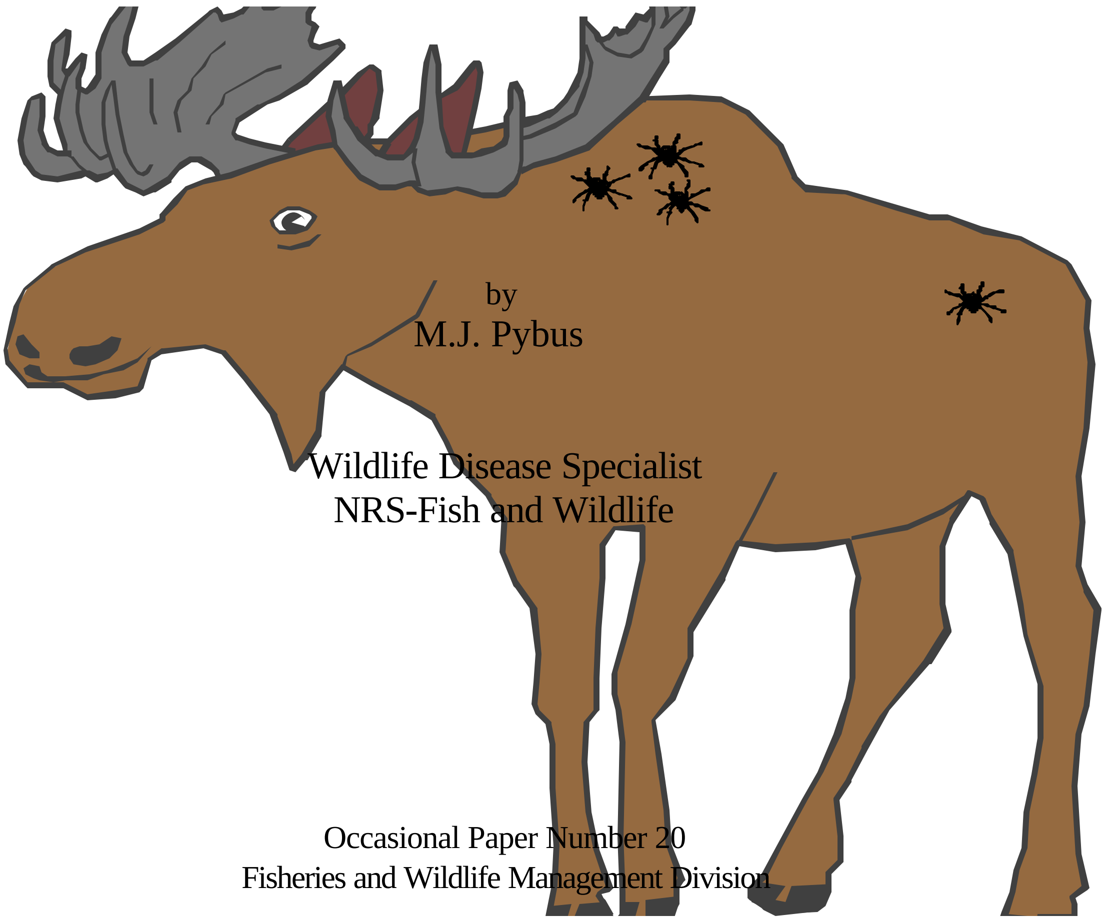
Moose and ticks in Alberta: a dieoff in 1998/99



by

M.J. Pybus

Wildlife Disease Specialist
NRS-Fish and Wildlife

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Alberta Environment
Information Centre
Main Floor, Great West Life Building
9920-108 Street
Edmonton, Alberta
T5K 2M4
(780)422-2079

ABSTRACT

Significant mortality of moose (*Alces alces*) occurred throughout broad regions of northern and western Alberta in early 1999. Occurrences involving moose were recorded at local Alberta Natural Resources Service (NRS) district offices. A total of 1130 occurrence reports involving moose throughout Alberta between January 1 and April 30, 1999 were submitted to the author for review. Although there was considerable inherent bias in the sample, some general patterns emerged. Most moose (92%) had evidence of hairloss and 28% of them were dead. In the overall sample, 35% were calves; however in the subsample of dead moose with hairloss, 43% were calves. It is assumed that the hairloss was a result of infestation with winter tick, *Dermacentor albipictus*. Most occurrences (96%) were within the boreal habitats of northern and western Alberta and half of them were recorded in March (50%). It is apparent that excessive mortality of moose, particularly calves, occurred in late winter. The outbreak is considered a direct result of the interactions among moose, ticks, habitat, and weather. Weather appears to have been the ultimate force driving the interactions. Late winter snow cover and moose densities may provide clues for potential management actions in the subsequent fall period.

Introduction

Moose are distributed throughout most of Alberta. Although relatively scare in the grassland regions of the south, they occur in varying densities throughout all other habitats. Local population estimates are generated on an irregular basis or as needed for specific management demands. In northern regions, an extensive program of aerial surveys was conducted in the early 1990s. Northern populations were relatively stable with an estimated 87,000 moose at an overall density of 0.25 moose/km^2 (NRS unpublished data). In contrast, moose populations in the parkland regions of central Alberta showed a steady increase in number and density over the last 25 years (Bjorge 1996). In 1996 mean density in this region was 0.18 moose/km^2.

Winter tick (*Dermacentor albipictus*) is an unusual tick that completes all life stages beyond the egg on the same host individual. Eggs laid in leaf litter in late spring hatch during the summer and appear as larvae on vegetation in the fall (Drew and Samuel 1985). In Alberta the timing of the rise onto the vegetation appears to be synchronised with the peak of moose activity during the rut. Once access is gained to an individual moose, the larvae quickly move down the long protective hair to the skin surface and overwinter in the comparative warmth and protection found there. In the meantime, the larvae moult to nymphs and again to adults. Adult ticks begin to appear in early January but the majority occur in late winter/early spring (Glines and Samuel 1984). Each female tick needs blood in order for her eggs to develop properly (just like mosquitoes) and she draws it from her moose host. She then drops off the moose and can lay over 5000 eggs in the litter (Addison and Smith 1981, Glines 1983). Most females do not reproduce if they drop off onto snow (Drew and Samuel 1986).

Successful reproduction of winter ticks is largely driven by temperature and snow conditions. In winters when the snowpack is minimal, females are more likely to successfully reach the leaf litter in spring and thus ensure greater survival of eggs. Similarly, development of eggs is temperature - related (Addison and Smith 1981, Addison et al. 1998) and, as such, warm weather speeds up development and increases hatching success. Thus in years with an unusually early spring or hot summer, more tick larvae are available to be picked up by moose in autumn.

Moose seem to be oblivious to tick larvae ('seed' ticks) acquired off vegetation in the fall (McLaughlin and Addison 1986, Welch et al. 1991). However, eventually the uninvited guests become a source of constant irritation. Infested moose use a variety of methods to respond: biting, chewing, licking, rubbing, and scratching (Samuel 1991, Mooring and Samuel 1998). They use their teeth, antlers, hooves, and tongue and even rub up against trees, logs, and buildings. Moose hair is white at the base and areas where the hair has been roughed up or broken are readily visible against the darker undamaged hair. The extent of hairloss has been characterized as an indicator of severity of infestation (Addison et al. 1979, Samuel and Barker 1979). However, the excessive grooming associated with damage to the haircoat removes many ticks (Glines and Samuel 1984) and once the hair has been reduced to short nubs, it becomes unsuitable habitat for those ticks remaining. Thus naked moose have very few ticks.

Winter ticks and moose appear to have an irruptive relationship in northern climates. As moose density increases, there is more habitat for moose ticks and a greater chance that larvae will be picked up in the fall. This leads to more female ticks the next spring and more larvae the next fall. When moose populations are at a low density, ticks are less successful at colonizing a host and thus the tick population decreases. In the early 1980s, there was a major outbreak of tick-related mortality of moose throughout much of northern Alberta (Samuel unpubl.). It appears the situation was repeated in 1998/99.

Methods

Alberta Natural Resources Service - Fish and Wildlife maintains records of occurrences involving wildlife. These include situations in which officers or biologists directly handle an animal, receive phone calls from the public or industry regarding animals in distress or found dead, and situations in which wildlife become a nuisance or a concern for public safety. In January 1999, an unusually large number of occurrences involving moose was documented and it was apparent that something out of the ordinary was happening. Many of the reports involved dead moose or moose with extensive hairloss associated with winter tick infestation. In early April, a request was circulated to all NRS-Fish and Wildlife offices to submit a summary of all moose occurrences from January 1 to April 30, 1999. Compliance was voluntary. Staff were requested to identify the location (Wildlife Management Unit, WMU), date, age, and sex of each animal in the occurrence (if recorded) as well as the presence or absence of hairloss. Many offices also included information about whether the moose was dead or alive at the time of the occurrence. For simplicity, moose that were found in distress and destroyed, or which died soon after the occurrence are included in the "dead" category. Due to inherent errors and weaknesses in the data, analysis is limited to presentation of frequency and proportions in the sample.

Results

A total of 1130 occurrences involving moose between January 1 and April 30 were received. The majority of moose had evidence of hairloss and apparently were alive at the time of the occurrence (Table 1). Overall, occurrences were evenly split among adults, calves, and those of unknown age (Table 2). However, in the subsample of dead moose with hairloss, calves were over-represented (Table 3). The sex ratio of moose for which gender was identified was 2 females to 1 male (n = 330) in the overall sample and 1.5:1 (n = 96) in the dead moose with hairloss. Also, there was a higher proportion of male calves but a lower proportion of male adults in the dead sample than in the live sample.

Thirty one NRS-Fish and Wildlife districts (approximately 40%) submitted occurrence records. Eight offices reported no occurrences involving moose: Cardston, Canmore, Drumheller, High Level, Kananaskis, Nordegg, Red Deer, Red Earth Creek. Of the districts reporting moose occurrences, Grande Prairie (n = 325), Valleyview (n = 205), Whitecourt (n = 127), and Athabasca (n = 125) accounted for 69% of the records (Table 4). The geographic distribution of those offices reporting hairloss and/or dead moose was heavily weighted to the boreal mixedwoods and foothills ecoregions that cover much of the northern and western portions of the province (Figure 1). Additional reports came from the aspen parkland (6 districts) and the mixed grasslands (1 district). Half of the occurrences (50%) were recorded in March. Remaining occurrences were in February (30%), January (10%), and April (10%).

Moose occurrence records involved 41 WMUs (Table 5). However, the majority of occurrences (n = 1054, 93%) were in 18 WMUs from which 10 or more occurrences were recorded (Table 6). In these WMUs the mean percentage of moose with hairloss was 92 $\pm$ 7. Although not specifically requested, in 11 of these WMUs information was provided about whether the moose was alive or dead at the time of the occurrence. On average, 30% $\pm$ 20 of 753 such occurrences involved dead moose. Moose density in these units was 0.53 $\pm$ 0.23 moose/km^2 (range 0.10-0.93). There is some indication of increasing occurrences with increasing density (Figure 2); however, the reader is reminded of the inherent variation in determining the original values used in the figure.

Discussion

There are always inherent weaknesses in generalized data collected after the fact. The data in this report are no different. However, such data often are the only means of describing natural events that occur as background to the milieu of day to day concerns and programs dealt with by wildlife management agencies. In a perfect world, we would hope to collect perfect data. In the real world, we often collate what data we have, assess it within its limitations, and suggest means of improving it. Or better yet, point the way for others to build on what we have or to put their own real-world data in perspective.

Specific to the data in this report, we cannot assume that all NRS offices used the same diligence in searching for moose, recording moose occurrences, or submitting the data. Such activities, done in conjunction with other daily activities and demands on time and resources, undoubtedly resulted in changing priorities over the four month period. In addition, human nature is such that after a while "just another dead moose" may go unnoticed or unrecorded, particularly when staffing and resources are limited.

Additional inconsistencies are associated with the location as well as timing of the occurrence. Public calls from within the settled areas are more likely to be associated with a request for direct action and thus be recorded as an occurrence. Particularly in the latter part of the dieoff, numerous public calls were received each day and priority was given to those situations which included moving a moose carcass, evaluating a sick moose, recording a moose-vehicle collision, or dealing with moose in haystacks. In contrast, calls from within forested regions were more likely made as a passing comment or "for your information" and thus less likely to be documented at any time. Field staff commented that in most areas where significant mortality was occurring, there was an unrecorded increase in calls regarding sick or dead moose from personnel working in the industrial sector in late March, April, and early May. Many of these calls concerned moose associated with wellsites, pipelines, and roads. Additional sightings involved dead moose seen from the air during routine industry-related helicopter flights. In addition bear hunters felt that during the spring hunt in 1999 there were so many moose carcasses scattered throughout the bush that bears were relatively sedentary and foraged less in open areas.

Not all carcasses were visited and thus information regarding age and sex were taken opportunistically in many cases and generally were not verified. Similarly whether or not the moose was dead may not have been recorded consistently. It is possible that some occurrences involved the same animal, although obvious duplications were screened out.

Having identified all the weaknesses, it is appropriate to ask if there is any value left in the data. The answer is a qualified YES. The data provide an index of moose-related activity at NRS-Fish and Wildlife offices. This can be compared to previous years in which moose occurrences were much more limited (but undocumented) and also lays a foundation upon which moose occurrences in subsequent years can be compared. We know for example that there was an apparent tick-related dieoff of moose in the early 1980s, but data were not summarized and, thus, comparative information is lacking. With the data in this report, we have something to compare to when the next dieoff occurs. Also, we can start to track trends in moose occurrences over the long term.

The data also reflect general trends in what was happening within local moose populations in 1998/99. There is little doubt that there was an extraordinary number of moose occurrences reported to NRS offices throughout the boreal regions of the northern and western portions of the province. This began early in the new year and largely involved moose with noticeable evidence of current or previous tick infestation (i.e., hairloss). By late winter it was apparent that a significant dieoff of moose populations in settled and forested areas of northwestern Alberta, particularly the Peace River/Grande Prairie region, had occurred. The effects are analogous to a wildfire that occurred over a large region killing both moose and ticks with incredible speed and efficiency.

The general feeling among NRS staff and the public was that there were a disproportionate number of sick/dead calves and adult females as well as a significant number of yearling males seen in the forested areas. This is supported to some extent by the occurrence data, with calves being over-represented in the sample of dead moose with hairloss. Although age beyond one year was not assessed it is likely that the increased proportion of males in the "dead" category were yearlings. Young moose have higher energy demands and tick infestation may limit growth and survival (Addison et al. 1994). Thus expenditure of energy to respond to tick infestations may be more significant in the overall energy budget of youngsters and put them at greater risk.

WHY DID THIS DIEOFF HAPPEN IN 1998/99? The winter of 1997/98 (a strong El Nino year) probably set the stage. It was notable for the limited amount of snowfall and snowpack throughout most of the province. Theoretically, this should have improved the reproductive success of female ticks after they dropped from the moose. It also may have improved moose survival during the winter. Further to this, moose cows in good condition are more likely to have twin calves. The mild winter was followed by a particularly hot dry summer over most of Alberta. This probably improved the development of eggs and survival of the larval ticks in the grass. As well a long warm fall likely extended the average time larval ticks survived on vegetation, thus extending into November the period over which moose were accumulating ticks. Although we have no specific data for this year, similar conditions in the past have resulted in many moose with over 50,000 ticks on them (Samuel unpubl.). As female ticks begin to take blood in January and February, moose spend a lot of time and energy trying to get rid of them (McLaughlin and Addison 1986, Delgiudice et al. 1997). It seems moose can only do one thing at a time and while they are fussing over the ticks, they spend less time eating (Mooring and Samuel 1999, Skorupka 1999). Added to these problems, late summer in 1998 was particularly dry, with little rain in northern regions. As a result grasses and forbes dried and browned off in August and leaves hardened and dropped earlier than usual. Thus, heat and lack of rain stressed the northern forests and resulted in poorer quality food available for the moose during the winter (moose preferentially choose the most recent growth on woody vegetation as their prime winter food). On top of this, snow finally arrived in January. Thus moose faced increased energy demands for movement and food gathering at the very time when the ticks were maturing and the moose was finally aware that they were there.

Add it all together and this year many moose were stressed by less food, poor quality food, deep snow and lots of ticks. Reduced energy reserves may also translate into greater likelihood of predation. Some moose that did not get eaten died of starvation. Others made increased use of roadways as travel lanes and were at greater risk of vehicle collisions. Some moose in settled areas compensated by spending more time in farmyards and acreage developments where there was respite from predators, shelter from wind and cold, and often alternate food sources. In many cases these moose died as a result of the rapid change in diet from natural wood browse to baled hay.

Animals can thrive only when 'energy-in' is greater than 'energy-out'. For moose, the balance this winter seems to have been much on the 'energy-out' side of things. As a result, we expect a large number of individuals were removed from the population. The outcome of the various interactions among moose, their ticks, their habitat, and the weather depends largely on individual fitness. Those in good condition can spend time removing ticks and still have enough energy to find food. Others apparently ignore the ticks and focus on finding food. If they find enough they can offset the increased energy costs and perhaps survive. However, some moose found dead have a complete haircoat and many many ticks. Regardless of the strategy used, many individuals simply run out of energy.

In theory, as wildlife managers and as responsible stewards of other species, we should be aware of the potential implications of any interference once a dieoff is underway. The number of ticks in the environment is related to the number of moose available to them as habitat – i.e., ticks need moose as a place to feed, take shelter, and reproduce. When moose die, the population of ticks declines directly through massive losses of ticks on moose that die early in winter; and indirectly through lack of moose in the following fall. On the contrary, as the number of moose in an area increases, so does the population of ticks. However, as the density of moose increases, so does their impact on the vegetation. The contribution of ticks in reducing the density of moose also contributes to rejuvenation of the stressed vegetation and in the long run improvement of the chances that some moose will survive. This is particularly important in populations that are at or near carrying capacity for moose. The southern boreal forest zone appears to be the battleground for this life and death interplay between moose and ticks (Addison et al. 1979, Samuel 1989) and their habitat. Although we may be stirred by sympathy for ticky moose, we need to look beyond the conspicuous elements of the moose/tick relationship and see the underlying balance that nature strives for in all systems. We need to look beyond the obvious effects on an individual moose and see the survival of the population as the greater goal to be achieved within the system.

The question arises as to whether the risk of tick-associated mortality in moose can be predicted prior to a dieoff. Based on what we know of tick biology, the extent and timing of snowcover during the preceding winter and particularly the spring, can be used to predict fall populations of ticks. This can be overlain with moose density data collected during routine aerial surveys conducted in late winter by many management agencies. Habitat conditions relative to carrying capacity and the associated nutritional condition of moose are an additional factor to consider. General conclusions regarding the potential for excessive tick infestations can be drawn. In years when increased ticks are predicted, management strategies could include increased fall harvest. Such harvest should be focused into areas where transfer of ticks to moose is most likely to occur (i.e., wherever the moose are predicted to be during September to November). The benefits of this approach are multiple: increased recreational activity, increased harvest of moose, and limited opportunities for successful tick reproduction. In essence the relationship between ticks and moose would not be altered, rather the moose are simply harvested in the fall before they die in late winter. Either way, they and their ticks are removed from the system.

In reality, we should review active management programs as a means of avoiding wide fluctuations and large-scale losses in local moose and tick populations. The tools we have available include aerial surveillance to provide evidence of moose density and targeted harvest to maintain moose populations below threshold levels where ticks can become a significant influence on mortality of individuals. Although census methods have improved recently with the inclusion of habitat stratification in aerial surveillance programs, frequency of data collection (in the range of once each 3-5 years) may limit the value of density estimates. In addition, improved documentation of moose occurrences would help define the densities at which tick-associated mortality affects the population. Similarly, improved assessment of range condition relative to supporting moose populations would improve our predictions. In the meantime, as density estimates rise or are at a steady high level in a local population, particularly in habitats suitable for ticks and in years of mild winter weather, it would seem appropriate to increase the harvest on moose cows and calves as a method of limiting the population growth in order to avoid increased tick populations.

In situations where a dieoff has occurred, we should assess using hunting seasons and limits as a means of conserving the reduced moose population. To do this, we need a better perspective of how the occurrence rate may reflect the actual losses in the wild. As an example, NRS Peace River recorded 83 occurrences concerning sick or dead moose in the vicinity of Peace River (Moyles unpub. rpt). Majority of occurrences were within an agricultural area (WMU 523). Aerial surveys in early March were used to compare hairloss in this area versus a forested area (WMU 520). Each moose seen was classified by age (calf, adult) and sex. The extent of hairloss was estimated as follows: *none* – no evidence of unusual haircoat; *slight* – small patches of hairloss, usually on the shoulder, <25% of total body surface; *moderate* - >25 but <50% of body surface affected; *severe* - >50% of body surface affected. A total of 261 moose was recorded (Table 7). The majority of moose seen in each area were adult cows. Hairloss was noted in both areas and occurred on all ages and both genders. However, hairloss occurred more frequently in the agricultural area (80%) than in the forest area (64%). In particular, it occurred on 89% of the calves from the agricultural area but only 53% of calves from the forested area. Similarly severe hairloss was more common in the agricultural area (14%) than in the forested area (6%). Hairloss was limited to moose in a small region in the forested area (Peace River valley), while it occurred throughout the agricultural area. It is apparent that ticks were more numerous and more widely distributed in agricultural areas and that the impact was greatest on moose calves. Thus the occurrence data presented in this report appear to reflect the general situation in the wild.

Unfortunately we cannot use either set of data to assess the actual impact or extent of losses in the provincial moose population. It is noteworthy that hairloss was not seen during routine aerial survey of WMU 523 in early January yet it was extensive during the flight in March (Moyles, pers. commun.). Similarly the proportion of calves in the population decreased from 0.44 in January to 0.26 in March (Moyles, unpub. rpt). This decrease occurred in an agricultural area where predation is limited and during a time when there was no hunting season. Similar observations were observed in the agricultural area around Grande Prairie (Hervieux, pers. comm.). It is apparent that late winter mortality in calves was extensive throughout northern agricultural areas and probably exceeded rates in 'non-tick' years. It would seem appropriate to reduce subsequent harvest and monitor recovery in local populations most affected by tick-related losses.

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Table 1. Health status of recorded moose occurrences (n=1130)

Haircoat	n	%	Mortality	n	%
hairloss	1035	92	alive	710	63
no hairloss	73	6	dead	311	28
unknown	22	2	unknown	109	9

Table 2. Age and sex of moose in NRS occurrence records (n=1130)

	n	Females	Males	Unknown	Overall
Adults	362	45[1]	18	37	32[2]
Calves	395	13	10	77	35
Unknown	373	2	1	97	33

[1] % of age category
[2] % of total sample

Table 3. Age and sex of dead moose with hairloss (n=293)

	n	Females	Males	Unknown	Overall
Adults	93	49[1]	11	40	32[2]
Calves	127	12	16	72	43
Unknown	73	1	-	99	25

[1] % of age category
[2] % of total sample

Table 4. District offices reporting moose occurrences (n=1130)

NRS District	NRS Region	Eco-region	# Occurrences
Athabasca	Northeast Boreal	boreal mixedwoods	125
Barrhead	Northern East Slopes	boreal mixedwoods	55
Claresholm	Southern East Slopes	mixed grasslands	1
Edmonton	Northeast Boreal	aspen parkland	5
Edson	Northern East Slopes	boreal foothills	23
Evansburg	Northern East Slopes	boreal mixedwoods	32
Fairview	Northwest Boreal	boreal mixedwoods	9
Fox Creek	Northwest Boreal	boreal mixedwoods	8
Ft. McMurray	Northeast Boreal	boreal mixedwoods	3
Grande Prairie	Northwest Boreal	boreal mixedwoods	325
Lac La Biche	Northeast Boreal	boreal mixedwoods	3
Peace River	Northwest Boreal	boreal mixedwoods	84
Ponoka	Parkland	aspen parkland	10
Spirit River	Northwest Boreal	boreal mixedwoods	61
St. Paul	Northeast Boreal	boreal mixedwoods	4
Stony Plain	Northern East Slopes	aspen parkland	8
Sundre	Southern East Slopes	boreal mixedwoods	2
Swan Hills	Northern East Slopes	boreal foothills	16
Valleyview	Northwest Boreal	boreal mixedwoods	205
Vegreville	Parkland	aspen parkland	2
Vermilion	Parkland	aspen parkland	2
Wetaskiwin	Parkland	aspen parkland	20
Whitecourt	Northern East Slopes	boreal mixedwoods	127

Table 5. Geographic distribution of recorded hairloss and mortality (n=1130)

WMU	# occur.	Hairloss	no hairloss	alive	dead
216	1	1	0	incomplete	incomplete
224	5	5	0	incomplete	incomplete
242	3	3	0	incomplete	incomplete
246	3	3	0	2	1
248	10	10	0	incomplete	incomplete
256	2	2	0	incomplete	incomplete
305	1	1	0	incomplete	incomplete
320	1	1	0	incomplete	incomplete
332	12	11	1	incomplete	incomplete
334	10	10	0	9	1
336	9	7	2	incomplete	incomplete
337	3	2	1	2	1
338	2	2	0	1	1
345	1	1	0	0	1
346	45	45	0	26	19
347	3	3	0	incomplete	incomplete
348	102	96	6	incomplete	incomplete
349	11	9	2	incomplete	incomplete
350	3	3	0	incomplete	incomplete
351	1	1	0	incomplete	incomplete
354	1	1	0	0	1
356	8	6	2	3	5
357	300	296	4	239	61
358	18	15	3	9	9
359	32[1]	22	4	14	12
360	91[1]	77	8	incomplete	incomplete
503	4	4	0	incomplete	incomplete
504	7	7	0	incomplete	incomplete
505	5	5	0	incomplete	incomplete
506	54[2]	53	0	36	17
507	42[2]	39	2	incomplete	incomplete
508	33	33	0	incomplete	incomplete
509	4	4	0	3	1
510	61	61	0	38	23
519	3	3	0	1	2
521	110[2]	92	17	76	33
522	34[3]	23	4	14	13
523	71	54	17	38	33
526	18	18	0	8	10
527	2	2	0	0	2
728	1	1	0	1	0
unknown	3	3	0	incomplete	incomplete

[1] 6, [2] 1, [3] 7 moose with no information re: health status

Table 6. Hairloss and mortality in WMUs with more than 10 moose occurrences

WMU	NRS District	# occur	% with hairloss	% found dead	moose density (yr)*
248	Barrhead, Edmonton, Stony Plain	10	100	0[1]	0.10 (98/98)
332	Ponoka, Wetaskiwin	12	92	8[1]	0.64 (98/99)
334	Evansburg, Wetaskiwin	10	100	10	0.35 (93/94)
346	Edson, Wetaskiwin, Whitecourt	45	100	42	0.65 (96/97)
348	Barrhead, Evansburg, Whitecourt	102	94	26[1]	0.85 (96/97)
349	Fox Creek, Whitecourt	11	82	0[1]	0.46 (96/97)
357	Grande Prairie, Valleyview	300	99	20	0.36 (93/94)
358	Grande Prairie, Spirit River	18	83	50	0.88 (97/98)
359	Grande Prairie, Spirit River	32[2]	79	46	0.52 (93/94)
360	Fox Creek, Valleyview	91[2]	85	26[1]	0.63 (94/95)
506	Athabasca, Edmonton	54[3]	100	32	0.70 (98/98)
507	Barrhead, Swan Hills, Whitecourt	42[3]	93	17[1]	0.51 (98/99)
508	Barrhead	33	100	0[1]	0.12 (94/95)
510	Athabasca, Edmonton	61	100	38	0.37 (97/98)
521	Grande Prairie, Valleyview	110[3]	84	30	0.93 (94/95)
522	Grande Prairie, Peace River, Spirit	34[4]	85	48	0.58 (94/95)
523	Valleyview, Peace River	71	76	47	0.51 (93/94)
526	Fairview, Grande Prairie, Peace River	18	100	56	0.36 (96/97)
	CUMULATIVE	1054	92	30[5]	0.53 +0.23

[1] incomplete data: Barrhead, Fox Creek, Ponoka, and St. Paul did not record mortality information

[2] 6, [3] 1, [4] 7 moose with no documented information re: hairloss or mortality

[5] based on 753 complete occurrences

* number of moose/km^2 (most recent year for which data are available)

Table 7. Hairloss observed during aerial surveys in Peace River area, March 1999.

WMU	moose	# seen	degree of hairloss (%)			
			none	slight	moderate	severe
520 (forested)	bulls	19	7[1]	3	8	4
	cows	55	21	25	15	1
	calves	15	8	6	2	1
	TOTAL	**89**	**36**	**34**	**24**	**6**
523 (agricultural)	bulls	28	4	5	4	4
	cows	106	14	20	20	8
	calves	36	2	11	7	1
	TOTAL	**172**	**20**	**35**	**31**	**14**

[1] proportion of WMU total

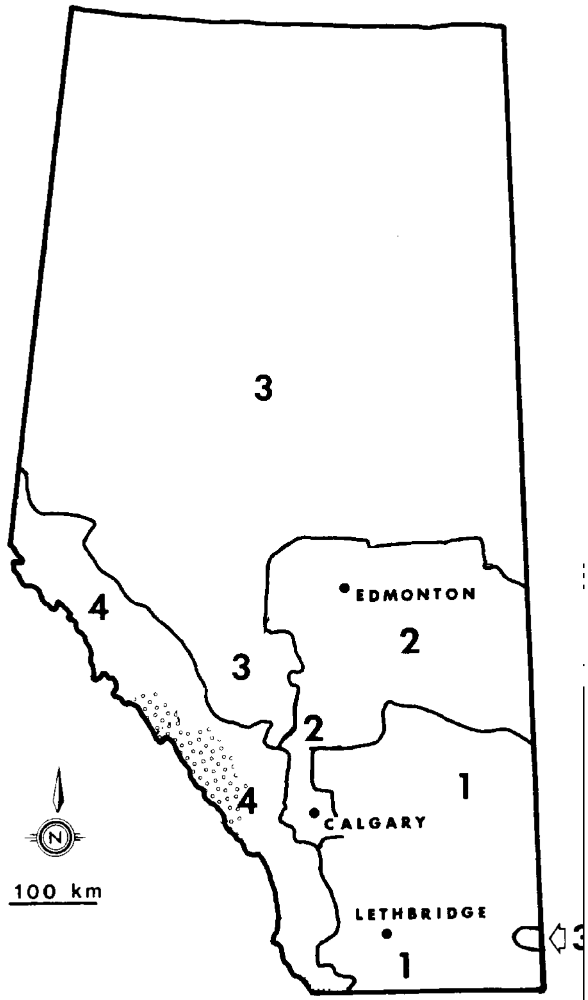

FIGURE 1. Major habitat types of Alberta (mod- ified to accomodate Wildlife Management Uni boundaries): 1, Grasslands; 2, Aspen Parkland; 3, Bo- real Uplands and Northern Mixedwoods; 4, East Slope and Foothills.

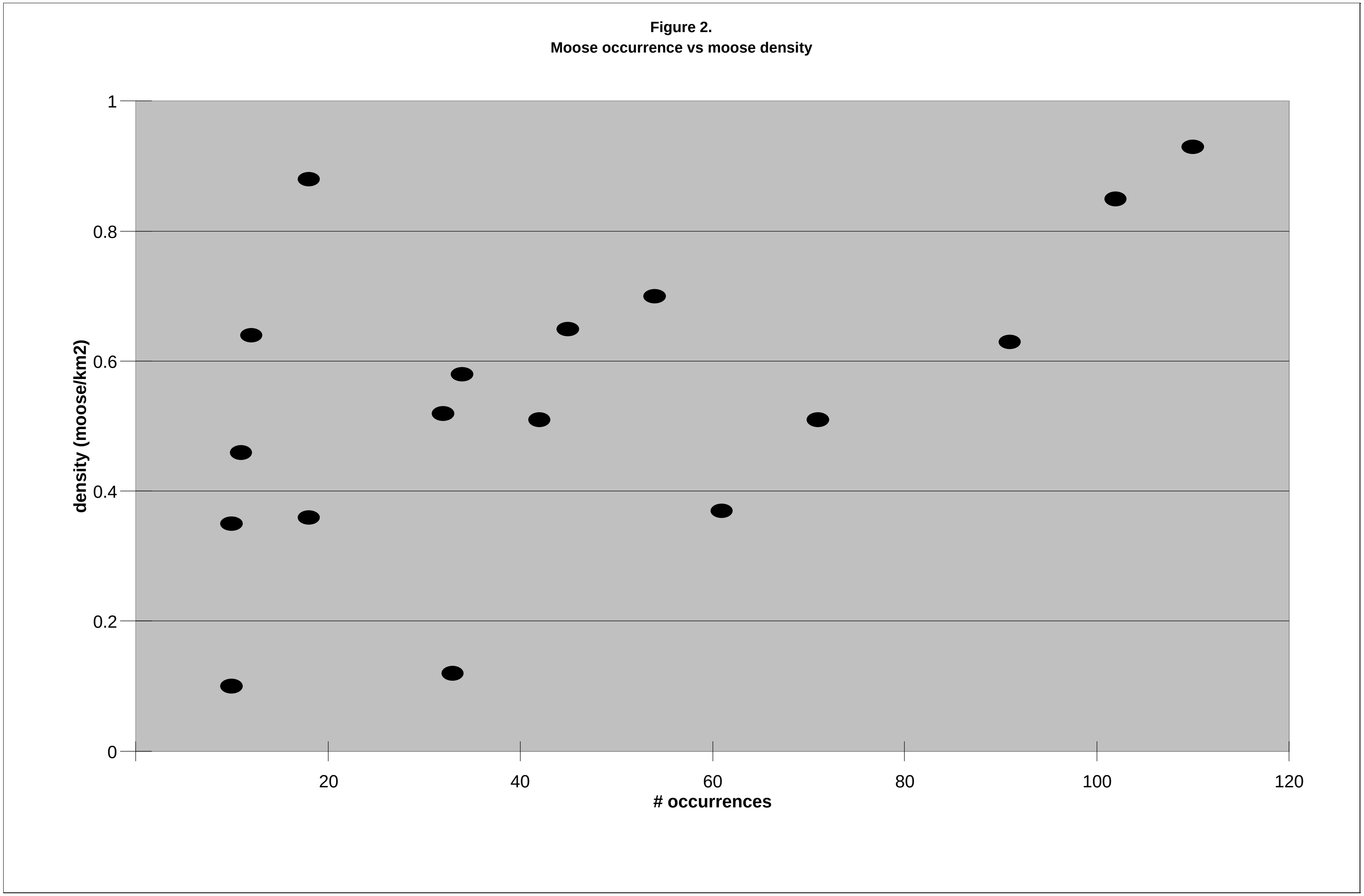
Figure 2.
Moose occurrence vs moose density
density (moose/km2)
occurrences
0
0.2
0.4
0.6
0.8
1
20
40
60
80
100
120