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**AERIAL SURVEY OF THE OLDMAN
RESERVOIR,
SOUTHWESTERN ALBERTA,
1 to 3 February 1993**

For
**The Oldman Dam Project Office
Alberta Public Works, Supplies and Services
Edmonton, Alberta**

Prepared by
**Garry E. Hornbeck, M.Sc., P.Biol.
and
Peter Balagus, B.Sc.**

April 1993

The Delta Environmental Management Group Ltd.

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Calgary, Alberta**

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AERIAL SURVEY OF THE

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1 to 3 February 1951

by

The Crown, The Project 1000
Alberta Wildlife Survey and
Department of Agriculture

Report by

Dr. E. H. Hume, M.S., F.R.S.

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Edmonton, Alberta

April 1951

EXECUTIVE SUMMARY

This was the first aerial survey to be conducted after the Reservoir became fully operational in 1992, and the first aerial survey to be conducted with radio-collared mule deer in the censused population. Ungulate aerial surveys were also conducted within nine regional Foothills Control Blocks within the Porcupine and Lundbreck Hills. These survey blocks were designed by the Alberta Fish and Wildlife Division and were intended to be used for monitoring regional ungulate population trends. The report also includes a collation of previous winter aerial survey results of the Reservoir and Foothills Control Blocks previously reported in order to provide a perspective for the current survey results.

During the survey, the Reservoir was near full supply level and the landscape was practically devoid of snow cover. The survey was flown with a Bell 206 B helicopter and closely-spaced parallel lines in order to provide complete visual coverage of the terrain. Three general regions were surveyed: the Reservoir and environs, the Foothills Control Blocks and a portion of the downstream river valley.

*Mule deer (*Odocoileus hemionus*) were the most common ungulate observed within the Oldman Reservoir basin and environs, and within surrounding regional Foothills Control Blocks. White-tailed deer were observed in comparatively small numbers downstream of the Oldman Dam and upstream of the full supply level on all three arms of the Reservoir. Relatively few moose were observed along the Castle and Crowsnest Rivers.*

The Oldman Dam mule deer population appears to have increased since construction of the Reservoir began during the mid-1980's. The current population of mule deer within the reservoir study area is at least 690 deer but less than 950 deer, based on information gained by the mark-recapture method. The current estimate is 25% greater than the most recent population estimates obtained by aerial surveys during February 1990 (554 mule deer) and January 1991 (552 mule deer). Compared to previous years, mule deer were observed in larger group sizes, and they were observed predominantly in cultivated landscapes. Observed fawn ratios remained high at 50 fawns:100 females. A comparison with ground counts indicates that aerial survey classifications have underestimated the actual age composition of the population, which has been estimated from ground counts to be about 79 fawns:100 females.

The regional population trend for mule deer, based on surveys of the Foothills Control Blocks, shows a decline since the late 1970's. The regional population of mule deer appears to have decreased by about half since 1980. The regional populations of white-tailed, moose and elk appears to have gradually increased.

ACKNOWLEDGEMENTS

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1.0 INTRODUCTION

1.1 BACKGROUND

Population estimates are required for detecting changes in wildlife abundance, particularly in areas where habitat availability may be decreasing. Concern for mule deer (*Odocoileus hemionus*), which are the most visible and economically important wildlife in the Oldman River basin area, arose during the construction of the Oldman Dam. The Oldman Dam was constructed during the late 1980's to regulate downstream flows by storing water in an onstream reservoir. Initial filling of the reservoir began during spring 1991, although the dam was not completely operational until 1992.

Various predictions have been made regarding the potential effects of the Oldman Reservoir on the local mule deer population. Predictions have included: severe populations declines, blockage of seasonal movements, shifts in movement and habitat utilization patterns toward increasing farmland depredation, an increase in the number of road kills on the paved grid road surrounding the reservoir, fatal injuries from the hazards of winter ice, both from lack of footing and the attendant danger of being trapped by shelf ice as the reservoir level subsides.

Mitigation programs have been established to lessen the impact of dam construction and operation on wildlife. Each component has been conducted in four general phases:

- Overview and Data Collection;
- Assessment and Mitigation Design;
- Mitigation Implementation; and
- Long-term Monitoring.

This progress report is part of the long-term monitoring program of the Oldman Dam mule deer population. The Delta Environmental Management Group Ltd. was retained by Alberta Public Works, Supply and Services Division, to conduct wildlife studies in the reservoir development area. We present the results of the February 1993 aerial survey of the Oldman Reservoir and environs. This was the first of a series of aerial surveys to be conducted since the reservoir became operational and was conducted with 16 radio-collared adult female mule deer in the censused population. During the survey the reservoir was near full supply level (approximately 1110 m asl, see Figure 2).

1.2 OBJECTIVE

The objective for the aerial survey was to obtain a minimum winter population estimate of mule deer within the reservoir basin and environs.

2.0 STUDY AREA

2.1 LOCATION AND LAND USE

The Oldman Reservoir basin is approximately 12 km north of the town of Pincher Creek (Figure 1). The area is located in the fescue grassland ecoregion of southwestern Alberta, adjacent to the eastern edge of the Rocky Mountain foothills (Strong and Leggat 1981). Because the reservoir has inundated the deep coulees and river breaks along the river systems, only remnant forest stands occur in the study area. The landscape surrounding the reservoir is gently undulating, dominated by mixed-farming practices. Hay crops, barely and wheat are the principle grains, and beef cattle are the dominant livestock (Alberta Agriculture 1991).

Native grasses within non-cultivated areas and coulee ridges immediately surrounding the reservoir include rough fescue (*Festuca scabrella*), western wheatgrass (*Agropyron smithii*), parry oat grass (*Panthonia parryi*) and june grass (*Koeleria gracilis*). Shrub communities within the remaining river breaks and coulees are comprised primarily of saskatoon (*Amelanchier alnifolia*), chokecherry (*Prunus virginiana*), wolf willow (*Elaeagnus commutata*), skunkbrush (*Rhus trilobata*) and creeping juniper (*Juniperus horizontalis*). Prior to clearing of the river valley to the elevation of the reservoir's full supply level, the river bottom was dominated by cottonwood (*Populus deltoides*), aspen (*Populus tremuloides*) and Douglas fir (*Pseudotsuga menziesii*) on the steeper, north-facing slopes of the river valleys. Only remnant stands of these forest communities now remain above the full supply line. A detailed description of the vegetation in the study area prior to flooding of the reservoir is provided by Reid *et al.* (1985).

2.2 DESCRIPTION OF THE RESERVOIR

Three river systems comprise the watershed and basin of the Oldman Reservoir: the Oldman River, the Crowsnest River and the Castle River (see Figure 1). The north stem of the Oldman River drains the lower slopes of the Porcupine Hills. The Castle River drains the Carbondale Hills along the eastern slopes of the Rocky Mountains, while the Crowsnest River drains the southern slopes of the Livingstone Range. The reservoir basin occupies 15.4 km of the original Main Stem of the Oldman river. Approximately 12 km of the Castle River channel and 7.5 km of the Crowsnest River channel have been incorporated into the reservoir. The reservoir also extends about 5.4 km into the north stem of the Oldman River. The volume of the reservoir at full supply level is 400,000 acre feet with a surface area of approximately 1,842 ha (1,118.6 m asl). The shoreline at full supply level has a perimeter of about 104 km (see Figure 2).

The Oldman Reservoir was initially filled during spring 1991, reaching the spillway on 4 June. The reservoir was allowed to empty during summer-fall 1991 and did not refill until mid-summer 1992 (Figure 3). The reservoir level was held about 5 meters below full supply during winter 1992-93 and was about 1110 m asl during this survey.

Figure 1. Oldman Reservoir in southwestern Alberta at full supply level (1118.6 m asl; surface area = 2400 ha).

Figure 2. Oldman Reservoir covered with ice, 1 February 1993. View of the Crownsnest River entering the Main Stem at the confluence with the North Stem.

Figure 3. Oldman Reservoir filling chronology between mid-summer 1991 and early 1993. (source: Oldman River Dam Office, Pincher Creek).

3.0 METHODS

3.1 AERIAL SURVEY TECHNIQUE

The survey were flown with a Bell 206B Jet Ranger helicopter, at a constant altitude of 120 m (400 ft.) above ground, and with a ground speed of approximately 130 km/hr (80 mph). The navigator/ observer sat in the front left seat of the helicopter accompanied by two rear-seated observers. The pilot also participated as an observer. The navigator/ observer plotted all wildlife observations on topographic maps recorded all of the information for each deer and other wildlife observation on tape recorder. Complete turns were made when wildlife were observed to obtain a complete count and to obtain age/sex information (if possible). Deer were sexed using the presence or absence of antlers, and fawns were identified by relative body size and conformation. Nose color, or the presence or absence of a vulva patch, was used to sex moose without antlers (Mitchell 1970).

Three regions of the study area were surveyed:

1. Oldman Reservoir basin and environs (environs include tributary streams and adjacent areas of the agricultural uplands). The flight path covering the reservoir basin followed linear, parallel north-south transects spaced at 400 m intervals providing a 200 m observation width that resulted in 100% visual coverage (Figure 4). Wildlife observation were plotted on a 1:50,000 scale topographic map (see Appendix Figure 1).

Flight lines within the Castle River section south of the full supply level of the reservoir paralleled the river channel following the contours of the associated coulee systems and upland benches. Two passes with the helicopter were made on each side of the Castle River while maintaining a 200 m observation width (Figure 4).

2. River basin downstream of the Oldman Dam. The downstream component of the survey was conducted with parallel 400 meter wide north-south transects aligned at right angles to the flow of the river (Figure 5). Wildlife observations were plotted on a 1:250,000 scale topographic map.
3. Regional Foothills Control Blocks. The Foothills Control Blocks were flown with parallel linear transects providing 100% visual ground coverage. Wildlife observations were plotted on 1:10,000 scale aerial photographs.

The Alberta Fish and Wildlife Division established the Foothills Control Blocks in 1978. The blocks were selected as representative of "key" ungulate winter ranges in the Lundbreck and Porcupine Hills. The survey blocks were designed for monitoring regional ungulate population trends in Wildlife Management Units 302, 304-306, and 308 (Figure 6). Survey blocks are within the montane ecoregion of southwestern Alberta, dominated by forests of lodgepole pine (*Pinus contorta*) mixed with stands of Douglas Fir and aspen. These blocks provide regional ungulate population information to aid the interpretation of survey results from the Oldman Reservoir basin.

Figure 4. Flight path during aerial surveys of the Oldman Reservoir and environs, 1 - 2 February 1993.

Figure 5. Flight path during aerial surveys of the Oldman River basin downstream of the Oldman Dam, 1 to 3 February 1993.

Figure 5. Flight path during aerial surveys of the Oldman River basin downstream of the Oldman Dam, 1 to 3 February 1993.

Figure 6. Location of Foothills aerial survey Control Blocks in southwestern Alberta.

The study area was surveyed in the following sequence in order to provide systematic, non-overlapping coverage:

1. North side of the Reservoir from Summerview to the North Stem;
2. South side of the Reservoir from Summerview to approximately Cowley;
3. Both sides of the Reservoir along the Crowsnest River, from the North Stem to approximately Lundbreck; and
4. Castle River south of the Alberta Forest Service Campground to the next bridge.
5. Downstream of the Reservoir within the riparian cottonwood forest and willow shrub habitat of the Oldman River. Survey coverage of this part of the study area was incomplete and did not extend to Fort McLeod as in previous surveys (see Figure 5 for a description of survey coverage downstream of the Oldman Dam).

3.2 AERIAL SURVEY INTENSITY

A summary of survey conditions and flight times area provided (Appendix Table 1). The current survey times are compared to the previous survey conducted during 10 to 12 January 1991 (Appendix Table 2). This comparison indicates that survey intensity within the Oldman Reservoir basin was somewhat greater during the current February 1993 survey compared to January 1991; 1.35 min./ km² vs. 1.27 min./ km², respectively. The survey intensity of 1.15 min./ km² within the Foothills Control Blocks, however, was identical during both years. The greater survey intensity was not intended, but may have resulted from a somewhat more systematic survey pattern. It should be noted that snow conditions during the current survey were extremely poor, with little snow on the ground and only old snow in lee sides of the topography (see Figure 2).

3.3 ACCURACY OF THE SURVEY

The current survey was the first aerial survey of the Oldman Reservoir study area conducted with radio-collared mule deer in the censused population. The accuracy of the aerial survey can be estimated from the ratio of marked (radio-collared) to unmarked deer. The radio collars were made of 5 cm wide (2.5 inches) off-white machine belting. These collars are highly visible and can be easily noticed at long range. The helicopter survey crew did not have any prior knowledge of the total number of marked deer or their precise locations.

Sixteen (16) radio-collared deer were known to be within the study area two days before the start of the aerial survey (30 January 1993; G. Hoffman, pers. comm.) (Appendix Table 3). This information was provided at the completion of the survey. Prior to the survey, recent relocations were not available for deer #42 or deer #45. The most recent relocation for deer #42 indicated she was outside of the survey area. Deer #45 was last relocated 16 November 1992. Since she had been relocated several times southwest of Lundbreck this deer was assumed also to have been outside of the survey area.

4.0 RESULTS AND DISCUSSION

4.1 MULE DEER

4.1.1 Population Estimate

A total of 690 mule deer were observed within the Oldman Reservoir basin and surrounding agricultural uplands (Table 1). This count is 25% larger than previously observed during two recent winter surveys conducted during February 1990 and January 1991 (Hornbeck and Balagus 1992a), and is considerably larger than earlier winter surveys of the reservoir by Allison and Russell (1985 and 1986). An increasing population trend is evident when the results of these 5 surveys are compared (Figure 7). The fact that mule deer have become more visible with the clearing of forest and shrublands during the preparation of the reservoir basin, and most recently during the actual filling of the reservoir, may account for part of the observed increase. As noted previously, the current 1993 aerial survey was the first winter count of mule deer with a completely operational reservoir that was near full supply level (see Figure 3 for Reservoir level during this survey).

Improved visibility from clearing the reservoir basin may account for the increase in deer numbers between the 1985-86 and the 1990-91 period. However, there were no further habitat changes (clearing of forest and shrublands) between the 1991 and 1993 winter surveys. The increase between 1991 and 1993 may reflect, in part, the improved aerial survey intensity (Appendix Table 2). However, the overall population trend shown in Figure 7 is highly significant ($r^2 = 0.977$), and it may be due to improved mule deer survival. For example, the winter 1991-92 was an extremely mild winter by comparison to recent years for which we have some information (Figure 8).

Figure 7. Winter aerial surveys of the Oldman Reservoir and environs, 1985 to 1993. The 1985 and 1986 surveys were conducted by Allison and Russell (1985 and 1986).

Table 1. Number of ungulates observed during mid-winter aerial surveys of the Oldman Reservoir and environs; 1 to 3 February 1990, 10 to 12 January 1991 and 1 to 3 February 1993. See Figures 4 and 5 for flight path.

Reservoir Segment	1 to 3 February 1990				10 to 12 January 1991				1 to 3 February 1993			
	White-tailed		Moose	Elk	Total	White-tailed		Moose	Elk	Total	White-tailed	
	Mule deer	deer				Mule deer	deer				Mule deer	deer
Castle	137	0	6	0	143	166	112	8	0	286	52	94
Crowsnest	129	0	1	0	130	73	22	3	0	98	138	40
North Stem	143	0	0	0	143	136	32	0	1	169	147	0
Main Stem	145	0	0	0	145	177	0	1	0	178	353	0
Subtotal	554	0	7	0	561	552	166	12	1	731	690	134
Downstream	177	139	0	0	316	10	79	0	0	89	12	59
Total	731	139	7	0	877	562	245	12	1	820	702	193
											3	0
											0	898

The Downstream survey during the current February 1993 survey was incomplete (see Figure 5).

Another factor that may have improved mule deer survival at the Oldman Dam has been the "sanctuary effect" created by the construction activity. The mule deer population has been at least partially protected from hunting since construction began in the mid-1980's, while at the same time cattle were withdrawn from the river valleys (reducing competition) as the mitigation plans were being implemented.

It seems apparent that the clearing of the river valley basin for the Oldman Reservoir may not have resulted in large habitat losses for the mule deer. The landscape was changed and altered, but 'habitat' remained. However, the flooding of the reservoir more recently has resulted in a considerable amount of habitat otherwise available for deer for travelling and feeding. It is speculative, but population changes may occur in the near future with the relatively recent loss of habitat below full supply level and with deer becoming increasingly dependent on the surrounding agricultural landscape (see section 4.1.2 - Distribution and Group Size). It appears that the deer are now more dependent upon the agricultural landscape and this places them in a more vulnerable position when they will be forced to cope with a severe winter.

Figure 8. Winter severity index (mean monthly temperature x total monthly snowfall as an integrated measure) for Pincher Creek during recent winters. (Source: Environment Canada, Climatology).

Mark-Recapture Estimate

Ten of the 16 radio-collared deer within the study area were observed during the survey. The proportion of marked deer counted (62.5%) suggests that the actual deer population was larger than observed. The precision of the mark-recapture method, however, is dependent upon a number of factors and the proportion of the population that is marked is an important one. In general, the larger the proportion of marked animals the better the precision. Also, the important assumption that there was a random intermixing of marked deer with unmarked deer, and that each marked deer had the same chance of being observed, obviously did not hold.

With consideration for the following conditions and constraints:

- the proportion of marked deer in the population during this survey was only about 2% (16 marked from an observed population of about 700);
- marked deer were not randomly intermixed within the population (two marked deer were observed together on the Crownest River, and three marked deer (#25, #28 and #46) were last relocated together in a single group);

it is not possible to apply the mark-recapture ratio as a linear function to correct the observed population estimate. It seems highly unlikely that the actual population was 38% larger than observed ($1 - 0.625 = 0.38$). A larger number of marked deer would be necessary in order to avoid the potential bias of a small sample size. The assumptions of randomness would also be more closely met with a larger proportion of marked deer. Therefore at the present time, we estimate that the population of mule deer at the Oldman Reservoir is between 690 deer and 950 deer.

4.1.2 Distribution and Group Size

Mule deer were observed for the most part during the current survey in the agricultural uplands, feeding in large groups on cropland (Figure 9). A comparison with the previous January 1991 aerial survey, before reservoir was filled, illustrates a change in winter distribution of deer. Concomitant with a decrease in available river valley and coulee habitat, mule deer appear to have moved away from the river corridors to the now predominantly available agricultural uplands (Figure 10).

Mule deer were observed around the Oldman Reservoir in fewer but larger groups compared to previous mid-winter aerial surveys (Table 2, Figure 11). The mean group size during the current survey was 16.8 deer/ group ($n = 41$; range 3 to 61) compared to 10.4 and 7.4 deer/ group during January 1991 and February 1990, respectively. Increasing group size appears to be correlated with decreasing amounts of shrub and forest habitat and diminishing topographic complexity that has occurred since the Oldman Dam came into operation during spring 1991 (i.e., large areas of rough terrain within coulee formations have been inundated by the Reservoir).

Notable concentrations of deer were observed in the vicinity of the Dam Control buildings where these animals are associated with two relatively deep coulee systems (Appendix Figure 1 shows wildlife locations with reference to topographic contours). Mule deer have been "enticed" into close proximity with people at the Dam site by a cover crop of oats that was seeded around the buildings in the landscape reclamation mix. This concentration of mule deer near the Dam was not evident during the previous winter survey (compare Figures 9 and 10), although the habitat value of the nearby coulee systems have been previously recognized (Allison and Russell 1986). It seems apparent that a degree of habituation (reduction or loss of a response to humans as a result of repeated experience) has occurred; a process that started several years ago when construction of the dam began several years ago.

Figure 9. Location and number of ungulates observed during mid-winter aerial surveys of the Oldman Reservoir, 1 - 3 February 1993.

Figure 10. Location and number of ungulates observed during aerial surveys of the Oldman Reservoir, 10 - 12 January 1991 (from Hornbeck and Balagus 1992).

Table 2. Mean size of ungulate groups observed during mid-winter aerial surveys of the Oldman Reservoir and environs: 1 to 3 February 1990, 10 to 12 January 1991 and 1 to 3 February 1993. (No. below mean is no. of groups observed.)

Reservoir segment	1 to 3 February 1990					10 to 12 January 1991					1 to 3 February 1993				
	White-tailed					White-tailed					White-tailed				
	Mule deer	tailed deer	Moose	Elk		Mule deer	tailed deer	Moose	Elk		Mule deer	tailed deer	Moose	Elk	
Castle	7.6 18	0.0	1.2 5	0.0		10.4 16	28.0 4	1.6 5	0.0		10.4 5	31.3 3	1.5 2	0.0	
Crowsnest	5.9 22	0.0	1.0 1	0.0		12.2 6	5.5 4	3.0 1	0.0		19.7 7	40.0 1	0.0	0.0	
North Stem	9.5 15	0.0	0.0	0.0		9.7 14	8.0 4	0.0	1.0 1		18.4 8	0.0	0.0	0.0	
Main Stem	7.2 20	0.0	0.0	0.0		10.4 17	0.0	1.0 1	0.0		16.8 21	0.0	0.0	0.0	
Downstream	3.8 46	5.0 28	0.0	0.0		3.3 3	4.2 19	0.0	0.0		5.5 2	7.4 8	0.0	0.0

Figure 11. Frequency distribution of mule deer group size around the Oldman Reservoir during recent winter aerial surveys; February 1990 (top), January 1991 (middle), and the current February 1993 survey (bottom).

As noted during previous surveys, a relatively small number of mule deer inhabit the riparian cottonwood forests downstream of the Dam (Table 1). However, the Oldman River valley downstream of the Dam appears to be primarily white-tailed deer habitat, where white-tails have been observed consistently in large numbers and with larger group sizes (Table 2, Figure 12).

4.1.3 Age and Sex Composition

The current survey results are compared to the most recent survey of January 1991 (from Hornbeck and Balagus 1992a). Age and sex classifications are reported only for deer within groups which were completely classified. The relatively large mid-winter fawn:female ratio (50:100) indicates that recruitment of mule deer is high and that the Oldman Reservoir mule deer population may be increasing (Table 3). The male composition is highly skewed toward females, which probably reflects the result of the previously held November antlered hunting seasons.

Age and sex ratio classifications obtained from aerial surveys tend to underestimate population parameters, particularly the young-of-the-year cohort. Based on repeated mule deer ground classifications at the Oldman Reservoir during an intensive deer trapping study conducted during February and March 1992, male:female ratios were 10:100 while a significantly larger fawn ratio was observed (79 fawns:100 females) (Hornbeck and Balagus 1992b). The results obtained from both the aerial surveys and the ground counts indicate that survival of fawn mule deer at the Oldman Dam is relatively high. These classification counts support the evidence from aerial survey counts that suggests the Oldman mule deer population may be increasing.

Table 3. Age and sex classification of mule deer observed during mid-winter aerial surveys of the Oldman Reservoir and environs, 10 to 12 January 1991 and 1 to 3 February 1993.

Date	Adult Female	Fawn	Yearling Male	Adult Male	Unclass.	Total
January 1991	290	143	3	16	16	452
February 1993 ¹	134	67	3	2		206
	Males:100 Females ¹		Fawns:100 Females ¹		% Fawns ²	
January 1991	7:100		49:100		32	
February 1993	4:100		50:100		32	

¹ Data from groups with all individuals classified.

² Fawns as a percent of all classified deer observed.

Figure 12. Location and number of deer observed downstream of the Oldman Dam during aerial surveys of 1 to 3 February 1993.

4.1.4 Habitat Use

The distribution patterns of mule deer observed among various vegetation categories during the current and recent aerial surveys are presented as a first approximation for analysis of habitat use. The data is not specific to landform or topography, and we do not have habitat availability information that would be useful in establishing a measure of habitat preference.

The general distribution of mule deer among habitat types indicates that changes in winter habitat use may have occurred during the course of the last few years, particularly with respect to use of croplands, and deciduous and shrub habitat which are both primarily associated with river valley and coulee formations (Figure 13). During the current survey, about 45% of the deer were observed in cultivated fields, obviously attracted to waste grain and chaff piles. By comparison, relatively few mule deer were observed in cropland during previous winter aerial surveys. Less than 10% of the deer during the current survey were observed in shrublands, which is part of a steady decline from 40% and 18% during winter 1989-90 and winter 1991-2, respectively. Increased use of agricultural lands may be a direct response to the availability of waste grain, but increased use of uplands may also be related to the loss of deciduous and shrubland river valley habitats that were removed from the landscape when inundated by the Reservoir (see Figure 2).

Figure 13. Distribution of mule deer by habitat type observed during winter aerial surveys of the Oldman Reservoir and environs, 1 to 3 February 1990 and 10 to 12 January 1991.

4.1.5 Regional Population Trend

Based on winter aerial surveys of the Foothill Control Blocks, the regional mule deer population appears to have declined over the course of the last 16 years (Table 4, Figure 14, and Appendix Table 5). Mule deer density within the control blocks declined from 11.4 deer/ km² in 1978 (793 deer/ 69.9 km²) to about 2.2 deer/ km² in 1993 (204 deer/ 92.5 km²). Although the population trend is based on only a few data points (6 surveys during 16 years), the strength of the relationship lies with the fact that this information has been collected over a relatively long term from several independent survey blocks.

Figure 14. Regional mule deer density (deer/ 100 km²) collected from mid-winter aerial surveys of Foothills Control Blocks in the Porcupine and Lundbreck Hills, 1978 to 1993. (See Table 4 and Appendix Table 5 for actual survey counts; the 1985 data is from Allison and Russell 1985). (n = no. of control blocks surveyed).

4.2 OTHER UNGULATES

As discussed, mule deer were the only ungulate observed around the Main Stem and periphery of the Reservoir (see Table 1). Mule deer were also the most abundant ungulate in the Oldman Reservoir study area and in the Foothills Control Blocks. White-tailed deer were observed both downstream of the Dam in the riverine cottonwood habitat, and upstream of the full supply level on all three arms of the Reservoir, associated primarily with agricultural uplands (Figures 9 and 10). The total count of white-tailed deer during recent aerial surveys of the reservoir and environs has ranged from 139 to 245 to 193 during February 1990, January 1991 and February 1993, respectively (Table 1).

Table 4. Number of ungulates observed during mid-winter aerial surveys of Alberta Fish and Wildlife Division's Control Blocks; 1978, 1980, 1990, 1991 and 1993. (See Figure 6 for map showing location of survey control blocks.)

Control Block	19 78				19 80				19 90				19 91				19 93			
	White-		White-		White-		White-		White-		White-		White-		White-		White-		White-	
	Mule deer	White-tailed deer	Mule deer	White-tailed deer	Mule deer	White-tailed deer	Mule deer	White-tailed deer	Mule deer	White-tailed deer	Mule deer	White-tailed deer	Mule deer	White-tailed deer	Mule deer	White-tailed deer	Mule deer	White-tailed deer	Mule deer	White-tailed deer
FH 1	262	0	8	22	73	0	6	8	67	0	3	1	48	0	1	34	13	0	3	0
FH 2	316	0	0	0	255	0	2	0	201	3	0	0	269	79	0	0	128	0	0	0
FH 4	65	0	3	0	39	0	0	0	11	20	5	2	Not surveyed				0	0	4	2
FH 9	51	0	3	0	Not surveyed				26	0	0	0	40	0	1	0	8	0	0	0
FH 10	25	0	0	0	39	0	0	0	36	0	0	0	9	0	0	0	49	0	0	0
FH 12	39	0	7	0	Not surveyed				14	2	6	9	8	0	5	8	2	0	15	85
FH 13	35	11	0	0	Not surveyed				39	4	7	0	6	0	13	0	0	15	20	0
FH 14	Not surveyed				32	0	2	11	4	0	0	47	0	0	0	0	0	0	2	0
FH 15	Not surveyed				18	0	4	48	5	0	2	0	Not surveyed				4	0	1	0
Total	793	11	21	22	456	0	14	67	403	29	23	59	380	79	20	42	204	15	45	87

Alberta Fish and Wildlife Division conducted the 1978 and 1980 surveys.

The Delta Group Ltd. conducted the February 1990, January 1991, and February 1993 surveys.

Moose have not been commonly observed around the planned Reservoir during recent surveys (Table 1). Small numbers of moose have been observed, however, on the Castle River upstream of the Reservoir full supply level. The number of moose in the reservoir survey area have ranged from 7 (February 1990) to 12 (January 1991) to 3 (February 1993) during recent surveys (Table 1). Only a single observation of a branch-antlered elk has been observed recently within the planned Reservoir survey area (January 1991).

4.2.1 Regional Populations

Within the foothills control blocks, the numbers of moose and elk have appeared to remain relatively stable over time with about three times as many elk as moose (i.e., since 1978) (Table 4). The numbers of white-tailed deer in the regional population has fluctuated widely among surveys, however there appears to be a general increase in total number. This is consistent with hunter success reports that show white-tailed deer increasing steadily in the southern foothills region (L. Gudmundson pers. comm.).

5.0 SUMMARY AND CONCLUSIONS

A total of 690 mule deer were observed within the Oldman Reservoir basin and surrounding agricultural uplands during this current survey. The count was 25% larger than previously observed during the two most recent surveys. This relatively high count continues an increasing population trend that has been apparent since mule deer surveys were initiated during 1985. Improved visibility of mule deer from clearing of the planned reservoir basin may account for part of the increase. In addition, a slightly improved aerial survey intensity may also have contributed to the apparent increase. However, the comparison of aerial survey results shows a highly significant relationship that can be attributed to high recruitment and survival.

Classification counts during aerial surveys show relatively large mid-winter fawn ratios (50 fawns:100 females), and when compared to ground classification counts (79 fawns:100 females), the aerial classifications are seen to be under-estimated. However, the results obtained during the aerial surveys and the ground counts revealed high winter survival and recruitment of fawns which could be expected to result in a population increase as observed by winter survey counts.

Over the course of the last three aerial surveys, there has been a trend toward increasing mule deer group sizes, which may be related to the loss of forest and shrub habitat. Habitat use has also changed over the last few surveys, with an increasing amount of use of the agricultural uplands and Douglas fir, and a decreasing amount of use of aspen and shrublands. These trends are attributed to the loss of habitat associated with the filling of the reservoir. The regional population of mule deer appears to have declined since the late 1970's, as indicated by the survey results of the Regional Foothills Control Blocks. The indication is that the white-tailed deer, moose and elk populations have gradually increased during the same time period.

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7.0 APPENDIX

Appendix Table 1. Flight summary for a mid-winter aerial wildlife surveys of the Oldman Reservoir and environs, 1 to 3 February 1993.

Date: 1 February 1993
 Helicopter: C-GFSE Bell 206B, Supplies and Services Alberta
 Pilot: Gary Flath
 Observers: G.E. Hornbeck (LF), P. Balagus (RR), C. Markle (LR)
 Snow conditions: Snow drifts only in treed areas; open areas and fields without snow
 Weather conditions: +6 °C , mostly clear skies, westerly chinook winds steady at 30 knots

		<u>Fly (min.)</u>	<u>Survey (min.)</u>
T-off Calgary, AFS Base	0825		
Land Pincher Creek Airport	0925	60	
T-off	0959		
Begin survey Main Stem north side	1006	7	
Stop survey	1121		75
Land Pincher Creek for fuel	1126	5	
T-off	1208		
Resume survey	1213	5	
Land for ground count	1255		42
T-off, resume survey	1322		
Complete Main Stem north side	1330		12
Begin survey Main Stem South side	1342		
Land for ground count	1404		22
T-off	1415		
Land at Dam Control Bldg.	1416	1	
T-off	1437		
Resume survey	1438	1	
Land for ground count	1514		36
T-off	1531		
Resume survey	1540	9	
Complete Main Stem south side	1610		30
Land / T-off Dam Control Bldg	1614	4	
Land AB Fish and Wildlife Cmpd.	1621	7	
		<u>111 min.</u> (1.85 hrs.)	<u>217 min.</u> (3.62 hrs.)

Total flying time = 5.47 hrs.(328 minutes)

Appendix Table 1. Continued.

Date: 2 February 1993
 Helicopter: C-GFSE Bell 206B, Supplies and Services Alberta
 Pilot: Gary Flath
 Observers: G.E. Hornbeck (LF), P. Balagus (RR), C. Markle (LR)
 Snow conditions: Snow drifts only in treed areas; open areas and fields without snow
 Weather conditions: +6 °C, clear skies, W. chinook winds steady but light ≤ 30 knots

		<u>Fly (min.)</u>	<u>Survey (min.)</u>
T-off AB Fish and Wildlife Cmpd.	0845		
Land Pincher Creek airport	0849	4	
T-off	0852		
Land at Dam Control Bldg.	0857	5	
T-off	0858		
Begin survey Castle River Segment	0912	14	
Complete Castle River Segment	1017		65
Begin survey Crowsnest R. Segment	1020	3	
Land for ground count	1050		30
T-off	1121		
Resume survey	1122	1	
Land for ground count	1130		8
T-off, resume survey	1134		
Complete Crowsnest River Segment	1154		20
Land for fuel at Pincher Creek	1159	5	
T-off	1223		
Land at Dam Control Bldg.	1228	5	
T-off	1324		
Begin survey south of Lundbreck	1334	10	
Land for ground count	1349		15
T-off, resume survey	1352		
Complete survey south of Lundbreck	1359		7
Begin survey FH12	1420	21	
Complete FH12	1446		26
Begin survey FH13	1448	2	
Complete FH13	1509		21
Begin survey FH9	1526	17	
Complete FH9	1546		20
Land for fuel at Blairmore AFS Base	1609	23	
T-off	1622		
L./T-off Pincher Creek	1637	15	
Land at AB Fish and Wildlife Cmpd.	1641	4	
		<u>129 min.</u> (2.15 hrs.)	<u>212 min.</u> (3.53 hrs.)

Total flying time = 5.68 hrs.(341 minutes)

Appendix Table 1. Concluded.

Date: 3 February 1993
 Helicopter: C-GFSE Bell 206B, Supplies and Services Alberta
 Pilot: Gary Flath
 Observers: G.E. Hornbeck (LF), P. Balagus (RR), C. Markle (LR)
 Snow conditions: Snow drifts only in treed areas; open areas and fields without snow
 Weather conditions:

		<u>Fly (min.)</u>	<u>Survey (min.)</u>
T-off AB Fish and Wildlife Cmpd.	0851		
Begin survey FH10	0908	17	
Land for ground count	0919		11
T-off, resume survey	0923		
Complete survey FH10	0936		13
Begin survey FH14	0944	8	
Complete survey FH14	1004		20
Begin survey FH2	1017	13	
Complete survey FH2	1050		33
Land for a rest stop	1054	4	
T-off	1115		
Begin survey FH1	1117	2	
Complete survey FH1	1158		41
Land for fuel in Blairmore AFS Base	1207	9	
T-off	1228		
Begin survey FH15	1241	13	
Complete survey FH15	1313		32
Begin survey FH4	1317	4	
Complete survey FH4	1345		28
Land at Dam Control Bldg.	1351	6	
T-off	1422		
Begin survey Downstream Segment	1424	2	
End survey	1515		51
Land at AB Fish and Wildlife Cmpd.	1524	9	
T-off	1535		
Land in Blairmore AFS Base	1553	18	
T-off	1610		
Land in Calgary AFS Base	1710	60	
		<u>165 min.</u> (2.75 hrs.)	<u>229 min.</u> (3.82 hrs.)

Total flying time = 6.57 hrs.(394 minutes)

Appendix Table 2. Aerial survey time (minutes) during mid-winter aerial surveys of the Oldman Reservoir and environs, 10 to 12 January 1991 and 1 to 3 February 1993.

Survey location	10 to 12 January 1991	1 to 3 February 1993
Oldman Reservoir and environs (268 km ²)	340	362
Downstream of Dam	83	51
Foothills Control Blocks		
FH 1	49	41
FH 2	39	33
FH 4	not surveyed	28
FH 9	24	20
FH 10	16	24
FH 12	24	26
FH 13	18	21
FH 14	15	20
FH 15	not surveyed	32
Total survey minutes (hrs.)	608 (10.13)	658 (10.97)

Note: The survey of the Downstream was incomplete during February 1993.

Appendix Table 3. Relocation data (UTM grid references) and the identification of radioed deer observed during the 1 to 3 February 1993 aerial survey of the Oldman Reservoir.

Radio-collared Deer No.	Date relocated	Easting		Northing (y1)	x1-x2	y1-y2	Dist. (km) from previous reloc.	Observed during survey
		Easting (x1)	adjusted					
No. 6	30-Jan-93	89.5	23.5	94.6				
	13-Feb-93	89.5	23.5	94	0.00	0.36	0.60	Yes
No. 7	30-Jan-93	7.3	7.3	96.9				
	13-Feb-93	93.1	8.9	98.9	2.56	4.00	2.56	Yes
No. 8	30-Jan-93	89.4	23.4	94.1				
	13-Feb-93	89.9	23.9	94	0.25	0.01	0.51	Yes
No. 13	30-Jan-93	92.3	26.3	94.3				
	13-Feb-93	92.3	26.3	95.2	0.00	0.81	0.90	No
No. 16	30-Jan-93	91.9	25.9	93.5				
	13-Feb-93	Not available						No
No. 22	30-Jan-93	84.1	18.1	94.1				
	13-Feb-93	89.5	23.5	94	29.16	0.01	5.40	Yes
No. 25	30-Jan-93		12.5	102.2				
	13-Feb-93		12.7	102.1	0.04	0.01	0.22	No
No. 26	30-Jan-93		7.3	96.9				
	13-Feb-93		8	98.9	0.49	4.00	2.12	Yes
No. 28	30-Jan-93		12.5	102.2				
	13-Feb-93		13	100.9	0.25	1.69	1.39	No
No. 29	30-Jan-93		12.6	101.5				
	13-Feb-93		12.7	102.1	0.01	0.36	0.61	Yes
No. 35	30-Jan-93		7.3	96.9				
	13-Feb-93		8.9	98.9	2.56	4.00	2.56	Yes
No. 38	30-Jan-93		13.7	90.6				
	13-Feb-93		15.2	89.6	2.25	1.00	1.80	Yes
No. 42	30-Jan-93	Not available						
	13-Feb-93	88.6	22.6	101.6	Outside study area			
No. 45	30-Jan-93	Not available						
	13-Feb-93	Not available			Outside study area			
No. 46	30-Jan-93		12.5	102.2				
	13-Feb-93		12.7	102.1	0.04	0.01	0.22	No
No. 47	30-Jan-93		8.9	98.9				
	13-Feb-93		8.9	98.9	0.00	0.00	0.00	Yes
No. Y4	30-Jan-93	83.9	17.9	93.7				
	13-Feb-93		16.6	94.6	1.69	0.81	1.58	Yes
No. Y8	30-Jan-93	83.9	17.9	93.7				
	13-Feb-93		16.5	93.8	1.96	0.01	1.40	No

Appendix Table 4. Number of wildlife observed during mid-winter aerial surveys of the Oldman Reservoir and environs, 1 to 3 February 1993.

Obs. no.	Date	Time	Reservoir segment	Species	No. Observed				Location (UTM)	Habitat Type	Activity when first observed		
					Female Y-o-y		Adult						
					Male	Yrl.	Male	Total					
1	1-Feb-93	1005	Main Stem	Mule Deer					8	8	TK 929 942	Grassland	Bed-remain
2	1-Feb-93	1010	Main Stem	Mule Deer					7	7	TK 912 942	Grassland	unrecorded
3	1-Feb-93	1030	Main Stem	Coyote					1	1	TL 903 038	Grassland	Running
4	1-Feb-93	1045	Main Stem	Coyote					2	2	TK 877 978	Shrubland	Running
5	1-Feb-93	1108	Main Stem	Coyote					1	1	TL 852 034	Cropland	Running
6	1-Feb-93	1109	Main Stem	Coyote					1	1	TL 848 020	Cropland	Running
7	1-Feb-93	1114	Main Stem	Coyote					1	1	TL 843 016	Cropland	Running
8	1-Feb-93	1120	Main Stem	Mule Deer					7	7	TK 841 982	Grassland	Bed-std-mill
9	1-Feb-93	1228	Main Stem	Mule Deer					7	7	QF 145 032	Douglas Fir	Standing-run
10	1-Feb-93	1243	Main Stem	Mule Deer	11	3			14	14	QF 134 039	Douglas Fir	Running
11	1-Feb-93	1244	Main Stem	Mule Deer	5	3			8	8	QF 133 023	Douglas Fir	Running
12	1-Feb-93	1244	Main Stem	Mule Deer					10	10	QF 136 023	Douglas Fir	Running
13	1-Feb-93	1255	Main Stem	Mule Deer					5	5	QF 135 026	Douglas Fir	Running
14	1-Feb-93	1300	North Stem	Mule Deer	15	7			1	23	QF 125 032	Cropland	Feed-remain
15	1-Feb-93	1300	North Stem	Mule Deer	1	3			4	4	QF 124 030	Grassland	Bed-remain
16	1-Feb-93	1300	North Stem	Mule Deer	5	2			3	10	QF 123 028	Grassland	Bed-remain
17	1-Feb-93	1310	North Stem	Mule Deer	14	9			20	43	QF 123 026	Grassland	Bed-remain
18	1-Feb-93	1310	North Stem	Mule Deer	13	7			20	20	QF 122 025	Grassland	Bed-remain
19	1-Feb-93	1310	North Stem	Mule Deer					28	28	QF 123 022	Grassland	Bed-remain
20	1-Feb-93	1310	North Stem	Mule Deer	6	2			8	8	QF 125 020	Grassland	Bed-remain
21	1-Feb-93	1330	North Stem	Mule Deer					11	11	QF 124 015	Shrubland	Sid-run
22	1-Feb-93	1342	Main Stem	Mule Deer					13	13	TK 904 937	Douglas Fir	Sid-run
23	1-Feb-93	1342	Main Stem	Mule Deer					5	5	TK 900 934	Douglas Fir	Sid-run
24	1-Feb-93	1342	Main Stem	Mule Deer					16	16	TK 902 933	Grassland	Sid-run
25	1-Feb-93	1342	Main Stem	Mule Deer	3	3			6	6	TK 906 929	Grassland	Sid-remain

Appendix Table 4. Number of wildlife observed during mid-winter aerial surveys of the Oldman Reservoir and environs, 1 to 3 February 1993.

Obs. no.	Date	Time	Reservoir segment	Species	No. Observed				Location (UTM)	Habitat Type	Activity when first observed
					Female	Y-o-y	Yrl. Male	Adult Male			
26	1-Feb-93	1342	Main Stem	Mule Deer	3	3			6 TK 903 927	Grassland	Std-remain
27	1-Feb-93	1342	Main Stem	Mule Deer	2	1			3 TK 901 926	Grassland	Std-remain
28	1-Feb-93	1404	Main Stem	Mule Deer	4	3		1	8 TK 915 927	Grassland	Std-run
29	1-Feb-93	1415	Main Stem	Mule Deer					35 TK 903 917	Cropland	Feed-run
30	1-Feb-93	1415	Main Stem	Mule Deer	21	11	1	1	2 TK 907 916	Cropland	Feed-remain
31	1-Feb-93	1440	Main Stem	Mule Deer	2	2			4 TK 894 945	Grassland	Bed-remain
32	1-Feb-93	1447	Main Stem	Mule Deer					61 TK 878 944	Cropland	Bed-remain
33	1-Feb-93	1505	Main Stem	Mule Deer					35 TK 844 948	Cropland	Feed-run
34	1-Feb-93	1534	Main Stem	Mule Deer	38	17	3	1	59 TK 838 939	Cropland	Feed-run
35	1-Feb-93	1600	Main Stem	Coyote					3 QE 149 946	Grassland	Running
36	1-Feb-93	1605	Castle	Mule Deer					4 QE 145 949	Grassland	Std-run
37	2-Feb-93	918	Castle	Coyote					6 QE 126 856	Aspen	Running
38	2-Feb-93	920	Castle	Mule Deer					18 QE 117 844	Shrubland	Running
39	2-Feb-93	925	Castle	White-tailed Deer					8 QE 122 845	Cropland	Std-mill
40	2-Feb-93	925	Castle	Mule Deer					8 QE 123 847	Cropland	Std-mill
41	2-Feb-93	935	Castle	Coyote					1 QE 129 870	River ice	Running
42	2-Feb-93	947	Castle	Mule Deer					10 QE 137 902	Aspen	Running
43	2-Feb-93	952	Castle	Coyote					1 QE 123 866	Grassland	Running
44	2-Feb-93	956	Castle	Moose	1				1 QE 115 856	Aspen	Bed-std
45	2-Feb-93	1002	Castle	Coyote					1 QE 064 849	Grassland	Running
46	2-Feb-93	1006	Castle	Mule Deer					12 QE 064 845	Douglas Fir	Run-mill
47	2-Feb-93	1017	Castle	Moose	1	1			2 QE 067 845	Douglas Fir	Run-std
48	2-Feb-93	1035	Crownsnest	Coyote					1 QF 094 014	Cropland	Std-remain
49	2-Feb-93	1044	Crownsnest	Mule Deer	11	4			15 QF 083 023	Cropland	Feed-remain
50	2-Feb-93	1049	Crownsnest	Mule Deer	4				4 QE 077 988	Pasture	Std-walk
51	2-Feb-93	1050	Crownsnest	Mule Deer	25	11			36 QE 078 992	Shrubland	Std-walk

Appendix Table 4. Number of wildlife observed during mid-winter aerial surveys of the Oldman Reservoir and environs, 1 to 3 February 1993.

Obs. no.	Date	Time	Reservoir segment	Species	No. Observed				Location (UTM)	Habitat Type	Activity when first observed	
					Female Y-o-y	Yrl. Male	Adult Male	Unclass. Total				
52	2-Feb-93	1120	Crowsnest	Mule Deer			4	47	51	QE 077 969	Douglas Fir	Run-mill
53	2-Feb-93	1143	Crowsnest	Mule Deer	6	5			11	QF 067 030	Cropland	Feed-remain
54	2-Feb-93	1150	Crowsnest	Mule Deer				18	18	QF 035 067	Cropland	Feed-remain
55	2-Feb-93	1146	Crowsnest	Coyote				1	1	QF 064 007	Shrubland	Std-remain
56	2-Feb-93	1147	Crowsnest	Coyote				1	1	QE 067 988	Cropland	Running
57	2-Feb-93	1148	Crowsnest	Coyote				1	1	QE 065 985	Shrubland	Running
58	2-Feb-93	1152	Crowsnest	White-tailed Deer				40	40	QF 049 006	Cropland	Feed-run
59	2-Feb-93	1155	Crowsnest	Mule Deer				3	3	QE 075 983	unrecorded	unrecorded
60	2-Feb-93	1337	Crowsnest	Coyote				1	1	QE 044 984	Shrubland	Running
61	2-Feb-93	1353	Castle	White-tailed Deer				82	82	QE 082 884	Cropland	Sid-run
62	2-Feb-93	1355	Castle	White-tailed Deer				4	4	QE 078 886	Cropland	Sid-run
1	3-Feb-93	1426	Downstream	Mule Deer			1	10	11	UL 290 121	Grassland	Sid-remain
2	3-Feb-93	1430	Downstream	White-tailed Deer				25	25	UL 284 125	Cropland	Sid-run
3	3-Feb-93	1430	Downstream	Coyote				2	2	UL 278 125	Cropland	unrecorded
4	3-Feb-93	1435	Downstream	Coyote				1	1	UL 279 133	Cropland	unrecorded
5	3-Feb-93	1439	Downstream	White-tailed Deer				7	7	UL 271 128	Riverine shrub	Running
6	3-Feb-93	1440	Downstream	White-tailed Deer				6	6	UL 279 115	Riverine shrub	Running
7	3-Feb-93	1442	Downstream	White-tailed Deer				4	4	UL 276 117	Riverine shrub	Running
8	3-Feb-93	1445	Downstream	White-tailed Deer				4	4	UL 267 122	Riverine shrub	Running
9	3-Feb-93	1447	Downstream	White-tailed Deer				9	9	UL 268 111	Riverine shrub	Running
10	3-Feb-93	1448	Downstream	Mule Deer				1	1	UL 254 109	Riverine shrub	Running
11	3-Feb-93	1453	Downstream	White-tailed Deer				2	2	UL 254 114	Riverine shrub	Running
12	3-Feb-93	1456	Downstream	White-tailed Deer				2	2	UL 248 104	Riverine shrub	Running

Appendix Table 5. Mule deer winter aerial survey counts within three Foothills Survey Blocks immediately adjacent to the Oldman Reservoir, 1978 to 1993.

Foothills Survey Block	AB F&W		Salix 1985		Salix 1986		The Delta Group		
	1978	1980	30-Jan-85	5-Nov-85	21-Jan-86	20-Feb-86	1-Feb-90	10-Jan-91	1-Feb-93
FH-1	262	73	116	69	23	no survey	67	48	13
FH-2	316	255	265	33	no survey	no survey	201	269	128
FH-10	25	39	3	no survey	no survey	22	36	9	49

Sources: AB F&W = Fish and Wildlife Division, Lethbridge.

Salix 1985 = Allison, L.M. and H.J. Russell. 1985. Late winter distribution of cervids in the vicinity of the proposed Oldman River Reservoir, 1985. Salix Enterprises Ltd. 63pp.

Salix 1986 = Allison, L.M. and H.J. Russell. 1986. Winter studies of cervids in the valleys of the Oldman River and its tributaries, 1985-86. Salix Enterprises Ltd. 53pp.

The Delta Group 1990 and 1991 = Hornbeck, G.E. and P. Balagus. 1992. Aerial surveys of the Oldman Reservoir, southwestern Alberta, 1990 and 1991. The Delta Environmental Management Group Ltd. 37pp.

The Delta Group 1993 (this report) = Hornbeck, G.E. and P. Balagus. 1993. Aerial surveys of the Oldman Reservoir, southwestern Alberta, 1993. The Delta Environmental Management Group Ltd. (in prep.)

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