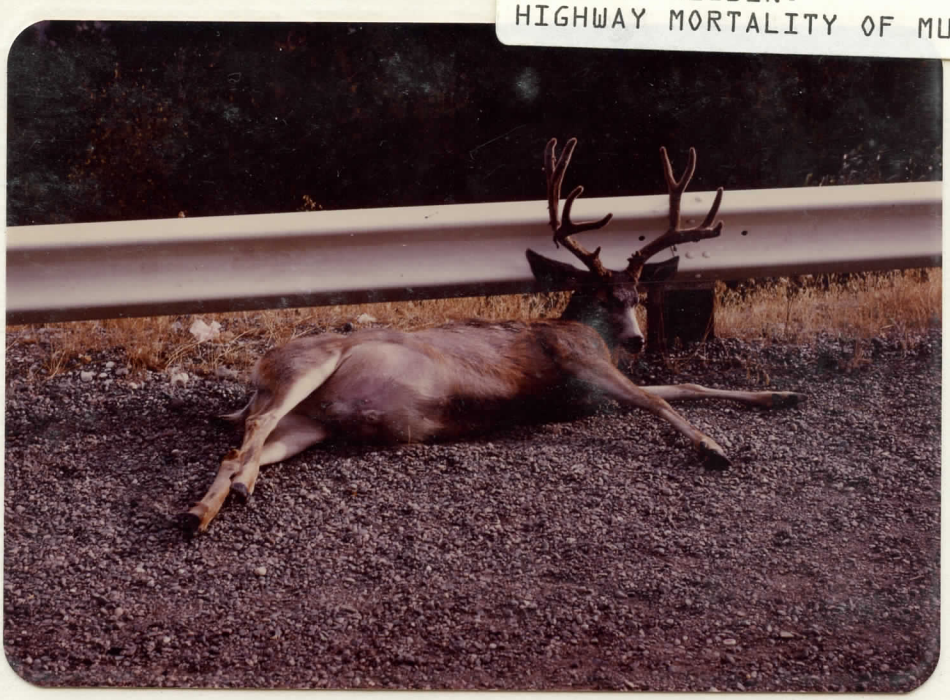


Highway Mortality Of Mule Deer And White-tailed Deer

n.d.

ABSTRACT

Discussed within this report is the current knowledge of deer-vehicle accidents and the solutions that have been tried. The author has discussed and given possible solutions and final recommendations to the current literature. From this literature the Grand Forks area was accessed and the best possible solution for the lowest cost was recommended to produce a workable study plan for the area.

TABLE OF CONTENTS

List Of Figures

INTRODUCTION

The literature review contains all available current information involving deer-vehicle accidents, and preventive solutions that have been tried. All solutions were researched in great detail to show all the facts concerning each possible solution, ranging from fencing, roadside mirrors, deer crossing signs, repellents, salt licks, highway lighting, to reduction of the deer population. A cost analysis of each solution was indicated when possible and taken into account in the final recommendations.

LITERATURE REVIEW

All available information was used from Selkirk College and the University of Victoria, and additional information was gained from writing to 63 agencies throughout North America. A list of the agencies is shown in Figure #1, and a copy of the letter can be seen in the appendix. Of the agencies named, there were 48 that responded with a reply, of which 23 agencies supplied supportive data to write the following section.

HIGHWAY MORTALITY OF DEER IN NORTH AMERICA

Deer are being killed along our highways at an epidemic rate. The general lack of attention to the problem is reflected in the haphazard way that many agencies collect data on such accidents. Many different authorities remove deer carcasses from the highways, and many accidents are not accurately tabulated. An accurate total of accidents is next to impossible to get and not totally reliable. Some accidents are not reported if the deer manages to crawl away, and the damage to the vehicle is minimal or not worth the bother on an old vehicle. Williams (14) stated that 45 percent of the deer killed by vehicles run far enough off the highway and probably were not reported. So the current method of counting deer-vehicle accidents is from the actual number of carcasses found along the highway, and there will be approximately 200,000 deer found and recorded in North America in 1980. With an estimate that 45% of the

Figure # 1

A list of agencies that the letter (see appendix) was sent to.

Alabama
Alaska
Arizona
Arkansas
California
Colorado
Connecticut
Delaware
District of Columbia
Florida
Georgia
Idaho
Illinois
Iowa
Kansas
Kentucky
Louisiana
Maine
Maryland
Massachusetts
Michigan
Minnesota
Mississippi
Missouri
Montana
Nebraska
Nevada
New Hampshire
New Jersey
New Mexico
New York
North Carolina
North Dakota
Ohio
Oklahoma
Oregon
Pennsylvania
Rhode Island
South Carolina
South Dakota
Tennessee
Texas
Utah
Vermont
Virginia
Washington
West Virginia
Wisconsin
Wyoming

Alberta
British Columbia
Manitoba
New Brunswick
Newfoundland
Nova Scotia
Ontario
Prince Edward Island
Quebec
Saskatchewan
North West Territories
Yukon

deer are not found, the total comes close to 300,000 deer killed this year, and this total increases every year. Damages to vehicles in 1977 amounted to $450.00 (7), and the total damage in 1980 could be as high as $100 million or more in North America. This expense alone should make more people and agencies aware of the problem, but still it goes uncontrolled, increasing every year, because agencies record the problem with a low priority. The urgency of the problem may be further appreciated by considering that an estimated 63 deaths and 10,465 injuries will occur from these collisions (see Figure #2). Although over 90% of the deer-vehicle accidents are single-vehicle accidents (2), head-on collisions, overturned vehicles, vehicles hitting fixed objects, and even parked vehicles are involved.

Six major factors may be important in contributing to an increase in deer-vehicle accidents.

(1) Increased deer populations throughout North America from good wildlife management.

(2) More highways, particularly highly-landscaped interstates with lush grass-covered edges and medians.

(3) More vehicles, and an increase in small, gas-efficient vehicles, which in turn increases vehicle damage and personal injuries and fatalities.

(4) Better secondary roads that can carry traffic at higher speeds.

(5) Higher average speeds, in spite of the 90 kilometre per hour average speed limit. The average speed of traffic is as high as it has ever been, and bringing up that average is the traffic on secondary roads.

(6) Increased urbanization into remote areas, increasing vehicle access to deer areas.

Although many areas do nothing to prevent deer-vehicle accidents, some areas with high losses are taking some initiative. Wisconsin has

Figure # 2

A relationship between the compulsory reported deer-vehicle accidents of Michigan to North America for a one year period, with a breakdown of the different vehicle collisions.

	Michigan	North America
Deer- Vehicle Collisions	12,637	200,000
Single Vehicle Collisions	11,848	187,400
- Deaths	2	32
- Injuries	295	4,720
Overturned Vehicles	203	3,213
- Deaths	1	9
- Injuries	137	2,168
Vehicles Hitting A Fixed Object	516	8,166
- Deaths	1	9
- Injuries	226	3,577
Vehicles Hitting A Moving Vehicle	50	791
Vehicles Hitting A Parked Vehicle	9	142
Pedestrian Deaths	1	13
Total Deaths	5	63
Total Injuries	658	10,465

developed a brochure to increase driver awareness, and Michigan, Colorado, California, and Pennsylvania have tried various prevention devices and have studied their effectiveness. These devices range from fencing and reflective mirrors to signing and repellents. A list of preventive measures to reduce deer-vehicle collisions is discussed below, followed by recommendations of present and possible future solutions.

FENCING

A major component in reducing highway deer mortalities has been through the use of fencing. Ordinary fencing for domestic animals does not provide containment of deer because they can easily jump over low fences. Innovative ideas have been used to provide adequate containment of deer. In 1956, Blaisdell and Hubbard (6) described the testing of an outrigger type of fence, which is only 1.4 metres high but has an extension sloping from the top of the fence to a distance 2.4 metres away from the fence. The idea was to keep the deer from getting too close to the fence to jump over with ease. After three years of experimental use, there was no sign of deer jumping the fence, providing a very effective barrier to deer. The cost of this fence in 1956 was $4.86 per lineal metre, equalling approximately $5000.00 per kilometre. This type of fencing proved effective only in areas where snow did not accumulate. Another study, done by Halls, Boyd, Lay and Goodrum (8), used a 2.6-metre fence, and found after continuous studies that the fence was 100% effective in keeping

deer from the highway, except when the deer went around the ends of the fence and were funneled down the highway. The cost of this fencing installation was approximately $2300.00 per kilometre in 1965.

Some problems of using fencing along highways have been studied by Bellis and Graves (5), who stated that fences need to be continuous over long stretches of forested areas, to prevent deer from walking around the ends and being funneled along the highway by the fence. Also, the fences should run parallel along both sides of the highway and as close to the highway as possible, to effectively reduce deer mortalities. If placing the fence next to the highway is not possible, the fence should be constructed within the forest stand. This stops the deer from seeking the grazing areas on the other side of the highway, by eliminating the sight of such areas.

Other problems occur when deer do get inside a fenced area and become trapped and frightened, running back and forth across the highway until eventually hit by a vehicle. Also, the placement of a fence along a highway may impede natural deer migration patterns, which could eradicate an entire herd, if it cannot travel to major wintering or summer range. Finally, along many developed highway routes, side roads to private property need openings to allow access without letting deer through. Possible solutions for some of the fencing problems are discussed below.

One-Way Gates

Potentially hazardous conditions exist when deer become trapped in or funneled along highway fences. To allow deer to pass back through the fence, a one-way gate system was developed and tested for its

effectiveness. Reed, Pojar and Woodard (11) found that one-way gates effectively allow deer to pass from the highway side of the fence to the forested area, while not allowing deer to enter the highway through the gates. The gates proved most effective when they were placed in an offset pattern (see Figure #3), where the gate is directly in front of the deer as they move along the fence from either direction. The use of these gates is advisable when extensive lengths of fencing is used, and one set should be used on relatively short lengths of fence.

Highway Underpass

Many times a highway bisects a major migratory path for deer between summer and winter ranges. Fencing along the highway, although effectively preventing deer from crossing the highway, would have to be long and expensive to prevent the deer from following the fence and crossing the highway to reach their destination. In known migratory routes, the installation of highway underpasses have the potential to allow deer to travel underneath the highway with no hazards to vehicles. The effectiveness of the underpass is increased when used in conjunction with fences to help guide the deer to the openings and through them (see Figure #4). Reed, Woodard and Pojar (13) studied the amount of use a 3 metre x 3 metre x 30.5 metre underpass received by deer. The underpass was located below Interstate 70 in Colorado and was studied during a four-year period after its completion in 1970. The underpass was successful in allowing 61 percent of the local deer population to pass safely under the highway. A large portion of the deer population that was reluctant to pass through the underpass seemed to be

Figure # 3

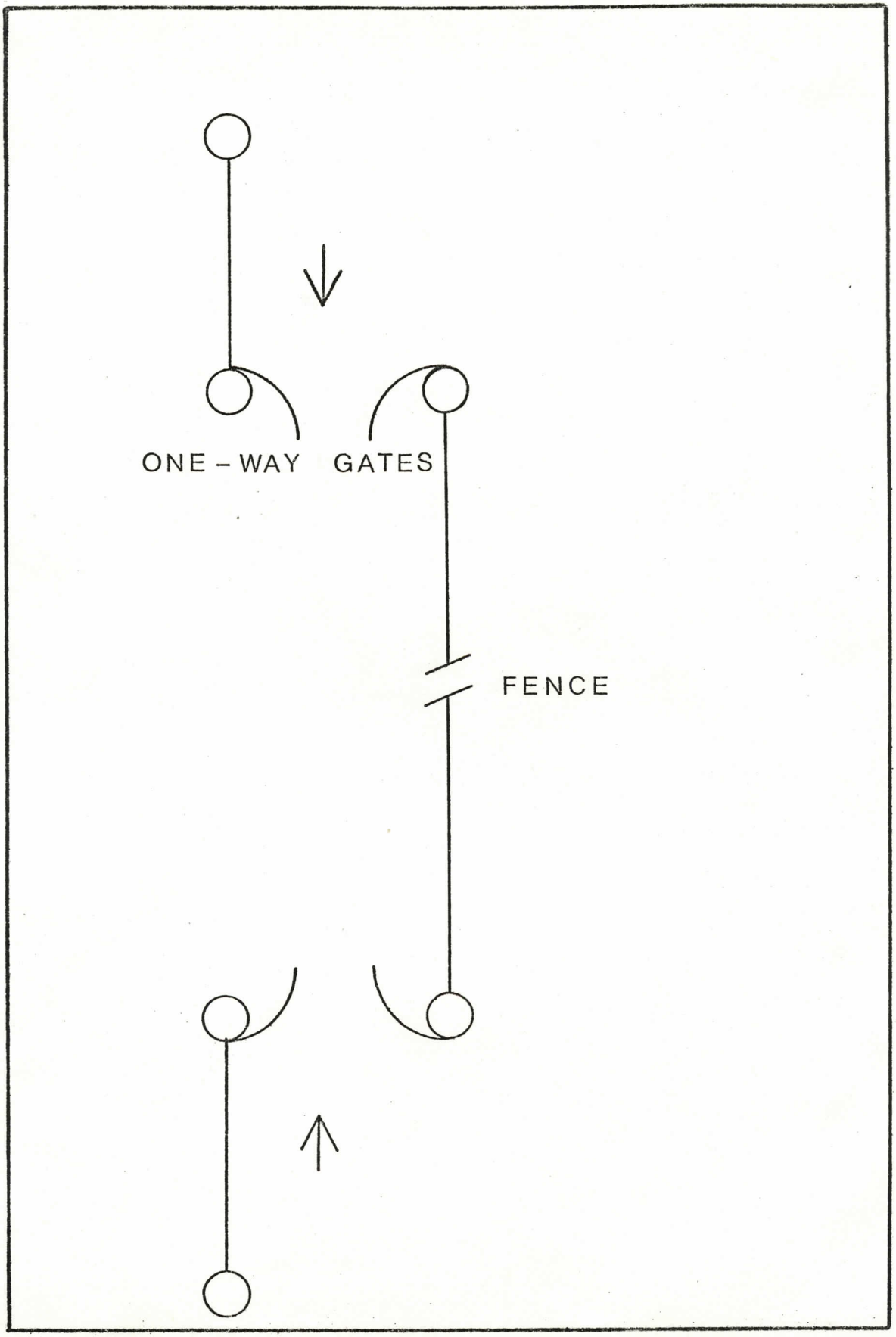
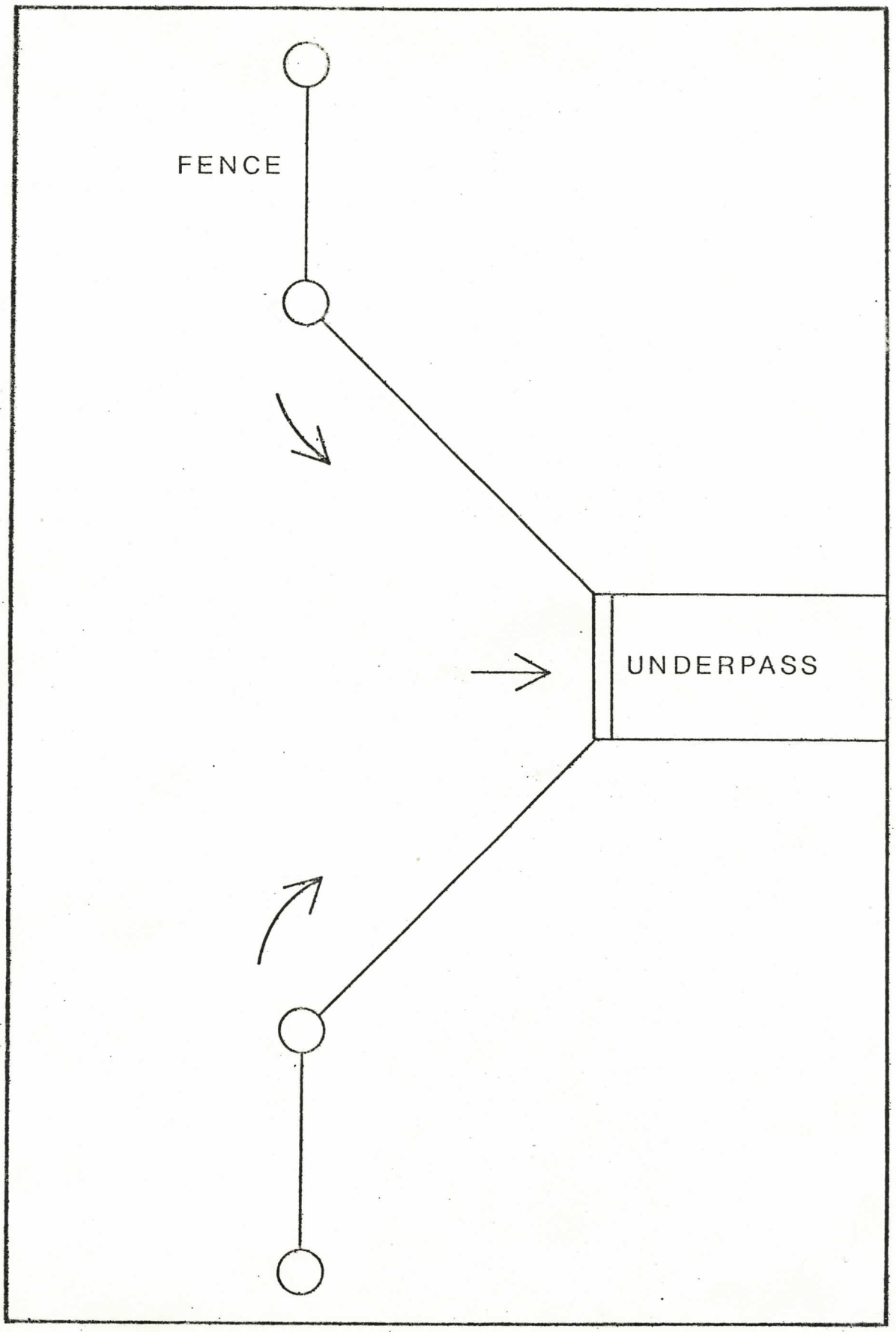


Figure # 4



distressed by the small size of the opening and the structural character. It was recommended that future underpasses be at least 4.3 metres high and wide, and the length be kept as small as possible to shorten the time spent in the underpass. It was also recommended that the underpass have dirt floors and that no skylights or artificial lighting be placed within.

Construction of underpasses in North America should be planned in the development of new highways, over known migratory routes, and construction is to be performed by highway construction crews to reduce costs. Although no figures were given for the cost of a highway underpass constructed on previously completed highways, an educated guess would place the cost in the $20,000.00 to $30,000.00 range.

Deer Guards

When fences are used along primary highways, problems arise when it is necessary to permit vehicle access through the fence. The use of gates provides the best protection, but may hinder traffic flow in heavy use areas. Structures such as modified cattleguards have been used in areas where gates were undesirable. Tests of these were conducted by Reed, Pojar and Woodard (12). The results showed that deer walked, trotted, or bounded across and showed no aversion to the cattleguard. In many cases, the deer were seen to use their dew claws to keep from falling through the cattleguard. There were a few cases when a deer fell completely through the cattleguard with all four legs, proceeded to roll completely over to replace their hooves on the guard, and continue across. The final conclusion is that modified cattleguards are not effective in preventing deer from crossing the

openings, and only gates should be used to permit vehicle access to side roads, thus maintaining the effectiveness of a fence.

ROADSIDE MIRRORS

The use of roadside mirrors along highways to warn or stop deer from crossing the highway during the time a vehicle passes by is potentially effective. A study in Michigan found that 70% of the deer-vehicle accidents occur after dark (2), and that vehicle headlights thus provide a light source for roadside mirrors. The principle of the mirrors is to reflect the light and flicker sharp, pencil-like beams, which startle approaching deer, causing them to stop and watch the light until the vehicle passes. A report from American Highways (1) indicates a degree of success from two round, stainless-steel, 7.6-centimetre mirrors mounted at a 45-degree angle on poles 1.2 metres above the ground at intervals of 23 metres along both sides of a test highway in the state of Missouri. Other reports claim 100% effectiveness in Maine, high success in Washington, and little success in Illinois and Minnesota. Also, there was some indication that these mirrors lose their effectiveness in a few years, but no studies are available on long-term effectiveness.

Another mirror-type reflector is currently on the market, called the "Swareflex Wildlife Warning Reflectors." The principle of this reflector is basically the same as the previous reflectors, except the light reflects in a red colour. Dieter Backhaus (4) has shown that hoofed animals are not completely colour-blind, and that the

colour red is aversive to the animals. This information was incorporated into production of a reflector that reflects a bright red light when exposed to vehicle headlights. This red light penetrates the surrounding landscape and frightens deer away from the highway when vehicles are approaching. These reflectors were installed and tested in Austria, and the Austrian Academy of Science (3) reported an 80% decrease in the number of deer killed along 24 kilometres of various roads. The cost for the reflectors, considering 50% curves and 50% straight stretches of highway, is $3800.00 per kilometre in 1980.

DEER CROSSING SIGNS

Used throughout North America, deer crossing signs seem to do little for speed reduction and driver awareness, although the effectiveness on deer conservation has never been studied. However, a study on the effectiveness of an animated deer crossing sign was undertaken in a Colorado deer wintering area (9). In this case, the sign was left on at night for a week and then removed from view for a week. Vehicle speeds were recorded at three locations beyond the sign, and the average drop in speed was found to be less than five kilometres per hour. The study concluded that the presence of the sign to the deer mortality ratio was not significant, and it was assumed that conventional deer crossing signs are not effective either. However, in areas where deer-vehicle accidents are especially numerous, warning signs may be useful for public relations and liability reasons.

HIGHWAY LIGHTING

Some areas have tried lighting of the highway to increase visibility of deer for motorists. An assessment of the effects of lights installed along a Colorado highway was done by Pojar, Woodard and Reed (10). For two years deer-vehicle accidents were recorded, and the results showed an increase in the number of accidents following the installation of the lights. The deer seemed to adjust to the lights, and even gather in the area, increasing the potential for deer-vehicle accidents. It was recommended that highway lighting not be installed.

REDUCTION OF DEER NUMBERS

The most effective method of reducing deer-vehicle accidents is to reduce the number of deer in the area, therefore reducing the number of deer crossing the highway. A quick or drastic cutback would be unacceptable to public opinion and is not necessarily a good management practice; there is some risk of accidentally eradicating an entire herd. Controlled reduction is not a recommended policy.

REPELLENTS

The use of repellents to discourage the use of road sides by deer has not been effective. Creosote, crankcase oil, fuel oil, and kerosene have been tried but proved ineffective and expensive. Also, commercial

repellents applied to vegetation and to salt areas offered no practical solution because of high cost and general ineffectiveness over long periods of time. These attempts were carried out for a number of years and were recorded as failures.

SALT LICKS

Salt blocks have been used to prevent deer from going to the highway to obtain salt from the road surface. However, studies have shown that salt blocks could not compete with the great amounts on the highway and were not successful.

RECOMMENDATIONS

The most effective preventive measure in reducing deer-vehicle collisions is fencing, as long as it incorporates one-way gates, highway underpasses and gates for vehicle access. Extensive fencing for large problem areas may reduce accidents by 85 to 100%. The only major drawback is the cost of the fence, installation and maintenance, which may be in the range of $10,000.00 to $25,000.00 per kilometre.

The most promising preventive measure is the use of reflective mirrors, particularly the new "Swareflex Wildlife Reflective Mirrors." From the data available, an 80% reduction level can be obtained for a smaller cost. The costing of the reflectors, poles, installation, and maintenance is approximately $5,000.00 to $6,000.00 per kilometre. Even in small sections the effectiveness is still high, due to its principle function to keep deer off the highway in safety until the vehicle has passed, and then allowing the deer to cross in safety.

INTRODUCTION

The Grand Forks area has a high deer-vehicle accident rate, due to its location of the deer wintering range. Highway #3 is the only major route to the Kootenays, and bisects the major winter area for use by east- and west-bound traffic. Deer cross the highway in search of food and water, and are often involved in deer-vehicle confrontations.

The author researched the road-kill records for the area and carried out field studies to discuss the problem areas and give possible solutions and recommendations for the area. A brief study plan is also included to show the best solution recommended and indicate the stretches of highway needing immediate attention.

METHODS

Information and data were received from two agencies, the Fish and Wildlife Branch in Grand Forks, and the Ministry of Highways in Grand Forks. The Fish and Wildlife Branch had records for the amount of road kills in the area for only the years of 1964-1966. Of these records, only data for nine months was kept, which showed the number of road kills found. From 1966, no information or records were kept on the number of road kills, until September of 1978, when the Fish and Wildlife Branch asked the Ministry of Highways employees to record all road kills found along their highway district. Included in the information of road kills was the date found, sex, road name, and location to the nearest kilometre marker. The information was recorded by highway patrols and reported to the formen to be included in a monthly report to be given to the Fish and Wildlife Branch. The reports are received at the Fish and Wildlife Branch and filed under deer road kill records.

Although this is a good method of recording road kills, because highway employees remove the carcasses from the highway, only the deer that are seriously injured and unable to escape from the highway are recorded. In many accidents, deer receive injuries that do not stop them from crawling away to the surrounding forest to eventually die. So although the carcasses are accurately recorded, the number of road kills is unknown.

The problem area locations have been investigated by the author through counts of tracks and actual sightings of deer (see Figures #5 and #6). Also, fence crossings by deer were determined by locating

Figure # 5

Deer tracks found along the banks of highway # 3.

Figure # 6

Deer feeding on upper and lower pastureland of highway #3

deepening tracks (see Figure #7) and by tracks leading over down fences and undercut fences (see Figure #8).

Wintering Areas

The major wintering area for deer is located about 25 kilometres north of Grand Forks and extends southeast along the Grandby River to the Kettle River and the United States border (see Figure #9). Deer from a radius of approximately 40-50 kilometres in Canadian and United States mountain ranges migrate to this major wintering range for many reasons, some of which are listed below:

(1) low snow accumulation (average 1.2 metres);

(2) good browse and young gree shoots in pasture lands;

(3) adequate cover.

Problem Areas

The major problem area is located 12 kilometres east of Grand Forks on Highway #3, and consists of a 4-kilometre strip of highway (see Figure #10). In a one-year period, from December 1978 to December 1979, 10 of the 17 road kills were recorded here. The highway has a high point with a corner (see Figures #11, #12, and #13), in the first kilometre, heading east. At this point, it passes by a rock wall on both sides of the highway. Traffic speed is increased through this section by the use of a passing lane for west-bound traffic (see Figure #14). With the passing lane, the chances of a vehicle hitting another vehicle or hitting the rock wall to avoid a collision with a deer are increased, which in turn increases the probability of injury or fatality to the occupants of the vehicles. The point of entry by the deer occurs after the deer are funneled along the outside of a

Figure # 7

Fence jumped over by deer, indicated by deepened deer tracks

Figure # 8

Down fences and undercut fences used by deer along highway # 3

Figure # 9

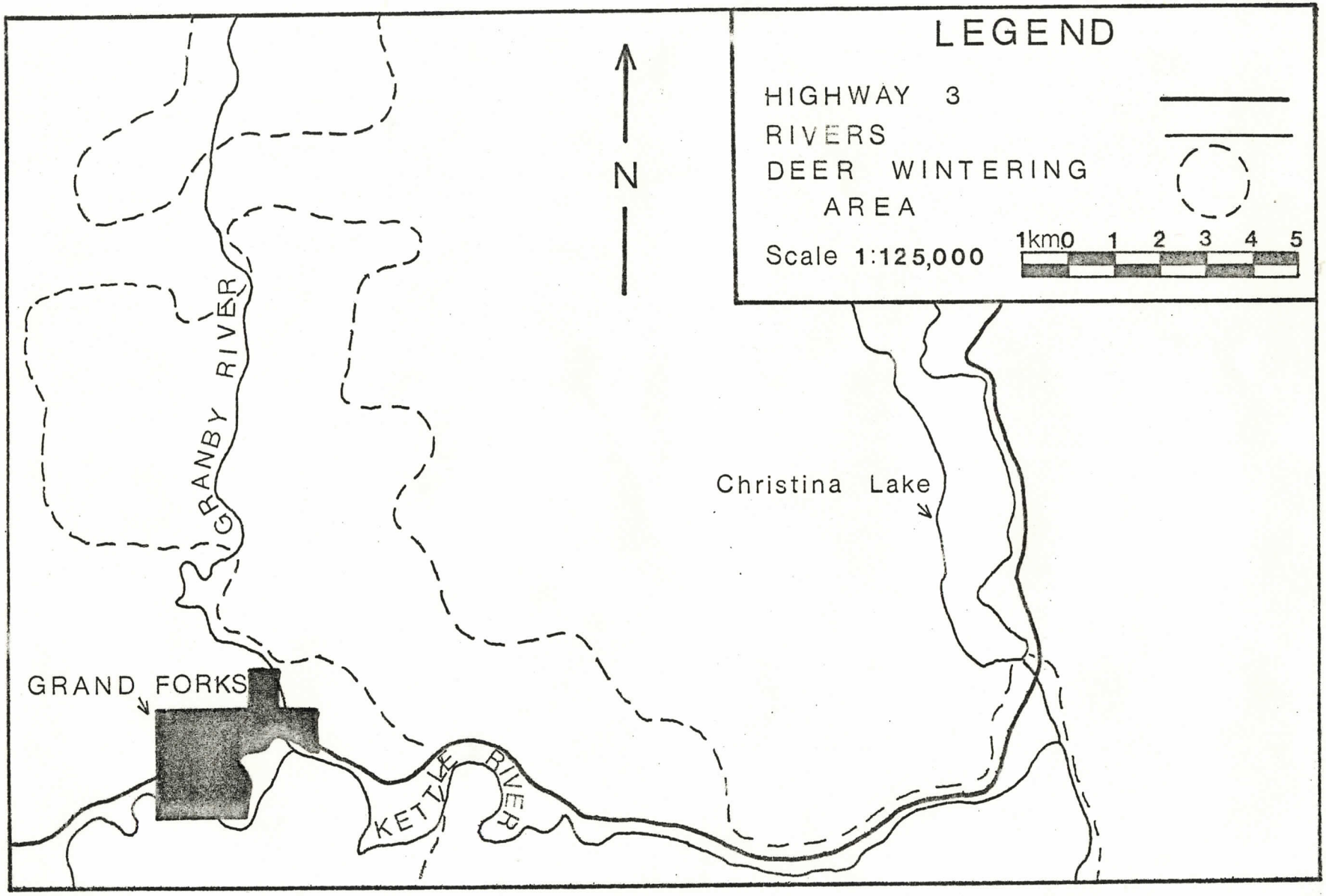

LEGEND
HIGHWAY 3
RIVERS
DEER WINTERING AREA
Scale 1:125,000
1km 0 1 2 3 4 5
N
GRANBY RIVER
Christina Lake
GRAND FORKS
KETTLE RIVER

Figure # 10

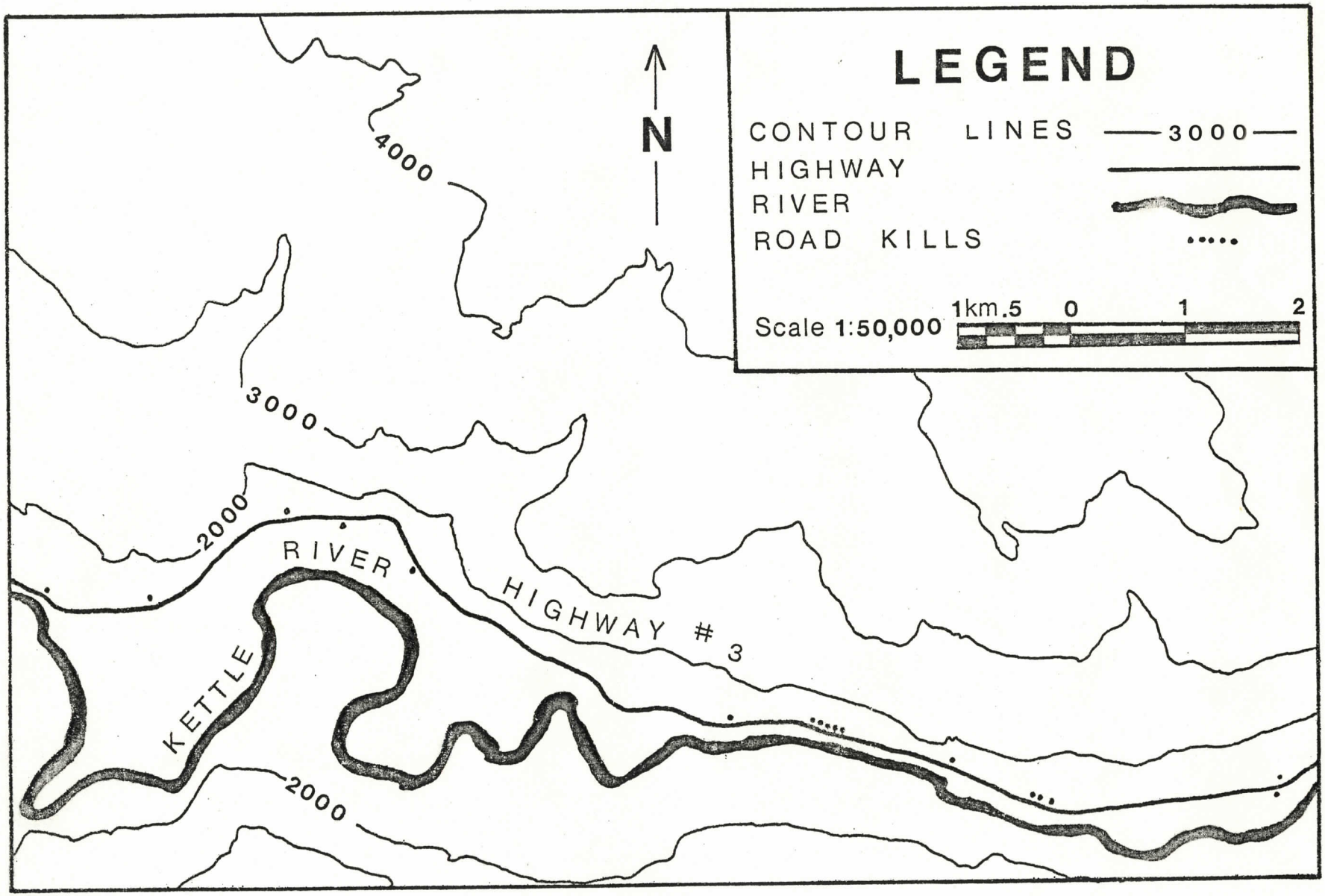

LEGEND
CONTOUR LINES
3000
HIGHWAY
RIVER
ROAD KILLS
Scale 1:50,000
1km .5 0 1 2
N
4000
3000
2000
RIVER
HIGHWAY # 3
KETTLE
2000

Figure # 11

View of corner looking east and west along highway # 3

Figure # 12

View of corner from the east, showing the highpoint

Oxford NO. M 721 R MADE IN CANADA

Figure # 13

View of rock wall from the north side of highway # 3

Figure # 14

View of westbound passing lane, looking towards the east

cattle fence, down to the north side of the highway (see Figure #15). The cattle fence continues uphill for 30 metres before it levels off, at which point the deer jump over the fence with ease (see Figure #16). On the south side of the highway, a fence enclosing the railway is the only obstacle to deer travelling the lower pastures and the river (see Figure #17). Also, portions of this fence are down, and other portions permit deer passage beneath the fence (see Figure #8). The remaining 3 kilometres east of the rock walls consist of large pasture areas on both sides of the highway, which deer cross readily in search of more available food and water.

Of the 17 recorded kills between 1978 and 1979, 5 occurred in a small area located between 3 and 8 kilometres east of Grand Forks. This area contains large areas of pasture land on both sides of the highway (see Figures #18 and #19), with only cattle fences, which do not contain deer wanting to cross the highway.

Figure # 15

View of cattle fence from the road and from the top

Figure # 16

Point at which deer jump over before heading down to the highway

Figure # 17

View of lower pasture, and of deer feeding in pasture

Oxford NO. M 721 R MADE IN CANADA

Figure # 18

View of pastureland on the north and south side of highway

Figure # 19

View of pastureland along the north side of the highway

RESULTS

The old road-kill records began in December 1964 and ended in April 1966, but did not include the months from June to November within that time period. The most recent records were kept by the Ministry of Highways for each month from September 1978 until present. If we assume that there was an insignificant number of road kills from June to November 1965, and we compare the total amount of road kills recorded between December 1964 and December 1965 against the totals for December 1978 to December 1979, it can be stated that there was a 45% increase in road kills in 15 years. This in turn means there was a 45% increase in vehicle damage, which was probably due to higher vehicle speeds, improved highway surfacing, and possibly an increase in deer population.

In relating the figures by each month, it can be shown that an average of 42% more deer were found in December 1964, January and February 1965, than in December 1978, January and February 1979 (see Figure #20). This could be caused by a heavier snowfall, or a severe winter, or due to inadequate snow removal along the highway in 1965. Also, comparing the months of April and May in 1965 and 1979, there was an average increase of 79% more road kills in 1979. Essentially, the area is used to support the deer population before the snow melts in the mountains, and so snowfall and snow removal in the valley cannot be used as a reason for the increase because of the lack of snow during this time. The most realistic theory is that road conditions during the winter months are more hazardous to make vehicle drivers drive slower and more defensively than in the spring months.

Figure # 20

Table of road-kills in Grand Forks area.

Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.

1964.....16
1965....11
1965.....20
1965.....14
1965.....4
1965.....2
1965.....1
1966.....5
1966.....13
1966.....7
1966.....3

1978.....4
1978.....5
1978.....8
1978.....9
1979.....4
1979.....7
1979.....14
1979.....13
1979.....21
1979.....12
1979.....16
1979.....10
1979.....10
1979.....1
1979.....2
1979.....5
1980.....3

The data recorded in 1978 to 1979 showed that 51% more female deer were hit than males. This may be due to the fact that females usually cross an opening first while the males follow when they cross safely, or it may be due to a higher activity by females to gain the needed nutrients for pregnancy.

DISCUSSION

To date the only solution used has been oversized deer crossing warning signs (see Figure #21), but as previously indicated in the literature by Pojar, Prosence, Reed and Woodard, warning signs may not significantly reduce average vehicle speed. So although the warning signs are larger and more impressive, it is likely that little attention is given by passing motorists.

It has been shown by other investigation that, although it is not completely accurate, the best method of counting deer-vehicle accidents is through the number of road kills found along the highway. This is due to the fact that many accidents are not reported because the deer were hit by large trucks or old vehicles, causing little damage to the vehicle. Although there is some inaccuracy due to the loss of deer which manage to crawl away from the accident and eventually die, counting the actual number of road kills is the only reasonable way to record deer-vehicle accidents.

Three years of accumulated data over a stretch of 15 years cannot predict accurate conclusions due to the large amount of variabilities. But the records compiled since September 1978, although meager, might be used as a baseline to judge if new preventive measures actually reduce the number of road kills.

More studies are needed to locate the heavily used areas and the different areas used during different times of the year.

Figure # 21

Deer crossing sign at the two kilometer marker, heading east from Grand Forks

POSSIBLE SOLUTIONS

The simplest solution to reduce the number of deer crossing the highway would be to enhance browse species and pasture land on the north side of the highway, and to develop large watering ponds. These features would make it unnecessary for deer to cross the highway. This could be done by enhancing and planting favourable browse species along the north side of the highway and reducing the favourable browse species along the south side of the highway. The last main component would be the construction of watering ponds for use by deer only, which could be accomplished by using a cattle fence to keep cattle away from the watering ponds but still allowing deer to jump over the fence to drink the water. This solution would reduce the amount of deer crossing the highway by a small percentage and would be relatively inexpensive.

To provide a reduction in possible deer-vehicle accidents in excess of 50%, the use of "Swareflex Wildlife Warning Reflectors" might be suitable. The cost of these reflectors, plus posts, is approximately $4,000.00 per kilometre for both sides of the road. Labour cost for installation and the occasional maintenance would possibly cost another $6,000.00 per kilometre. Although the reflectors can be used in short hazardous sections, the intervals should be greater than one kilometre long to attain the projected rate of prevention, To equip the present problem areas, the cost would be about $100,000.00 for 9 kilometres of highway.

The final possible solution would be the use of fencing over long stretches of highway. When used in short sections, deer tend to go

around the ends and get funneled along the fence to be trapped within the two fences. To provide the best protection, the deer fence would have to be approximately 20 to 30 kilometres along both sides of the highway and include one-way gates for deer that still come around the ends of the fence. The fence would also have to include one or two underpasses to allow deer access to water on the south side of the highway. The cost of these facilities would be approximately $300,000.00 to $400,000.00 for the entire project. This figure would not balance the cost of deer-vehicle accidents for many decades.

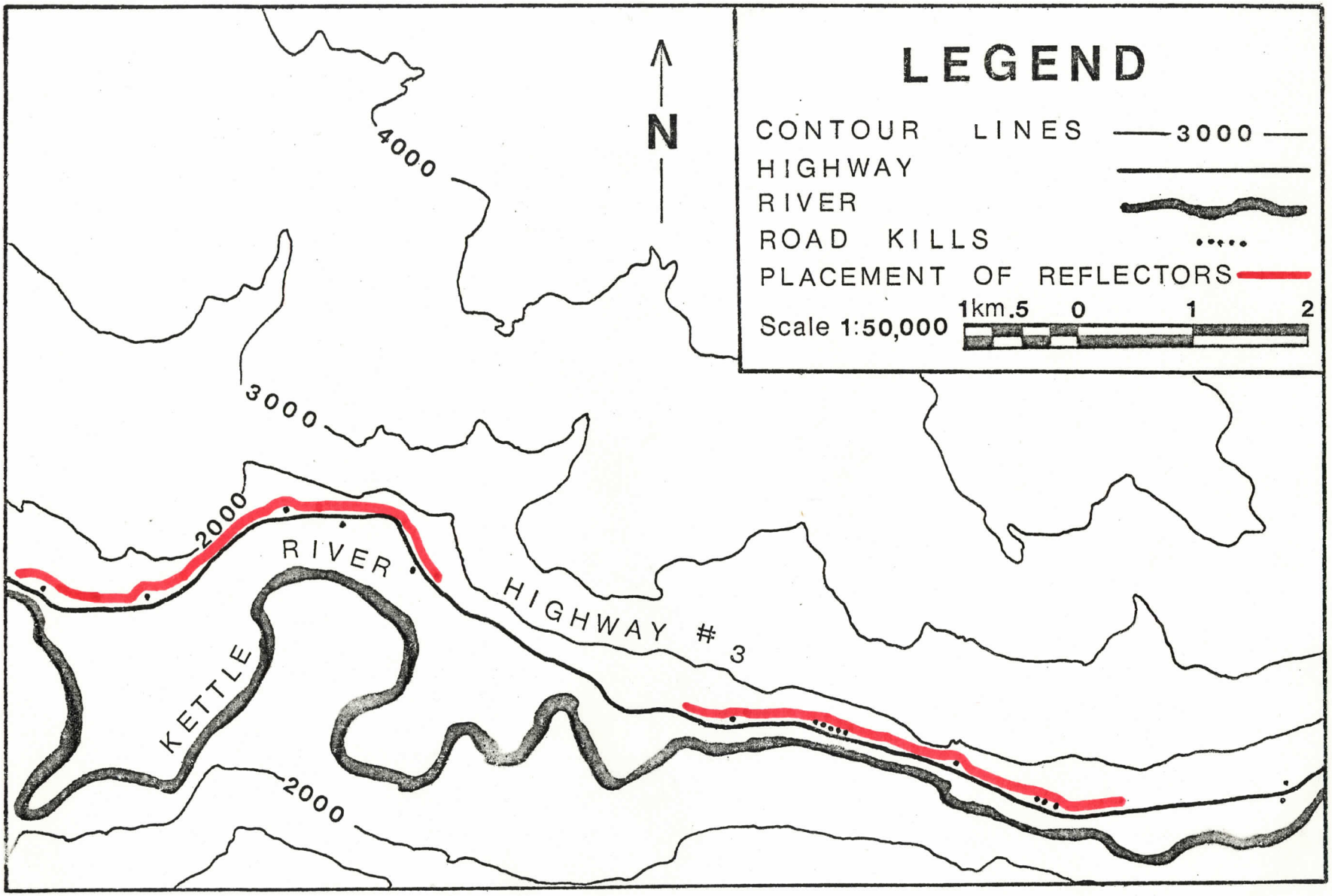
RECOMMENDATIONS

The best solution for use in the Grand Forks area would be the installation of the "Swareflex Wildlife Warning Reflectors," because of their versatile use in short hazardous sections of highway and yet maintain a high percentage of accident prevention along the highway. The initial benefit would be realized after a two-year period, even if the reduction by the reflectors was only 60%, assuming average vehicle damage to be $500.00. To enhance this reduction, additional reflectors could then be justified, or by enhancing deer browse and pasture land on the north side of the highway with the addition of watering ponds, a further reduction of deer-vehicle accidents can be possibly gained.

STUDY PLAN

The study plan involves the placement of "Swareflex Wildlife Warning Reflectors" on 1.2-metre wooden poles at a distance of 3 metres away from the edge of the highway surface. Also, they will be located 22 metres apart on straight stretches and 11 metres apart around corners on both sides of the road. The reflectors will be located on a 5-kilometre stretch of highway, starting 3 kilometres east of Grand Forks, and on a 4-kilometre stretch of highway, starting 11 kilometres east of Grand Forks (see Figure #22).

Figure # 22



LITERATURE CITED

1. Anonymous. Deer mirrors in Missouri. American Highways, 51(1):17, 1972.

2. Arnold, David A. Characteristics and cost of highway deer kills. Michigan Department of Natural Resources, 1977.

3. Austrian Academy of Sciences. Behaviourism helps to prevent animals from being killed in traffic accidents. Bulletin #6, 1974.

4. Backhaus, Dieter. Experimental investigations on the acuity of vision and colour vision in some hoofed animals. Zoological Institute, Munster University, 1970.

5. Bellis, E. D. and H. B. Graves. Deer mortality on a Pennsylvania interstate highway. Journal of Wildlife Management, 35(2):232-237, 1971.

6. Blaisdell, James A. and Richard L. Hubbard. An outrigger type deer fence. U.S. Forest Service, Forest Research Notes #108, 1956.

7. Conley, Clare. Road kills: the shameful waste. Outdoor Life, 1979.

8. Halls, L. K., G. E. Boyd, D. W. Lay, and P.D. Goodrum. Deer fence construction and costs. Journal of Wildlife Management, 29(4): 885-888, 1965.

9. Pojar, T. M., R. A. Prosence, D. F. Reed, and T. N. Woodard. Effectiveness of a lighted, animated deer crossing sign. Journal of Wildlife Management, 39(1):87-91, 1975.

10. Pojar, T. M., T. N. Woodard, and D. F. Reed. Effectiveness of highway lighting on number of deer killed by vehicles. Colorado Division of Wildlife, Game Research Report, 1972.

11. Reed, D. F., T. M. Pojar, and T. N. Woodard. Use of one-way gates by mule deer. Journal of Wildlife Management, 38(1):9-15, 1974.

12. Reed, D. F., T. M. Pojar, and T. N. Woodard. Mule deer responses to deer guards. Journal of Wildlife Management, 27(2):111-113, 1974.

13. Reed, D. F., T. N. Woodard, and T. M. Pojar. Behavioral response of mule deer to a highway underpass. Journal of Wildlife Management, 39(2):361-367, 1975.

14. Williams, J. E. Deer, death and destruction. Colorado Outdoors, 13(2):1-3, 1964.

BIBLIOGRAPHY

Anonymous. Deer mirrors in Missouri. American Highways, 51(1):17, 1972.

Anonymous. Mirrors quell deer kills. Better Roads, 1971.

Arnold, David A. Characteristics and costs of highway deer kills. Michigan Department of Natural Resources, 1977.

Austrian Academy of Science. Behaviourism helps to prevent animals from being killed in traffic accidents. Bulletin #6, Austria, 1974.

Backhaus, Dieter. Experimental investigations on the acuity of vision and colour vision in some hoofed animals. Zoological Institute, Munster University, 1970.

Bellis, E. D. and H. B. Graves. Deer mortality on a Pennsylvania interstate highway. Journal of Wildlife Management, 35(2):232-237, 1971.

Blaisdell, James A. and Richard L. Hubbard. An outrigger type deer fence. U.S. Forest Service, Forest Research Notes #108, 1956.

Conley, Clare. Road kills: the shameful waste. Outdoor Life, 1979.

Gordon, D. F. A report on the effectiveness of Van de Ree mirrors. Midwest Wildlife Conservation, 1967.

Halls, L. K., G. E. Boyd, D. W. Lay, and P. D. Goodrum. Deer fence construction and costs. Journal of Wildlife Management, 29(4): 885-888, 1965.

Howe, W. S. Experimentation with reflecting devices. Research Project Segment, 1966.

Jahn, L. R. Highway mortality as an index of deer-population change. Journal of Wildlife Management, 12(2):187-196, 1956.

Leedy, D. L. Highway-Wildlife relationships: Volume 1. Federal Highways Administration, 1975.

Messner, H. E., D. R. Dietz, and E. C. Garrett. A modification of the slanting deer fence. Journal of Range Management, 26(3):233-235, 1973.

Pojar, T. M., R. A. Prosence, D. F. Reed, and T. N. Woodard. Effectiveness of a lighted, animated deer crossing sign. Journal of Wildlife Management, 39(1):87-91, 1975.

Pojar, T. M., T. N. Woodard, and D. F. Reed. Effectiveness of highway lighting on number of deer killed by vehicles. Colorado Division of Wildlife, Game Research Report, 1972.

Pojar, T. M., Dale F. Reed, and T. C. Reseigh. Highway construction--motorist and deer safety. Colorado Division of Wildlife, 1972.

Pojar, T. M., T. N. Woodard, and D. F. Reed. Deer underpass evaluation. Colorado Division of Wildlife, 1973.

Queal, L. M. Effectiveness of roadside mirrors in controlling deer-car accidents. Michigan Department of Conservation, 1968.

Reed, D. F., J. Pojar, W. R. Heicher, L. L. Green, J. K. Moser, and T. N. Woodard. An evaluation of deer-proof fence length required to prevent deer movements on or across high speed highways. Colorado Division of Wildlife, 1973.

Reed, D. F., T. M. Pojar, and T. N. Woodard. Use of one-way gates by mule deer. Journal of Wildlife Management, 38(1):9-15, 1974.

Reed, D. F., T. M. Pojar, and T. N. Woodard. Mule deer responses to deer guards. Journal of Wildlife Management, 27(2):111-113, 1974.

Reed, D. F., T. N. Woodard, and T. M. Pojar. Behavioral response of mule deer to a highway underpass. Journal of Wildlife Management, 39(2):361-367, 1975.

Svoboda, F. J. Big game--highway safety conflicts and suggested solutions. Minnesota Highway Department, 1974.

Williams, J. E. Deer, death and destruction. Colorado Outdoors, 13(2):1-3, 1964.

Woodard, T. N., T. M. Pojar, and D. F. Reed. Investigation of one-way deer structures. Colorado Division of Wildlife, 1973.

Woodard, T. N. and D. F. Reed. Economic considerations in reduction of deer-vehicle accidents. Wildlife Society Conference, 1974.

APPENDIX

Selkirk College
Box 1200, Castlegar, British Columbia, V1N 3J1
Telephone 604-365-7292

Reuben Irvine
#3 - 134 Columbia Ave.
Castlegar B.C.
V1N 1A9

Dear Sirs:

I am presently attending Wildland Recreation Technology at Selkirk College Institute of Technology in Castlegar B.C. I am currently writing a major technical report for course completion.

My interests are directed to the problems arising from deer-vehicle accidents on major highways. The area of my particular study is bisected by highway 3 between Grand Forks and Christina Lake, and is a major winter range for Odocoileus hemionus (Mule deer) and Odocoileus virginiana (white-tailed deer). The loss of deer from deer-vehicle accidents is over one hundred deer every winter. The British Columbia Fish and Wildlife Branch have tried salt blocks, roadside mirrors and lower speed limits with very little success. I will be working with the B.C. Fish and Wildlife Branch to test and document results of new techniques during the winter of 1979/1980.

I would like to know if you have any data on deer-vehicle accidents on your highways, and the techniques you have tried, and their successes. Please send all articles to the above address. Any and all articles will be gratefully appreciated.

Thank you for your time and consideration.

Sincerely,

Reuben Irvine

RI/dbj