn 1959). Although moose managers consider population size an important contributing factor to the number of MVCs (Oosenbrug *et al.* 1991, Del Frate and Spraker 1991, Lavsund and Sandegren 1991) the value of MVC statistics as an index to moose population size is not clear (Hicks and McGowan 1992). A reliable MVC index correlated to population size could be useful in verifying other indices or monitoring changes in relative density and distribution of unexploited populations. It would also allow managers to predict how changes in the moose population will affect highway safety.

LITERATURE REVIEW

Road-kill indices are not widely used by wildlife managers as most have developed other, often harvest related, indices to meet their needs. Existing studies suggest that annual road-kill numbers might be another useful index to help identify changes in a variety of wildlife species.

Raccoon and Pheasant

The Illinois Department of Conservation, for example, have used road-kills as an index to raccoon (*Procyon lotor*) populations since the mid 1970's. When compared to March through April roadside spotlight surveys, correlations were strongest for May-July road-kills ($r=0.867$, $p<0.01$, 7df) and August to October road-kills ($r=0.767$, $p<0.02$, 7df) (Hubert 1990).

Case (1978) found that annual road-killed pheasants (*Phasianus colchicus*) correlated well with the spring rural mail carrier survey in Nebraska for both hens and all birds ($r=0.95$, $0.01>p<0.001$ and $r=0.88$, $0.01>p<0.001$ respectively).

Deer

Several studies have found favorable correlations between road kills and white-tailed deer counts and harvest. Bellis and Graves (1971) reported a correlation between spotlight and road-kill surveys for white-tailed deer (*Odocoileus virginianus*) in Pennsylvania ($r=0.90$, $p<0.01$). Arnold (1978) compared nine years of white-tailed buck harvest with highway deer kills adjusted for traffic volumes in 4 districts in Michigan. The results suggested a correlation existed ($r^2=0.95$, 0.85, 0.90 and 0.98).

Culbertson and Stoll (1990) correlated 11 years of Ohio county gun harvest of adult buck white-tailed deer to reported deer-vehicle collisions. They reported $r\geq0.90$ in 46 (52%) of the counties and $r\geq0.80$ in 66 counties (75%). Finally, McCaffery (1973) used data from 29 groups of Wisconsin counties and compared 8-10 years of antlered white-tailed deer buck harvest with the number of road kills adjusted for traffic volumes. All but three were highly significant at $p<0.01$ with $r\geq0.90$ in 18 (62%).

Moose

In Vermont, Alexander *et. al.* (1992) used annual known moose mortalities, comprised largely of road-kills, to determine the size of the states moose population and its rate of increase. Their estimate was the minimum population size necessary to sustain those losses.

Hicks and McGowan (1992) developed a predictive model for moose collisions in New York. To do so, they used a regression analysis of highway densities, traffic volumes, MVCs and estimates of moose density from areas within 9 jurisdictions (parks, states, or provinces) outside New York State. The strongest relationship was between subjective estimates of moose densities and annual MVCs adjusted for traffic volumes for counties in Maine, Vermont and New Hampshire (r^2=0.836, p=0.0001, n=142).

DISCUSSION

Not all road-kill and population level indices were strongly correlated in the studies reviewed. Possible explanations for poor correlations include: (1) the quality or quantity of data are not sufficient to identify correlations; (2) there are variables that mask the influence of population size on collision rates; or (3) road-kills are not reliable indicators of population size.

Data Quality and Quantity

McCaffrey (1973) compared deer road-kill trends to population trends in Wisconsin. He reported only one of 29 correlations was insignificant and another 2 that were considerably weaker than the others. The strongest correlations came from areas where the deer population varied over the duration of the study, buck harvest rates were consistent and there was reliable reporting of road kills.

In Ohio, Culbertson and Stoll (1990) found $r < 0.70$ in 8 (9%) of 88 districts. The strengths of correlations appeared to vary between districts. Stoll (Ohio Dept. Nat. Res., New Marshfield, OH pers. comm.) attributed the weak correlations to inconsistencies in reporting road kills. Child *et. al.* (1991) called for data collection standards to improve the reliability of MVC data in British Columbia.

Hicks and McGowan (1992) solicited information from 53 jurisdictions with moose but received complete data sets for areas within only 9. In all jurisdictions record keeping and data collection appeared related to the perceived importance of MVC's to wildlife and motor vehicle agencies. Standards of data collection often varied between and sometimes within jurisdictions for moose, highway, and traffic related data. Confidence in the data varied widely, most notably for moose densities and number of collisions. Confidence in population estimates was the lowest in areas such as New England where harvests are insufficient for estimating population trends.

The correlation between estimates of moose densities and MVCs was not significant for 6 of the 9 jurisdictions analyzed (Algonquin Park, Ont.; Elk Island Park, Alta.; Kouchibouguac Park N.B.; Mauricie Park, Que.; and both Terra Nova Park and a single highway in Newfoundland). Among them the Newfoundland highway data had the strongest correlation (r^2=0.065, p>.10, n=15).

Several characteristics separated areas within the 3 jurisdictions having significant correlations from those within the 6 jurisdictions that did not. Those with insignificant correlations had fewer km of roads ($\bar{X}$ =41, range 13km - 77km, n=68) than those with a significant correlation ($\bar{X}$=2,316, range 570km - 4,956 km., n=126). Excluding Newfoundland, which did not include area data, the insignificant correlation group had a lower density of roads ($\bar{X}$= 0.15 km/km^2, range 0.11-0.210 km/km^2, n=32), than the significant correlation group ($\bar{X}$=1.0 km/km^2, range 0.12-2.18 km/km^2 n=116). Those with insignificant correlations had less traffic, as measured in million vehicle kilometers traveled annually (MVKT) ($\bar{X}$=29 MVKT, range 3.13 - 82.8 MVKT, n=68) than jurisdictions with a significant correlation ($\bar{X}$=115 MVKT, range 111.9 - 3,949 MVKT, n=116).

These differences in traffic levels and of highway kilometers could influence the value of comparisons between and within groups. Jurisdictions with insignificant correlations may not have sufficient traffic or sufficient highway kilometers for MVCs to sample the moose population or habitat as adequately as jurisdictions with more roads and traffic.

Few highway kilometers in a jurisdiction (eg. a single highway through a park) may provide a narrow range of driving conditions such as practical and legal speed limits, quality of roads, and visibility. Where this occurs the probability of hitting roadside moose may be sufficiently unique as to bias comparisons with other jurisdictions. Consequently, jurisdictions with many kilometers of highways that provide a wide range of driving conditions, are most likely to be the most comparable to one another.

Areas in the six jurisdictions without a significant correlation between collisions and moose populations also had fewer MVCs ($\bar{X}$= 6.4, range 0 - 28, n=68) than units within jurisdictions having a significant correlation ($\bar{X}$= 21.5, range 0 - 130, n=142).

Masking Variables

Numerous authors have noted factors that influence wildlife collisions with vehicles.

Traffic speed

Oosenbrug *et al.* (1991) attributed an increase in collisions in part to greater traffic speeds. This view was supported by Del Frate and Spraker (1991) who noted a switch to a "dry road" policy for winter highway maintenance on the Kenai Peninsula of Alaska resulted in faster vehicle traffic and a significantly greater number of road-kills (t=8.16, p<0.001). Vehicle speed may have also effected white-tailed deer road-kills in the lower peninsula of Michigan (Arnold 1978). Arnold's observations of declining vehicle speeds in early 1974, following the oil shortages of late 1973, resulted in the only reversal of the upward trend in deer vehicle collisions in recent years.

Case (1978) analyzed road kill reports for 9 wildlife species on a Nebraska Interstate and found a significant linear correlation between traffic speed and annual road-kills (r=0.92,p< 0.01) for all species combined. His results may be suspect as there was not a concurrent tabulation of road-kills on similar road sections with differing traffic speeds.

Rolley and Lehman (1992) reported that the number of road-kill raccoons in Indiana was correlated with vehicle speed (n=20, r = 0.704, p=0.001).

Traffic volumes

Neither Rolley and Lehman (1992) nor Case (1978) found road-kill numbers correlated well with traffic volumes although the latter thought his findings could have been a result of using unrefined traffic statistics.

Arnold (1978) and Hansen (1977, in Arnold 1978) strengthened correlations between buck harvest and road kills by adjusting for traffic volumes.

McCaffery (1973) believed increased traffic volumes increased the number of road-killed deer but provided no supportive evidence. Hicks and McGowan (1992) found that adjusting for traffic volumes improved the predictive value of estimating moose population changes from MVCs in New England.

Other

Unusually heavy snows as reported by Del Frate and Spraker (1991) can cause substantial, although short term, fluctuations in the number of MVCs. Collision preventive measures, such as those reported by McDonald (1992), Del Frate and Spraker (1991), and Lavsund and Sandegren (1991) could influence long-term data sets.

Roadside salt pools can attract moose and contribute to MVCs (Fraser 1979, Fraser and Thomas 1982). The importance of these pools may vary regionally depending on the availability of alternative sources of salt.

Correlation with Population Size

Researchers have conducted numerous studies to determine if road-kills and wildlife population levels correlate. The major obstacle appears to be the lack of accurate population estimates for comparison with road-kill indices. For example, Rolley and Lehman (1992) could not correlate road-killed raccoons numbers in Indiana with raccoon densities as reflected by pelt sales, because raccoon harvest appeared density-independent. Although they have conducted raccoon road-kill surveys for years they are still searching for an accurate and independent means to estimate raccoon populations and verify the accuracy of the index. The same is true for management agencies in Ohio (J. Weeks, Ohio Div. Wildl. Oak Harbor OH. pers. comm.) and Illinois (Hubert, 1990). Studies involving deer correlated one index (road-kills) with another index (buck take) but not with results of population surveys (McCaffery 1973, Culbertson and Stoll 1990). New England moose density estimates used by Hicks and McGowan (1992) were often best guesses by the state's moose biologists because of insufficient harvest for harvest-related indices. The strong correlation between MVCs and population density estimates may have weakened if rigorous and entirely independent population survey data been available.

SUMMARY

Although MVCs are not currently used as an index to trends in moose populations, existing studies suggest they could indicate population trends or support the findings of other indices.

The utility of MVC indices might increase as the kilometer of highways, traffic levels and number of MVCs increase. Some variables that may mask the effects of population size on collisions, such as traffic speed and volume, tend to change gradually and have less of an influence in jurisdictions with a wide range of geographic, habitat, and highway conditions. Traffic-related variables are usually monitored by highway departments allowing managers to determine the amount of change that has occurred.

Researchers find road-kills an inexpensive index to population change (Case 1978, McCaffery 1973). Given the low cost, moose managers should look more closely at MVC indices and improve the quality of associated data.

MVCs hold promise as a management tool in areas lacking sufficient harvest to provide harvest related indices. In some cases, MVCs are one of the few options available to managers interested in tracking moose population trends. Data from road-killed animals can provide insights into the status of unhunted populations that are otherwise unavailable (Alexander *et al.* 1992). Should future surveys prove the utility of a MVC index, managers will always have the opportunity for retrospective analysis of population changes. Even if an MVC index eventually proves ineffective in monitoring population trends, a record of collision information on file could provide baseline information for evaluating the effectiveness of management actions designed to reduce MVCs.

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