

BEVERLY AND KAMINURIAK BARREN-GROUND
CARIBOU HERDS: AN ANNOTATED BIBLIOGRAPHY

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INTRODUCTION

The Caribou Management Board is responsible for the management of the Beverly and Kaminuriak barren-ground caribou (Rangifer tarandus groenlandicus) herds under the terms of the Beverly/Kaminuriak Caribou Management Agreement. In August 1982 the board recommended as a preliminary step to undertaking management decisions that all literature relevant to the Beverly and Kaminuriak herds be compiled in an annotated bibliography. The Northwest Territories Wildlife Service agreed to undertake this project for presentation to the board in January 1983.

The Canadian Wildlife Service undertook the first extensive caribou surveys in the late 1940's in response to reports of rapid declines in the caribou populations between the Mackenzie River and Hudson Bay.

This document summarizes literature describing caribou studies in the Mackenzie and Keewatin Districts, N.W.T. and northern Manitoba and Saskatchewan from the 1940's to the present.

We also summarized selected reports that present general information relevant to caribou biology (eg. Schofield 1975).

HOW TO USE THE BIBLIOGRAPHY

If you know the author(s) and publication date (eg. Darby 1978) of any paper, proceed to the section of annotated citations. Citations are listed alphabetically by author. If you would like to find all citations on a given subject turn to the Subject Index Headings. Find the number of the subject heading(s) that describe your area(s) of interest (eg. Behaviour - rutting, number 2C). Look up this number in the Subject Index Listings to find the authors of reports on the appropriate subject(s). Section 2C, Behaviour - rutting lists Banfield, 2 papers by Bergerud, Kelsall, Loughrey, Lawrie and Wilk. Find the abstracts and complete reference listed alphabetically by author in the section of annotated citations.

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Gunn and Decker 1982
Hawkins 1973a
Hawkins and Howard 1974
Kelsall 1953b
Kelsall and Loughrey 1955
Land and Bowden 1971
Land and Hawkins 1973
Loughrey 1952, 1955, 1956
McEwan 1959
Miller, D.R. 1975
Parker 1968, 1971, 1974, 1975
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Thomas 1969
Thompson and Fischer 1979

b) Classification

Banfield 1960
Loughrey 1956
Miller, S. 1972
Moshenko 1972
Parker 1968
Ruttan 1962b, 1966, 1969

c) Range Study

Beckel 1958a, b
Miller, D.R. 1980
Thompson, Klassen and Fischer 1978

d) Food Habits and Preferences

Bergerud 1972
Loughrey 1952
Miller, D.R. 1970, 1974
Scotter 1966
Thompson, Klassen and Fischer 1978

1. Techniques (continued)

e) Capture, Collecting, Marking and Tracking

Anderka, Jonkel, and F.L. Miller 1973
 Anonymous 1979
 Engen 1966
 Hawkins 1973b
 Heard (in press)
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 Kelsall 1960, 1966
 Macpherson 1967
 McEwan 1960a
 Miller, D.R. 1980
 Miller, D.R. and Robertson 1967
 Miller, F.L., Anderka, Vithayasae and McClure 1975
 Miller, F.L., Behrand and Tessier 1971
 Parker 1968, 1972b, d, 1975
 Robertson 1961
 Ruttan 1962a, 1965b, 1966, 1969
 Stephenson and Heard 1982
 Thomas 1960a, b

f) Behaviour Study

Jingfors, Gunn and F.L. Miller 1982

g) Mapping, Photographic and Remote Sensing

Beckel 1958a, b
 Loughrey 1955, 1956
 Miller, D.R. 1980
 Parker 1968, 1975
 Thomas 1969
 Thompson, Klassen and Cihlar 1980
 Thompson, Klassen and Fischer 1978
 Williams and Gunn 1982

h) Disturbance

Gunn and F.L. Miller 1980

i) Aging and Reproduction

McEwan 1963

2. Behaviour

a) General

Banfield n.d.b, 1948a, b, 1949, 1950a, b, 1951a, b, 1954b
 Fischer and Duncan 1975
 Harper 1955
 Kelsall 1958
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 Miller, F.L., Jonkel and Tessier 1972
 Miller, F.L., Anderka, Vithayasae and McClure 1975
 Pruitt 1958, 1960

b) Calving

Altman 1962
 Clement (in prep)
 de Vos 1960
 Gunn and F.L. Miller 1980
 Kelsall and Loughrey 1958
 Miller, F.L. and Parker 1968
 Miller, F.L. and Broughton 1973
 Miller, F.L., Anderka, Vithayasae and McClure 1975
 Pruitt 1958, 1960

c) Rutting

Banfield n.d.b
 Bergerud 1974b
 Kelsall 1958
 Loughrey 1956
 Lawrie 1950
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3. Migration, Movement and Distribution

a) General

Banfield 1948a, b, 1950a, b, 1951a, b, c, 1954a, b, 1980
 Bergerud 1974c
 Fischer and Duncan 1975
 Fuller 1948
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 Kelsall 1953b, 1957a, b, 1958, 1963, 1968

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 Thomas 1975
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 Fuller 1948
 Miller, F.L., Anderka, Vithayasae and McClure 1975
 Parker 1972c
 Ruttan 1962b, 1967
 Thomas 1969
 Williams and Gunn 1982

c) Timing

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 Fuller 1948
 Howard 1962
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 Clement 1982, (in prep.)
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 Loughrey 1957
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 Thomas 1969

e) Summer, Autumn and Winter

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3. Migration, Movement and Distribution, Summer, Autumn and Winter (continued)

Howard 1961
 Look 1971
 Loughrey 1952
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f) Population Shifts

Klein 1980
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 McEwan 1960a
 Miller, F.L. 1972a
 Miller, F.L. and Broughton 1974
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h) Predation

Bergerud 1974a, c
 Fleck and Gunn 1982
 Jakimchuk 1980
 Miller, F.L. and Broughton 1974
 Parker 1973

i) Climate and Snow

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 Fleck and Gunn 1982
 Jingfors, Gunn and F.L. Miller 1982
 Kelsall 1958
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 McEwan 1960a
 Miller, D.R. 1970, 1974
 Pruitt 1958, 1959

3. Migration, Movement and Distribution (continued)

j) Topography

Bergerud 1974c
 Fleck and Gunn 1982
 Kelsall and Loughrey 1958
 Kelsall 1960
 Lawrie 1950
 Williams and Gunn 1982

k) Fire

Johnson and Rowe 1975
 Miller, D.R. 1974, 1976b, 1980
 Scotter 1964

l) Alterations in Range Use

Jakimchuk 1979
 Kelsall 1950a
 Miller, D.R. 1974, 1980
 Miller, D.R. and Robertson 1967
 Parker 1972b
 Thompson and Fischer 1979
 Yule 1948

4. Disturbance Effects

a) General

Anonymous 1979
 Bergerud 1974c
 Calef n.d.
 Fischer, Thomas, Wooley, and Thompson 1977
 Jakimchuk 1980
 Jingfors, Gunn and F.L. Miller 1982
 Klein 1980
 Miller, F.L., Jonkel and Tessier 1972
 Parker 1972a
 Stager 1977
 Thomas 1975

b) Roads, Railways and Pipelines

Anonymous 1979
 Bergerud, Jackimchuk and Carruthers 1982

4. Disturbance Effects, Roads, Railways and Pipelines (continued)

Calef n.d.
Jakimchuk 1980
Klein 1980

c) Aircraft

Anonymous 1979
Calef, DeBock and Lortie 1976
Darby 1978
Fischer, Thomas, Wooley, and Thompson 1977
Gunn and F.L. Miller 1980
Jakimchuk 1980

d) Snowmobiles and Noise

Jakimchuk 1980

5. Population Dynamics

a) General

Bergerud 1980
Banfield n.d.a, 1948a, b, 1950a, b, 1951a, b, 1954a, b, 1957,
1980
Calef 1979
Kelsall 1955, 1963, 1968
Thomas 1975, 1981
Urquhart (in prep.)

b) Composition

Banfield 1955
Calef 1978
Calef and Heard 1980
Gates 1981
Gunn and Decker 1982
Hawkins 1973b
Hawkins and Howard 1974
Heard 1980, 1981, 1982a
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Howard 1961
Kelsall 1957a, b
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Loughrey 1952, 1955, 1956, 1957

5. Population Dynamics, Composition (continued)

McEwan 1959, 1960a
 Miller, F.L. 1962, 1974a
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 Parker 1968, 1972c
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 Rippen 1971
 Robertson 1975
 Ruttan 1962b
 Thomas 1969, 1975
 Thomas and Kiliaan 1982
 Wilk 1958

c) Size, Status and Trends

Anonymous n.d.a, b, c, 1955
 Banfield n.d.a, 1948a, b, 1949, 1950a, b, 1951a, b, c, 1954a,
 b, 1957, 1980
 Bergerud 1974a, 1980
 Calef n.d., 1979
 Bowden and Timmerman 1972
 Calef and Hawkins 1977
 Calef and Heard 1980
 Cooper 1981
 Fischer and Duncan 1975
 Fischer, Thomas, Wooley and Thompson 1977
 Gates 1981
 Gunn and Decker 1982
 Harper 1955
 Hawkins and Howard 1974
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 Heard and Calef (in prep.)
 Heard and Decker 1980
 Howard 1961
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 Kelsall and Loughrey 1955
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 Miller, D.R. and Robertson 1967
 Moshenko 1974
 Parker 1971, 1972a, b, 1974
 Pruitt 1958
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 Rippen 1971

5. Population Dynamics, Size, Status and Trends (continued)

Robertson 1975
 Ruttan 1962b, 1965a, 1967
 Thomas, 1960a, b, 1969, 1975, 1981
 Thomas and Kiliaan 1982
 Thomas, Parker, Kelsall and Loughrey 1968
 Thompson and Fischer 1979
 Williams 1979
 Yule 1948

d) Reproduction and Birth Rates

Anonymous 1955
 Bergerud 1974b, 1980
 Calef 1978
 Calef and Heard 1980
 Clement (in prep.)
 Dauphine and McClure 1974
 Gates 1981
 Gunn and Decker 1982
 Hawkins and Howard 1974
 Heard 1980, 1981
 Heard and Decker 1980
 Howard 1962
 Jakimchuk 1979
 Kelsall 1958
 Kelsall and Loughrey 1955, 1958
 Klein 1980
 Land and Bowden 1971
 Land and Hawkins 1973
 Loughrey 1952, 1956, 1957
 Macpherson 1967
 Macpherson and Parker 1970
 Malfair 1963
 McEwan 1959, 1960a, b, 1963, 1971
 McEwan and Whitehead 1972
 Miller, F.L. 1962
 Miller, F.L., Broughton and Gunn 1982
 Miller, S. 1972
 Moshenko 1974
 Parker 1968, 1972c
 Pruitt 1961
 Rippen 1971
 Thomas 1975
 Thomas and Kiliaan 1982
 Thomas, Parker, Kelsall and Loughrey 1968
 Urquhart (in prep.)
 Williams 1979

5. Population Dynamics (continued)

e) Mortality

(i) General

Banfield n.d.a, 1948a, b, 1950a, b, 1951a, b, 1954a, b, 1957
 Bergerud 1980
 Heard and Calef (in prep.)
 Kelsall 1953a, 1957a, b, 1958, 1960, 1963, 1968
 Loughrey 1955, 1957
 McEwan 1959, 1960a
 Miller, F.L. 1974
 Miller, F.L. and Broughton 1974
 Miller, F.L., Broughton and Gunn 1982a, b
 Parker 1972a, b, c, 1974
 Pruitt 1961
 Thomas 1975
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 Yule 1948

(ii) Hunting

Anonymous n.d.a, b, 1955
 Banfield n.d.a, 1948a, b, 1950a, b, 1951a, b, 1954a, b, 1957
 Bergerud 1974a
 Calef n.d., 1979
 Fischer, Thomas, Wooley and Thompson 1977
 Hawkins 1973c, 1974
 Heard 1980, (in prep.)
 Heard and Calef (in prep.)
 Jakimchuk 1979
 Kelsall 1950b, 1957a, b, 1960, 1963, 1968
 Kelsall and Loughrey 1955, 1958
 Loughrey 1955, 1956
 Macpherson n.d., 1967
 Macpherson and Parker 1970
 McEwan 1959
 Parker 1968, 1969, 1972a, b, c
 Robertson 1975
 Thomas 1960b, 1969, 1975, 1981
 Thomas, Parker, Kelsall and Loughrey 1968
 Thompson and Fischer 1979
 Williams 1979
 Yule 1948

5. Population Dynamics, Mortality (continued)

(iii) Predation

Anonymous n.d.a, 1955
 Bailey 1970
 Banfield 1951b, 1954b, 1957
 Bergerud 1974a, 1980
 Harper 1955
 Holleman, White, Luick and Stephenson 1980
 Kelsall 1953c, 1957a, b, 1958, 1960, 1963, 1968
 Kelsall and Loughrey 1955, 1958
 Kuyt 1972
 Look 1971
 Loughrey 1952, 1957
 Macpherson and Parker 1970
 McEwan 1959
 Miller, F.L. and Broughton 1974
 Miller, F.L., Broughton and Gunn 1982a, b
 Parker 1972c, 1973
 Pruitt 1958
 Thomas 1975, 1981
 Yule 1948

(iv) Parasites, Disease and Other

Anonymous 1955
 Banfield 1951b, 1954b
 Broughton and Choquette 1968
 Broughton, Choquette, Cousineau and F.L. Miller 1970
 Choquette, Broughton, F.L. Miller, Gibbs, and Cousineau
 1967
 Fuller 1951
 Gibbs 1958
 Kelsall 1960, 1975
 Miller, F.L. and Broughton 1974
 Miller, F.L., Broughton and Gunn 1982a, b
 Parker 1974

f) Computer Simulation

Bunnell, Dauphine, Hilborn, D.R. Miller, F.L. Miller, McEwan,
 Parker, Peterman, Scotter and Walters 1975
 Gates 1981
 Walters, Hilborn and Peterman 1975

6. Population Management

Anonymous n.d.a, b, c, d, 1955, 1979a, b
 Banfield n.d.a, 1950a, 1951a, 1957

6. Population Management (continued)

Bergerud 1974a
 Bunnell, Dauphine, Hilborn, D.R. Miller, F.L. Miller, McEwan,
 Parker, Peterman, Scotter and Walters 1975
 Clement 1982, (in prep.)
 Cooper 1981
 Courtwright 1959
 Darby 1978, 1979, 1980
 Dauphine, D.R. Miller, F.L. Miller and Parker 1970
 Gates 1981
 Heard and Calef (in prep.)
 Howard, Monaghan, Pepper and Robertson 1974
 Kelsall 1950b, 1960, 1963, 1968
 Look 1965
 Loughrey 1955, 1966
 Macpherson and Parker 1970
 McEwan 1960a
 Parker 1969, 1972a
 Pruitt 1958
 Robertson 1977
 Ruttan 1967, 1968
 Scotter 1968
 Simmons, Heard and Calef 1979
 Thomas 1975, 1981

7. Range and Habitat Management

a) General

Anonymous 1955
 Banfield 1948a, b, 1950a, b, 1951a, b, c, 1954b
 Beckel 1958a, b
 Bergerud 1974a
 Calef n.d.
 Engen 1964, 1965
 Fleck and Gunn 1982
 Kelsall 1960, 1963
 Kelsall and Loughrey 1958
 Klein 1982
 Loughrey 1952
 Macpherson 1967
 Urquhart (in prep.)

7. Range and Habitat Management (continued)

b) Vegetation Mapping and Surveys

Beckel 1958a, b
 Courtwright 1959
 Fischer and Duncan 1975
 Fleck and Gunn 1982
 Jingfors, Gunn and F.L. Miller 1982
 Kelsall 1957b
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 Miller, D.R. 1970, 1974, 1976a, b, 1980
 Scotter 1964
 Thompson, Klassen and Cihlar 1980
 Thompson, Klassen and Fischer 1978

c) Fire

Kelsall 1957b
 Klein 1982
 Look 1965
 Macpherson and Parker 1970
 Miller, D.R. 1974, 1976b, 1980
 Scotter 1962, 1963a, b, 1964, 1965a, b, 1967, 1968, 1970,
 1971, 1978

d) Productivity and Carrying Capacity

Engen 1964, 1965
 Loughrey 1957
 Ruttan 1965a, 1967
 Strong 1975

e) Land Use

Clement 1982, (in prep.)
 Cooper 1981
 Darby 1978, 1979, 1980

f) Air Pollution and Radioactive Fallout

Anonymous 1961
 Schofield 1975

8. Food Habits and Range Use

a) Food Preferences and Analysis of Diet

Banfield 1950a, b, 1951a, b, c, 1954b
 Bergerud 1972
 Courtwright 1959
 Fischer and Duncan 1975
 Fischer, Thomas, Wooley and Thompson 1977
 Fleck and Gunn 1982
 Loughrey 1952
 Miller, D.R. 1970, 1974, 1976a, b, 1980
 Miller, F.L. and Parker 1968
 Scotter 1965a, 1966, 1967

b) Quantitative Aspects

Courtwright 1959
 Fischer, Thomas, Wooley and Thompson 1977
 Hanson, Wicker and Upscomb 1975
 Holleman, White, Luick and Stephenson 1980
 McEwan and Whitehead 1970
 Miller, D.R. 1976b
 Scotter 1960
 Thompson, Klassen and Cihlar 1980
 Thompson, Klassen and Fischer 1978

c) Feeding Behaviour

Courtwright 1959
 Fischer and Duncan 1975
 Kelsall 1957c, 1968, 1970
 Miller, D.R. 1974, 1976a, b
 Pruitt 1959

9. Morphology, Physiology and Metabolism

a) General

Banfield 1961
 Kelsall 1953a
 Klein 1980
 Macpherson 1967
 McEwan 1960b
 McEwan and Whitehead 1972
 McEwan and Wood 1966
 Miller, F.L. 1962, 1972b, 1974a, b
 Miller, F.L. and Broughton 1971a
 Miller, F.L., Cowley, Choquette and Broughton 1975

9. Morphology, Physiology and Metabolism (continued)

b) Physical Condition

Bergerud 1976
 Dauphine 1966, 1968, 1971, 1975, 1976
 Dauphine and McClure 1974
 Neiland 1970
 Thomas and Kiliaan 1982

c) Reproduction

Dauphine 1976
 Dauphine and McClure 1974
 McEwan 1971
 McEwan and Whitehead 1972

d) Thermoregulation

Hart, Heroux, Cottle and Mills 1961

10. Climate

Courtwright 1959
 Fleck and Gunn 1982
 Kelsall 1953a
 Pruitt 1958

11. Topography and Geology

Beckel 1958a, b
 Fleck and Gunn 1982

12. Native Rights

Darby 1978, 1980
 Kelsall 1960, 1963

13. Summary Documents

a) General

Anonymous n.d.c, 1955
 Banfield n.d.a, 1948a, b, 1949, 1950a, b, 1951a, b, c, 1954a,
 b, 1957, 1961, 1980

13. Summary Documents, General (continued)

Britton 1981
Calef n.d.
Courtwright 1959
Harper 1955
Kelsall 1963, 1968
Luick, Lent, Klein, and White 1975
Macpherson and Parker 1970
Miller, D.R. 1976
Parker 1972c
Pruitt 1958
Reimers, Gaare and Skjenneberg 1980
Thomas 1975
Urquhart (in prep.)

b) Bibliographies

Britton 1981
Courtwright 1959
Darby 1978
Fleck and Gunn 1982
Harper 1955
Kelsall and Bisdee 1979
Kelsall, Telfer and Wright 1977
Moyles 1978
Williams and Gunn 1982

ANNOTATED CITATIONS

Altmann, S.A. 1962. Caribou behaviour at calving time. Canadian Wildlife Service unpublished report. 23 pp.

A report on caribou behaviour on the Beverly calving grounds. Results list socially significant behaviour patterns, temporal distribution of major activities, time of calving and time of antler shedding by cows. Particular emphasis was placed on cow-calf relations. The author felt that the high nutritional value of caribou milk and its probable significance in calf survival places a selective advantage on strong cow-calf social bonds. Social mechanisms which strengthen these bonds include vocalizations, sniffing of calves by cows, cows terminating suckling before the calf is finished, cows head bobbing gesture and the aggression of cows towards strange calves.

Anderka, F.W., C.S. Jonkel and F.L. Miller. 1973. Radio-tracking polar bears, barren-ground caribou and muskoxen in northern Canada. Proceedings of the Third International Symposium: Aerospace services to conservation of the environment. Vancouver, Vol. 2, Appendix A. 43 pp.

Twenty-seven barren ground caribou (Rangifer tarandus groenlandicus) were captured in northern Manitoba in April 1970, and were fitted with radio-transmitter collars. They were later found on their calving ground in the District of Keewatin, Northwest Territories, and radio-tracked about 150 kilometers west of the calving ground. During their mid-summer migrations they were followed south-southeast for about 375 kilometers to the McConnell River drainage at the northeastern edge of the taiga. 246 contacts were made with radio-marked caribou; 109 radio detections and 47 visual observations in June, 137 radio detections and 86 visual observations in July. The greatest number of observations for one animal was 27, and 11 radio-marked caribou were contacted more than 10 times each. The technique may prove useful for conducting studies during continuously dark periods of the winter.

Anonymous. n.d.(a). A question of survival - the barren-ground caribou. Canadian Wildlife Service National Park Branch Publication. 16 pp.

A comic-book style publication outlining the history of the barren-ground caribou and its value to the native people. Caribou populations have declined to 200,000 from 2,000,000. Caribou die from wolf predation, accidents, weather, forest fires, and primarily hunting. Management requires the native hunter to limit caribou kill, prevent wastage, kill only bulls, and reduce wounding.

Anonymous. n.d.(b). Caribou population estimates. Canadian Wildlife Service unpublished report. 18 pp.

Aerial surveys of the (Kaminuriak) winter and summer ranges in 1948-49 estimated 80,000 and 3-400,000 animals respectively. The number of caribou killed per family, use of caribou, and hunting, caching and storing techniques are outlined. The kill in southern Keewatin, excluding Chesterfield Inlet, was estimated to be 10,000/yr and the kill during the winter of 1948-49 in northern Manitoba was estimated at 32,250.

Anonymous. n.d.(c). Education in the conservation of caribou. Canadian Wildlife Service unpublished report. 2 pp.

A draft dealing with the need for public education with regard to the conservation of caribou. The author states that caribou have declined rapidly due to hunting with modern firearms and that any further decline would make population recovery difficult. The author stresses the importance of subsistence hunting but suggests measures with which hunters can reduce their total kill. These are; 1) feeding dogs only on meat which is unfit for people, 2) getting rid of dogs not required, 3) making better caches, 4) using other game where possible, and 5) predator control. The author recommends that conservation education be taught in the schools and stresses the importance of obtaining the co-operation of all peoples involved with caribou.

Anonymous. n.d.(d). Memorandum of understanding in regard to coordinated management of barren-ground caribou. 4 pp.

Memorandum dealing with the need for cooperation between Alberta, Saskatchewan, Manitoba and the Northwest Territories in the management of the 4 major barren-ground caribou herds (Beverly, Kaminuriak, Bathurst and Bluenose). Management principles to be adopted are; 1) management should be based on caribou populations, not political boundaries, 2) harvests should allow the populations to increase until demands for use are satisfied or the carrying capacity of the range is reached, 3) management of herds which occur in more than one political district should be based on the co-operation of the agencies involved, and 4) the cost of management activities should be distributed among the agencies which benefit from those activities. The minimum management requirements for barren-ground caribou are; 1) a representative sample of the annual hunter kill should be sexed and aged (lower jaw collection), 2) total annual hunter kill should be determined, 3) aerial inventories should be undertaken every other year, 4) tagging should be continued to monitor population shifts, and 5) non-hunting limiting factors to caribou population growth should be determined.

Anonymous. 1955. Appreciation of the mainland caribou situation - Eastern Mackenzie and Keewatin Districts. Canadian Wildlife Service unpublished report. 5 pp.

This report outlines the status of mainland caribou and includes recommendations for management. Population estimates from (1948 - 668,000) and (1955 - 300,000) aerial censuses are presented. The author felt that no large herds were missed in either survey, therefore a comparison of the two surveys suggests a rapid decline in caribou numbers. Possible causes are 1) low natality, 2) high predation, 3) range poverty and 4) losses due to drowning, disease and accidents. Lack of supporting data precludes a definite explanation of the decline. Recommendations for action to arrest the decline are; 1) elimination of meat wastage, 2) establishment of a conservation education program, 3) implementation of predator control, 4) consideration of legislative restrictions, 5) establishment of patrols and contact with the hunters, 6) collection of hunter kill data, 7) initiation of caribou movement studies, 8) implementation of range studies, 9) formation of a caribou committee to co-ordinate management efforts and 10) consideration of reindeer introductions. The report suggested that all aspects of caribou research be intensified.

Anonymous. 1961. The effect of radioactive fallout on lichens, caribou and man. unpublished report. 15 pp.

This report documents the accumulation of radioactive fallout, Strontium 90, in lichen, caribou and humans in Alaska. Lichens absorb more fallout than other plants because they obtain their mineral nutrition from dust in the air. Thus, caribou and people in Alaska have higher Strontium 90 levels than animals and people elsewhere even though fallout in the soil is much lower. The effect of Strontium 90 accumulation on caribou or people is not known but it is assumed that any increase in radiation exposure carries with it an increased risk of disease.

Anonymous. 1979. Transactions of the caribou disturbance workshop, Yellowknife, N.W.T., October 17, 1979. N.W.T. Wildlife Service Manuscript Report. 120 pp.

A workshop report concerning man's disturbance of caribou. Topics covered were 1) sources of stress on caribou (notably the effects of mining activity), 2) disturbance by aircraft, 3) disturbances at water crossings, 4) the need for baseline data on behavioural responses, 5) the use of telemetry for measuring heart rate and 6) the need for quantification of behavioural responses. The discussion generated a series of recommendations divided into three priorities. Priority one consisted of 1) reviewing existing knowledge of Rangifer tarandus reactions to disturbance, 2) undertaking behavioural baseline studies, 3) intensifying public

education efforts, and 4) reviewing literature on radio-collared caribou to determine possible detrimental consequences of handling. Priority two recommendations were also considered essential while priority three recommendations were considered peripheral to the central theme of the workshop.

Ayotte, N.D. 1975. Reconnaissance caribou survey, Eskimo Point, N.W.T., February, 1975. N.W.T. Wildlife Service unpublished report. 7 pp.

This report summarizes an aerial survey conducted from 19-20 February 1975 between Hubbard Point, Manitoba to north of Maguse River, N.W.T. Results indicated that approximately 6000 caribou occupied the study area. The majority of animals were cows and yearlings. The author felt that more studies would be required to determine if the observed animals were part of the Kaminuriak herd.

Bailey, F.S. 1970. Caribou study - Kaminuriak herd. N.W.T. Wildlife Service unpublished report. 2 pp.

This report discusses the progress of the 1970 Canadian Wildlife Service collaring project. The majority of calving occurred prior to June 10, with low mortality until the 14th. Many wolves were observed. Twenty-eight cows were equipped with radio-transmitters in northern Manitoba and were relocated in the Gibson-Calf Lake area (Manitoba).

Baker, K. 1974a. The barren-ground caribou calving ground census technique, April 1974. N.W.T. Wildlife Service unpublished report. 7 pp.

This paper outlines suggestions for an improved census technique for the 1974 aerial survey of barren-ground caribou calving grounds. A review of past survey techniques is included. The first several days should be spent doing reconnaissance flights to determine the progress of migration and the composition of the herd. Altitude should be 400 feet and air speed should be 100 mph. When new calves appear, east-west 1/4 mile transects should be flown 4 miles apart at an altitude of 400 feet and an air speed of 90 mph. A count should be made and the calving ground further delineated. The survey should then be repeated. Figures are included for converting the number of adult cows counted into other age and sex components of the herd (including total population size). New conversion figures should be obtained from fall and spring composition counts made in Saskatchewan and Manitoba for maximum accuracy. The author suggests that the addition of the standard 20% to compensate for the blind spot under the plane is unnecessary when flying transects.

Baker, K. 1974b. Calving ground census techniques. N.W.T. Wildlife Service unpublished report. 4 pp.

This paper is a review of the standard aerial calving ground census techniques. Step 1: reconnaissance flights are flown. Progress flights (1000 ft altitude, 120 mph) to determine progress of migration and composition flights (400 ft altitude, 90 mph) to determine herd composition. Step 2: delineate the calving grounds using transects flown 4 miles apart (1000 ft, 120 mph). Step 3: divide the calving ground into equal sampling units and sample 15%. Blocks are 4 miles apart and transect width is 1/4 mile flown at 400 ft and 90 mph. An upward adjustment of 20% to the number of caribou counted is arbitrary but is used for comparative purposes.

Banfield, A.W.F. n.d.(a) The barren-ground caribou. Canadian Wildlife Service unpublished report. 3 pp.

This paper describes the status and future of the barren-ground caribou and includes a brief history of caribou study by early Europeans. The author states that there was a tremendous decline in population size since the time of the explorers and that this decline is probably due to modern fire-arms and exploitation associated with the whaling and fur industries. The present annual hunter kill is estimated at 100,000 animals. The importance of the caribou to native peoples is stressed, as is the need for wise management to ensure continued utilization of the resource.

Banfield, A.W.F. n.d.(b) Sociality and behaviour. Canadian Wildlife Service unpublished report. 24 pp.

This report gives a descriptive account, based on passages from the author's field notes, of the structure, formation and responses of herds to geographic and climatic factors. Aggregations are seen as "fortuitous" since the basic social unit is the individual. Defense and rutting behaviour is described.

Banfield, A.W.F. 1948a. The barren-ground caribou investigation. Arctic. Circular 1(7):77-78.

See Banfield, A.W.F. 1954a.

Banfield, A.W.F. 1948b. Second progress report on the barren ground caribou investigation. Arctic Circular 4(4):43-44.

See Banfield, A.W.F. 1954a.

Banfield, A.W.F. 1949. The present status of North American caribou. Transcript of the North American Wildlife Conference. 14:477-491.

A general description of various "races" of caribou.

Banfield, A.W.F. 1950a. The barren ground caribou. Canadian Wildlife Service unpublished report. 275 pp.

see Banfield, A.W.F. 1951a.

Banfield, A.W.F. 1950b. Investigation of barren-ground caribou in Mackenzie and Keewatin districts, N.W.T 1948-50. Canadian Wildlife Service unpublished report. 157 pp.

see Banfield, A.W.F. 1951a

Banfield, A.W.F. 1951a. The status, ecology and utilization of the continental barren-ground caribou. Ph.D. Thesis, University of Michigan. 339 pp.

This report deals with caribou ranges, migration, food requirements and diseases. It includes a description of the species, its environment, behaviour and the nature of man's influence on caribou. The harvest of caribou is worth 50 million dollars to Canada. There was an estimated population decrease of 2 million animals from 1900 to 1950. This is probably due to increases in the human population, native harvest with modern weapons and increased harvest by Eskimos and whaling ship crews. Annual decline in the herds is now 3,000 animals. Human wastage of meat could account for the over-harvest. Research indicates that four basic requirements for future management are; 1) education of natives in conservation principles, 2) supervision of hunting and utilization, 3) collection of accurate kill statistics and 4) regulations to allow killing for basic needs. Fourteen specific recommendations are included for fulfilling these requirements.

Banfield, A.W.F. 1951b. The barren-ground caribou. Can. Dep. of Resources and Development, Northern Administration and Lands Branch, Ottawa. 52 pp.

This report is a summary of information from a special investigation in 1948, '49 and '50. Physical environment, distribution and seasonal ranges are discussed. The effect of weather and diet requirements and the need to escape from biting insects are possible causes for migration. Pathology (warble flies, tapeworms, bovine T.B.), predation and human influence (range destruction and hunting) are reported. The annual hunter kill is estimated at 93,000 caribou. An estimated 62% reduction

in herd sizes since 1900 is partly due to a wasteful native harvest. The author recommends control of hunter kill to allow for recovery of the caribou herds.

Banfield, A.W.F. 1951c. Second report on the barren-ground caribou investigation. Canadian Wildlife Service unpublished report. No. 143.

A survey to be used as a basis for management policies and to provide continuing information on the population status of the caribou. Summer range studies were conducted from 1 June to 1 September. Aerial surveys indicated an estimated population of 670,000 between Hudson Bay and the Mackenzie and Slave Rivers. Studies of calving ground ranges, vegetation, Eskimo utilization and hunting techniques were included in the survey. Estimated annual increment was 141,000 calves; annual hunter kill was estimated at 100,000 animals; annual predator kill was 34,000 with the same toll from disease and accidents.

Banfield, A.W.F. 1954a. Preliminary investigation of the barren-ground caribou. Part 1: Former and present distribution, migrations and status. Canadian Department of Northern Affairs and Natural Resources. Canadian Wildlife Service Wildlife Management Bulletin, Series 1, Number 10A. 79 pp.

About 1900, the caribou population was about 1,750,000. On the basis of aerial surveys during the present investigation it is estimated that the present population consists of about 670,000 caribou, indicating an apparent reduction of 62 per cent. The areas showing the greatest reduction are: (1) the area north of Great Bear Lake, from Bernard Harbour to Mackenzie Delta (Bluenose range); (2) northern Keewatin District, Adelaide, Boothia and Melville Peninsulas, and the continental area east of the mouth of the Back River and north of Chesterfield Inlet; (3) King William Island; and (4) the tundra adjacent to Hudson Bay from York Factory to the Severn River (Kaminuriak range). In the central portion of the range there may have been a gradual reduction in numbers. The drastic population reduction in area (1) is thought to have been due to the coming of whaling ships along the Arctic coast from 1890 to 1910. Reductions in areas (2) and (3) are thought to have been caused by increased activities of natives supplied with introduced firearms and ammunition as a result of the introduction of the fur industry. The reduction in area (4) is thought to have been caused by the increase of human population in northern Manitoba coupled with the introduction of modern firearms. The gradual reduction in the central portion of the range has been due to increased human population, the introduction of firearms and the development of the fur industry.

Banfield, A.W.F. 1954b. Preliminary investigation of the barren-ground caribou. Part II: Life history, ecology, and utilization. Canadian Wildlife Service Wildlife Management Bulletin, Series 1, Number 10B.

The physical description, behaviour, parasites and diseases of caribou, and range vegetation are discussed in detail. The present annual human utilization of caribou was estimated to be about 100,000 animals by groups as follows: Indians, 50,000; Eskimos, 30,000; other trappers and hunters, 20,000. Next to man, the wolf is the most important predator on caribou. Scanty data indicated that wolf predation accounted for approximately 2.5 per cent of the caribou population in one year in one instance. Maximum wolf predation was estimated to account for 34,000 animals annually. Disease was thought to be of less importance as a mortality factor but accidents and weather losses were believed to have an appreciable effect: losses caused by disease, accidents and weather might account for another 34,000 animals annually. The annual increment was estimated to be approximately 145,000 calves. Mortality figures indicate an approximate annual loss of 178,000 animals, resulting in a deficit of about 32,000 animals per year.

Banfield, A.W.F. 1955. A provisional life table for the barren ground caribou. Canadian Journal of Zoology 33:143-147.

A provisional life table for the continental barren-ground caribou Rangifer arcticus arcticus (Richardson), was prepared from a collection of 292 mandibles collected in 1948 and 1949 on the summer and winter ranges of the species in northern Canada. The data include both sexes. The age of the specimens was estimated by the eruption and wear of the teeth. The mean expected life span at birth was found to be 4.09 years. The average mortality rate for the first 10 years of life was 71%. The apparent potential natural longevity was about 13 years.

Banfield, A.W.F. 1957. The plight of the barren-ground caribou. Oryx 4(1):1-20.

This paper gives a general account of caribou and their habits. The effects of wolf predation (accounting for 5% per year of the caribou population), migration and past and present ranges are discussed. The reduction in caribou numbers and territory between 1900 and 1950 was caused by the use of firearms by native peoples and the harvest of caribou by whaling crews. The mainland barren-ground caribou population was 670,000 in 1949 (62% drop from 1900). 145,000 calves were born and 168,000 caribou were harvested in 1949. Methods of killing are described as is wastage of caribou by hunters. The author concludes that there are enough caribou if wastage is eliminated and suggests a program of conservation education and restricted hunting for northern people.

Banfield, A.W.F. 1960. The use of caribou antler pedicels for age determination. *Journal of Wildlife Management* 24(1): 99-102.

Annulations in pedicel sections are correlated with tooth eruption and wear aging techniques. Pedicel annuli appear to be useful up to the fifth year and compliments other aging methods. Sectioning and examining procedures are discussed as well as potential for uses other than aging; annual nutritional level of range and radioactive fallout indication.

Banfield, A.W.F. 1961. A revision of the reindeer and caribou genus Rangifer. *National Museum of Canada Bulletin* Number 177. (Biology Series Number 66). 137 pp.

This report is the definitive work on caribou taxonomy. Beverly and Kaminuriak caribou are Rangifer tarandus groenlandicus.

Banfield, A.W.F. 1980. Notes on caribou distribution, abundance and use in the Northwest Territories, 1933-1949. In Analysis of the characteristics and behaviour of barren-ground caribou in Canada. A.W.F. Banfield and R.D. Jakimchuk (eds). Prepared for Polar Gas Project.

A reanalysis of data collected during the preliminary caribou investigation of 1948-50, including the caribou questionnaires, native game returns and historical observations led to the conclusion that the currently recognized caribou herds have persisted individually since the early nineteenth century and undertake migrations over generally similar routes. All herds have shown variability in their calving grounds and wintering range. Caribou migrations have followed traditional routes from wintering range to calving grounds, except during the 1930's and 40's when the Beverly herd traveled a more westerly route near Artillery and Clinton-Colden Lakes and the Upper Back River Valley. Population estimates of the four major herds during 1948-49 were: Bluenose, 35,000; Bathurst, 219,000; Beverly, 260,000; and Kaminuriak, 145,000. Native utilization of the caribou herds averaged 12.8 per cent ranging from 4.4 to 7.8 per cent for the Bluenose, Bathurst and Beverly herds and 27.5 per cent for the Kaminuriak herd.

Banfield, A.W.F., D.R. Flook, J.P. Kelsall and A.G. Loughrey. 1955. An aerial survey technique for northern big game. *Transactions of the Twentieth North American Wildlife Conference*, March 1955. 519-529.

Aerial survey has proved to be the only practical method of obtaining data on big game populations, herd composition and annual increment in the wilderness areas of northern Canada.

Different big game species require different handling of data. Caribou populations are best surveyed in early spring. Caribou populations are best segregated into herds for study. The following technique is best suited to varied northern conditions. Individual angles of sight to animals observed and altitude are recorded. The effective transect width may be obtained by grouping the distances to the animals in standard intervals. Outer and inner intervals may be discarded when the scarcity of records indicates low efficiency of observation. Low oblique aerial photographs are used extensively to obtain segregation data by examining them under a binocular microscope or stereoscope in the laboratory.

Beckel, D.K.B. 1958a. A pilot study of caribou winter range Brochet, Manitoba. By means of airphoto analysis and interpretation. Canadian Wildlife Service unpublished report. 41 pp.

This report summarizes a study to determine the feasibility of studying the caribou range in northern Canada (Kaminuriak range) by means of air photo analysis and interpretation. The use of airphotos allows a larger area to be surveyed than would be possible with field work alone. Sites representative of vegetation soil and land form types were photographed. The photos were analyzed and the interpretation of the analysis traced on acetate overlays. The author describes land forms and vegetation types and discusses post-burn forest composition and reproduction. The mineral content of soil types (phosphates, potash, calcium and magnesium) is presented as are suggestions for future study.

Beckel, D.K.B. 1958b. A pilot study of caribou summer range (calving ground) Kaminuriak Lake, N.W.T. by means of airphoto interpretation and analysis. Canadian Wildlife Service unpublished report Number 920. 13 pp.

This report describes a pilot study to determine the feasibility of using aerial photographs to classify caribou range. The report discusses land forms, soils, mineral content and vegetation. Four classifications are used: well-drained uplands, medium-drained uplands, poorly-drained uplands and very poorly drained-uplands. Floristics and physiognomy are discussed. The well-drained uplands is most common in the north and eastern part of the range with its high lichen content, the poorly-drained uplands, with birch and sedges is most common in the south and west. A finer scaled study is recommended.

Benson, D.A. 1965. Statistical refinements of caribou aerial census techniques. Paper presented at 10th meeting of the Technical Committee for Caribou Preservation. Edmonton, Alberta. February 1965. 9 pp.

A paper in which statistical problems of aerial surveys are stated including the assumption of a random, normal distribution of animals which are contagiously distributed (should use stratified sampling) and the treatment of unequal transects as if they were of equal length. Recommendations for improving census techniques are that, 1) a statistician design and help complete the surveys, 2) that no standard statistical design can be developed for all surveys due to lack of expertise and 3) that population analyses (not just surveys) should be the goal of managers. A summary of aerial caribou surveys to date is included, as well as a review of photographic techniques.

Bergerud, A.T. 1972. Food habits of Newfoundland caribou. *Journal of Wildlife Management* 36(3): 913-923.

The food habits of caribou (Rangifer tarandus) in Newfoundland were studied by an examination of the contents of rumina. Important groups of plants in the diet in the spring were broad-leaved evergreen and deciduous shrubs and sedges; in the summer, deciduous shrubs, reindeer lichens (Cladonia spp.) and fungi; in the autumn, reindeer lichens; and in the winter, arboreal lichens and evergreen shrubs. It was concluded that caribou do not have specialized food habits; when necessary they can use most plants. However, the caribou preferred fungi, green leaves of deciduous shrubs and forbs, and new spring growth of sedges when these were available.

Bergerud, A.T. 1974a. Decline of caribou in North America following settlement. *Journal of Wildlife Management* 38(4):757-770.

The numbers of caribou (Rangifer tarandus) in North America generally declined in the 1800s and early 1900s. Four hypotheses are discussed relative to this decline: (1) numbers decreased because of a shortage of lichen supplies caused by the destruction of lichen pastures by fire and logging; (2) populations declined because of increased hunting mortality, augmented by increased natural predation of some herds by wolves (Canis lupus); (3) a combination of hypotheses 1 and 2 above; and (4) caribou declined in Alaska because of increased movement to marginal habitats with high numbers. This review supports hypothesis 2 - that numbers declined because of increased hunting mortality and natural predation of some herds, and argues that the range-destruction hypothesis has not been shown to be either a necessary or sufficient cause to explain the decline.

Bergerud, A.T. 1974b. Rutting behaviour of Newfoundland caribou. pp. 395-435. In: V. Geist and F. Walther (eds.), *The behaviour of ungulates and its relation to management*. International Union for Conservation of Nature and Natural Resources. New Series 24. Morges, Switzerland. 940 pp.

The breeding behaviour of caribou (Rangifer tarandus) in Newfoundland was studied during the fall rutting season for 10 years. Prior to the rut males and females were mostly segregated. In mid-September there was a fall shuffle in which stags joined female groups. The week prior to actual breeding animals banded together in small companies, usually with only one dominant stag present. In this pre-rut period there was considerable agonistic behaviour between males and between males and females. It is believed the function of this behaviour was to establish dominance relations prior to actual breeding. Common breeding displays seen in this period and described in the paper include: bush gazing, bush thrashing, hock rubbing, mock battles, dominance battles, sparring and rearing and flailing. During the actual rut (October 8-18) females that were in heat were tended by males; the males courted and tested the females by a vacuum-licking display called slurping. Large-antlered stags did most of the breeding. It is hypothesized that the force of natural selection declines more rapidly with age in males than in females because older males are not permitted to breed females. If this hypothesis is valid it would suggest that males grow older faster than females, and there is a preponderance of females in caribou populations because males reach senility at an earlier age than females.

Bergerud, A.T. 1974c. The role of the environment in the aggregation, movement and disturbance behaviour of caribou. pp. 552-584. In: Geist, V. and F. Walther (eds.), The behaviour of ungulates and its relation to management. International Union for Conservation of Nature and Natural Resources. New Series 24. Morges, Switzerland. 940 pp.

The aggregation, movement and disturbance behaviour of caribou (Rangifer tarandus) is discussed in relation to the interaction of extrinsic environmental factors:

- (1) other animals (wolves, insects, and caribou);
- (2) a-place-in-which-to-live (open habitats);
- (3) food (slow growing plants); and
- (4) weather (snow and wind).

It is hypothesized that wolves interacting with caribou in open habitats have been a consistent contingency resulting in the formation of nursery bands during calving. The gregarious herd structure during the rutting season is also believed to be a consistent contingency resultant from the intraspecific interaction of caribou in open habitats. It is also theorized that disturbance behaviour results from the above interactions. Movement and aggregating behaviour vary with various phases of the annual cycle and appear liable to adaptive modification. These facultative responses seem to be due to the interactions of the variable environmental contingencies of food x weather and a-place-in-which-to-live x insects.

Bergerud, A.T. 1976. The annual antler cycle of caribou in Newfoundland. Canadian Field-Naturalist 90(4): 449-463.

The author studied the occurrence, growth, and size of antlers of caribou (Rangifer tarandus) in Newfoundland from 1956 to 1966. All the mature males possessed antlers but many females had no visible antlers: 55% in the Interior herd, 28% in the Humber herd, and 91% in the Avalon Peninsula herd. Antlers were first visible in mature stags in April, barren does in May, parous does in June 3 weeks after calving, yearlings in June, and male calves in August. Stags shed their velvet in the second and third weeks of September, 80% of the females shed their velvet 2-10 days before estrus (2-9 October), and 20% shed their velvet 2-3 weeks before breeding. Large stags shed their antlers in November and December, barren does in late March and early April, and parous does shortly after calving in June. The size of antlers was correlated with age, body size and winter snow falls. Antlers were larger on animals in eastern Newfoundland than in western Newfoundland.

Bergerud, A.T. 1980. A review of the population dynamics of caribou and wild reindeer in North America. In: E. Reimers, E. Gaare and S. Skjenneberg (eds.), Proceedings of the 2nd International Reindeer/Caribou Symposium, Røros, Norway, 1979. Direktoratet for vilt og ferskvannsfisk, Trondheim.

Birth and mortality rates are reviewed relative to caribou in North America and related to population growth. Generally caribou first come into estrus at about 19 months of age and with good nutrition some animals can conceive at 17 months of age. The average pregnancy rate for eight herds for animals two and one half years and older was 82 percent. The average percentage of parous females in seven herds was 86 percent. In general, the reproductive rate showed little variation between years or herds. In contrast to a consistent birth rate the mortality rate of caribou calves in many herds in North America was variable, exceeding 50 percent and frequently being as high as 80-90 percent. Most of the mortality occurred in the first few months of life and the greatest mortality factor was predation. In two herds monitored for more than 10 years some calves probably starved in two and possibly six winters. This starvation was not due to an absolute shortage of food but resulted from deep snows and ice conditions. The annual adult mortality rate is estimated to vary from 7 to 13 percent (mean 10 percent) if predators are common and 5 to 6 percent if predators are rare. In general, herds without predators showed rapid population growth approaching the r_m of the species of 0.30; whereas populations coexisting with predators showed little or no growth and if also hunted usually show population decline. Predation is considered the chief limiting factor to population growth and sets the level of

stocking commonly at one to two animals per mi.² (0.4-0.8/km²) or less. Limits imposed by dispersion or food supplies occur at much higher densities.

Bergerud, A.T., R.D. Jakimchuk and D.R. Carruthers. 1982. Interactions between caribou (Rangifer tarandus sp.), human developments and transportation corridors. Paper presented at the Third International Reindeer/Caribou Symposium, Saraselka, Finland and submitted to Arctic. 66 pp.

Concerns for caribou populations encountering industrial development and transportation corridors include effects on demography, loss of habitats, displacement, disruption of movements, sensory disturbance and bio-energetic costs. The authors reviewed the demography and movement behaviour patterns for six populations (Kaminuriak, Nelchina, Central Arctic, Porcupine, British Columbia and Newfoundland) exposed to industrial activities. Behaviour patterns of caribou encountering transportation corridors are explainable by adaptive responses to natural environmental features. There is no evidence that disturbance activities or alteration of habitats have affected productivity. Transportation corridors have adversely affected populations by facilitating access by hunters. The authors believe that caribou have a high degree of resilience to human disturbance and that seasonal movement patterns and extent of range occupancy are a function of population size rather than extrinsic disturbance. The carrying capacity of the habitat is based on the space caribou need to successfully interact with their natural predators. Caribou must not be prevented from crossing transportation corridors by the construction of physical barriers, by firing-line or intense harassment - a loss in usable space will ultimately mean reduced abundance.

Bowden, E. and J. Timmerman. 1972. Kaminuriak population of barren-ground caribou calving ground survey. N.W.T. Wildlife Service unpublished report. 8 pp.

The number of caribou over 1 year old on the calving ground of the Kaminuriak caribou herd in June 1972 was estimated at 13,500. Eighteen randomly selected 16 square mile blocks were counted. The average density in those blocks was 108 caribou/block. Counting conditions were poor because of low clouds, fog and a mixed snow and bare-ground background.

Britton, B. 1981. The Beverly caribou winter range. 1950-1981. N.W.T. Wildlife Service unpublished report. 160 pp.

This report is a literature review on the winter range of the Beverly caribou population. Included are the methods and results

sections from every major Beverly caribou census report from Banfield (1951) to Decker (1980). The results are presented as a series of maps depicting winter range, spring and fall migration routes, densities, distribution, movements, aerial survey routes, forest fires and field camps. Precipitation, temperature and snow depth data are also provided. Generally, the winter range of the Beverly herd is immediately southeast of Great Slave Lake including the northernmost regions of Alberta, Saskatchewan and Manitoba.

Broughton, E. and L.P.E. Choquette. 1969. Additional information and comments on disease conditions and parasites of barren-ground caribou. Transactions of the 33rd Federal Provincial Wildlife Conference (Edmonton). July 1969. 30-39.

A report on field studies conducted during April 1966 to July 1968. 999 caribou; 436 male, and 563 female of various ages, including 99 calves were taken during that period. 253 animals were autopsied by a veterinary pathologist, the others were examined by biologists and technicians who recorded the presence or collected for laboratory examinations, parasites or tissues they thought abnormal. The lungs of each animal were examined for hydatid cysts. Samples of blood were collected for serological studies. From the field observations and results of post mortem and laboratory examinations the authors conclude that the health of the Kaminuriak barren-ground caribou population is generally good at this time.

Broughton, E., L.P.E. Choquette, J.G. Cousineau, and F.L. Miller. 1970. Brucellosis in reindeer, Rangifer tarandus L., and the migratory barren-ground caribou, Rangifer tarandus groenlandicus (L.), in Canada. Canadian Journal of Zoology 48:1023-1027.

Serum samples from 1692 reindeer slaughtered in the Mackenzie River Delta in the last decade and from 320 Kaminuriak barren-ground caribou killed between June 1966 and July 1968 were tested for brucellosis. All sera yielding titers of 1:25 or higher were considered to be positive. A positive reaction was obtained in 148 of the 1692 reindeer and 14 of the 320 barren-ground caribou tested, giving an overall reactor percentage of 8.74 in reindeer and 4.37 in caribou. Orchitis, epididymitis, bursitis, metritis, abortion, and placental retention - conditions associated with brucellosis in reindeer in the U.S.S.R. and caribou in Alaska - were not noted in the autopsy of the 1692 reindeer and of 500 sexually mature barren-ground caribou. Three possible records of bursitis, of unknown nature, in barren-ground caribou are discussed. Brucellosis does not represent a serious threat to either the Mackenzie River Delta reindeer or the Kaminuriak barren-ground caribou population, but its detection in

these animal populations is of interest from a public health standpoint.

Broughton, E., F.L. Miller and P.E. Choquette. 1972. Cutaneous fibropapillomas in migratory barren-ground caribou. *Journal of Wildlife Diseases* 8(1): 138-140.

The finding of cutaneous fibropapillomas in migratory barren-ground caribou Rangifer tarandus groenlandicus in Canada is reported for the first time. No transmission studies were carried out to determine if the neoplasms were of viral aetiology.

Bunnell, F., D.C. Dauphine, R. Hilborn, D.R. Miller, F.L. Miller, E.H. McEwan, G.R. Parker, R. Peterman, G.W. Scotter and C.S. Walters. 1975. Preliminary report on computer simulation of barren ground caribou management. pp. 189-193. In: Luick, J.R., P.C. Lent, D.R. Klein and R.G. White (eds.), *Proceedings of the First International Reindeer and Caribou Symposium*. University of Alaska, Fairbanks, Alaska. 551 pp.

see Walters et al. 1975.

Calef, G.W. n.d. Barren-ground caribou: the great herds and their coming conflict with man. N.W.T. Wildlife Service unpublished manuscript. 26 pp.

A descriptive account of the annual life cycle of the barren-ground caribou and the future of man's co-existence with caribou. Past censuses are described and the author concludes that the number of caribou (700,000 between Hudson Bay and the Mackenzie River) is the same now as in the past. New threats to caribou numbers result from increased human populations in the north and from the increased accessibility of the caribou's habitat. These threats are divided into four categories; 1) barriers to migration (eg., pipelines, roads), 2) direct killing of animals by hunting or by vehicular traffic, 3) disturbance of animals and subsequent energy losses and (4) habitat destruction (fires, erosion). Continued survival of the great herds depends on man's enlightened attitude and on the poor potential for agriculture in the north.

Calef, G.W. 1978. Recruitment of Beverly caribou herd. Letter to members of the Caribou Technical Committee. Fish and Wildlife Service, Department of Natural and Cultural Affairs. 3 pp.

An estimated 60-90,000 caribou were located near Sandy Lake and Smalltree Lake (on the Beverly herd winter range). Few mature bulls were observed, the majority of which were at Hill Island

Lake. 1,100 were classified into age and sex. The calf population composed 22.7% of the herd. Table included.

Calef, G.W. 1979. Population status of caribou in the Northwest Territories. N.W.T. Wildlife Service Progress Report Number 1. 30 pp.

All four sub-species of North American caribou (Rangifer tarandus) occur in the Northwest Territories. Of these, only the barren-ground caribou (R. t. groenlandicus) are of major economic importance and have been intensively studied. Eight major herds of barren-ground caribou totalling over 600,000 animals range entirely or partly within the Northwest Territories. The most recent population estimates suggest that the Melville Peninsula, Wager Bay and Bluenose herds are increasing, the Bathurst, Beverly and Porcupine herds are stable in numbers, and the Kaminuriak and Baffin herds are declining. The most heavily hunted herds (by percentage) are declining and the most lightly hunted herds are increasing. Population estimates of caribou herds in the Northwest Territories were carried out using various survey designs. However, these suffered from ineffective sampling procedures and observer bias, resulting in a high variance on the estimates and unmeasured inaccuracies. Improvements in survey design have reduced the 95% confidence intervals on estimates to 15-20% of the mean, but bias still remains unmeasured. Remote sensing or new statistical analyses have the potential for reducing or eliminating bias in caribou surveys. Despite improvements in technique for censusing caribou, additional understanding of caribou ecology is required for successful management of the herds.

Calef, G.W., E.A. DeBock and G.M. Lortie. 1976. The reaction of barren-ground caribou to aircraft. Arctic 29(4): 202-212.

The responses of barren-ground caribou to fixed-wing aircraft and to helicopters were observed in the northern Yukon and Alaska. Effects of aircraft altitude, type of aircraft, season and terrain were determined together with the activity and size of group of the caribou. Panic reactions or strong escape reactions were observed in a high percentage of all groups when aircraft flew at altitudes of less than 60 metres. Flying at a minimum aircraft altitude of 150 metres during spring and fall migrations, and 300 metres at other periods, would prevent the caribou reacting in the ways most immediately injurious to them.

Calef, G.W. and R. Hawkins. 1977. Kaminuriak caribou herd calving ground survey, 1976. N.W.T. Wildlife Service unpublished report. 11 pp.

The calving grounds of the Kaminuriak caribou herd were located and surveyed 30 May to 4 June 1976, using 20% coverage aerial transects. The 1976 calving area was nearly identical to that of other years, although the majority of the herd wintered on the tundra north of Baker Lake in 1976. Caribou density on the calving grounds averaged 2.0 adult caribou/km². The population was estimated at 43,800 animals $\pm$ 34.0% with 95% confidence. To increase precision of population estimates from caribou surveys in the future the allocation of transects in study areas should be stratified according to density.

Calef, G.W. and D.C. Heard. 1980. The status of three wintering caribou herds in northeastern mainland Northwest Territories. pp. 582-594. In: Reimers, E., E. Gaare and S. Skjenneberg (eds.), Proceedings of the 2nd International Reindeer/Caribou Symposium, Røros, Norway, 1979. Direktoratet for vilt og ferskvannsfisk, Trondheim.

The authors determined the distribution, population size and calf production of three herds of barren-ground caribou (Rangifer tarandus groenlandicus) which range year-round on the mainland tundra of northeastern Northwest Territories. Population estimates were based on aerial transect surveys flown over a 170,000 km² area in June 1976. Data on population structure and distribution were collected during the summers of 1976 and 1977. Separate calving grounds and distinct summer ranges were the criteria used to define the three herds. The Lorillard herd, occupying the region between Chesterfield Inlet and Wager Bay, contained about 17,000 animals over 1 year of age. The Wager herd, ranging north of Wager Bay, was the smallest with only 12,000 caribou. The Melville Peninsula herd was estimated at 52,000 based on a calving ground population of 28,000. These results indicate that substantially more caribou inhabit northeastern Northwest Territories than was previously thought. In August, calves averaged over 20% of the total population and yearlings comprised about 16% of the caribou over 1 year of age. Because calf and yearling survival is so high and few animals are killed by hunters, these herds are probably increasing.

Choquette, L.P.E., E. Broughten, F.L. Miller, H.C. Gibbs and J.G. Cousineau. 1967. Besnoitiosis in barren-ground caribou in northern Canada. Canadian Veterinary Journal 8(12):282-287.

This is the first report of besnoitiosis in caribou in Canada. Cysts were found in cutaneous lesions and in the subcutaneous fascia of 2 caribou. Pathology of the disease is described. The infection may exist without skin involvement. The method of transmission is unknown but arthropod vectors seem likely. The significance of besnoitiosis to caribou populations is unknown.

Clement, H. 1982. Beverly and Kaminuriak caribou monitoring and land-use controls. N.W.T. Wildlife Service Progress Report Number 6. 49 pp.

Beverly and Kaminuriak barren-ground caribou (Rangifer tarandus groenlandicus) movements were monitored from 10 May to 31 July 1981 in relation to the Caribou Protection Areas and land-use activities. The Caribou Monitor advised the Department of Indian Affairs and Northern Development Land-use Inspectors on cow-calf distribution in areas of proposed land-use activity. Aerial reconnaissance was the primary monitoring method. The Beverly cows were observed on the calving ground by 23 May. Post-calving movements began by mid-June; by 13 July the entire Beverly Caribou Protection Area was released for land-use activity. Seven land-use permits were issued to companies and agencies working within the Beverly Caribou Protection Area during the monitoring period. The Kaminuriak cows were on the calving ground by 29 May. Post-calving movements began in mid to late June. Three land-use permits were issued to companies working within the Kaminuriak Caribou Protection Area during the monitoring period. As a result of the Caribou Protection Measures and the Monitoring Program, potential caribou - land-use conflicts were avoided.

Clement, H. In prep. Beverly and Kaminuriak caribou monitoring and land-use controls. N.W.T. Wildlife Service Progress Report Number 8.

Barren-ground caribou (Rangifer tarandus groenlandicus) movements were monitored by aerial reconnaissance from 14 May to 12 July 1982 in relation to the Caribou Protection Areas and land-use activities. The Caribou Monitor advised the Department of Indian Affairs and Northern Development (DIAND) Land-use Inspectors on cow-calf distribution in areas of proposed land-use activity. The Beverly cows were observed on the calving ground by 15 May. Peak calving was observed by 10 June in the central area of the calving ground. Post-calving aggregations were formed by the last week in June. Most caribou had left the Kaminuriak Caribou Protection Area by 18 July. During the monitoring period eight land-use sites were released within the Beverly Caribou Protection Area and two land-use sites were released within the Kaminuriak Caribou Protection Area. The Caribou Protection Measures and the Monitoring Program acted to prevent potentially harmful contact between caribou and land-use activities.

Cook, R.D. and J.O. Jacobson. 1976. Statistical analysis of Kaminuriak calving ground survey data, 1971-1974. Interdisciplinary Systems Ltd. 15 pp.

This report reviews the results and analysis of the 1971-1974 estimates of the number of caribou on the calving grounds of the Kaminuriak caribou herd. Surveys were conducted using 16 mi²

blocks as sample units. The most questionable aspect of all surveys was the extreme variability in the number of caribou per block; the occurrence of a few blocks with very low and very high caribou density. Moreover, caribou in the high density blocks could not be counted; groups size had to be estimated. Efforts to produce more accurate population estimates should concentrate on reducing the variability among sample units. Increasing sample size and using transects rather than blocks would help. The estimates from 1971-1974 were considered unreliable.

Cooper, S. 1981. Beverly and Kaminuriak caribou monitoring and land use controls, 1980. N.W.T. Wildlife Service Progress Report Number 4. 74 pp.

Beverly and Kaminuriak caribou herd movements were monitored from 12 May to 31 July, 1980 in relation to Caribou Protection Areas and land use activities. The Caribou Monitor advised DIAND land use personnel on caribou distribution in specific areas for land use activities. Aerial reconnaissance was the main monitoring method. An early spring caused the Beverly herd to migrate early; the caribou cows approached their calving ground north of Sand Lake by late May. During calving in early to mid June the total Beverly herd population was estimated to be 97,000 caribou. Following the calving period, caribou moved into the Thelon Game Sanctuary, leaving the Caribou Protection Area devoid of large groups. The Caribou Protection Areas were opened for mineral exploration by late July. Many animals remained scattered over the broad summer ranges, both within and outside the Caribou Protection Area. The Beverly herd area contained the preponderance of mineral-related land use activity in 1980 in the Baker Lake District. Kaminuriak cows calved in a small area near Kaminuriak lake. A calving ground census estimated the total Kaminuriak population to be about 39,000 caribou. Caribou cows had largely left the Caribou Protection Area by the end of June, heading southeast toward Eskimo Point. From there, they spread out, many moving west and north around the perimeter of the Caribou Protection Area, and probably many going south. There was limited land use activity on their summer range. It was felt that the monitoring program, coupled with land use controls, significantly reduced the potential for conflicts between caribou and mineral exploration land use activities.

Courtwright, A.M. 1959. Range management and the genus Rangifer: a review of selected literature. MSc. Thesis, University of Alaska, Alaska, U.S.A. 172 pp.

This MSc. thesis is a literature review on the foods, food habits, and food requirements of the genus Rangifer and the relationship of these studies to range management. Section one is a brief review of the following subjects; 1) floral composition of the range, availability of forage and grazing capacities, 2)

nutritional composition of the forage, 3) palatability of the forage, 4) nutritional requirements of the genus Rangifer, 5) effects of utilization on the forage, 6) effects of fire, other animals, and climate on the range and 7) notes on lichens and northern range management. Section two contains abstracted papers dealing with these subjects. Section three is a collection of tabulated data selected from the works in section two.

Darby, W.R. 1978. Beverly and Kaminuriak caribou monitoring and land use controls, 1978. N.W.T. Wildlife Service Completion Report Number 1. 83 pp.

In April 1978, a court injunction and a new policy announcement of the Department of Indian Affairs and Northern Development resulted in temporary changes to controls on land use activities in the Baker Lake area, N.W.T. Special zones and restrictions were applied at certain times to protect the Beverly and Kaminuriak populations of barren-ground caribou (Rangifer tarandus groenlandicus). A monitoring program was conducted from April to late August 1978, to record caribou movements and to determine the effectiveness of these special zones and restrictions. Distribution and movement data were obtained by aerial reconnaissance and systematic survey. The scientific literature was reviewed to summarize tundra range use by the two populations and relevant disturbance studies. Approximately half of the area where Beverly caribou calved in 1978 was outside of the pertinent area of restricted land use activity. During July, Beverly cows and calves were in the Thelon Game Sanctuary west of the pertinent area of restrictions. The majority of Kaminuriak cows and calves occupied the appropriate areas until 2 weeks before the termination of restrictions. At that time approximately half of the cows and calves moved elsewhere. A disadvantage of the 1978 controls is that restricted areas cannot be released for land use activity in advance of the termination date even though no substantial number of caribou remain in the areas or are expected to return. The scientific literature suggests the need to exclude land use activities from traditional calving and post-calving areas, or any area used for calving, during sensitive times. There is no suggestion that exclusion from other areas is necessary as long as aircraft activity involving numerous passes at low altitudes near caribou can be avoided. Except for aircraft disturbance, mineral exploration activity is considered to be of less concern than long term development. Neither the 1978 controls nor proposed Land Management Zones of the Minister, DIAND, address the issue of long term development. Recommendations are given for more flexible controls on exploration activity. In addition, it is recommended that development of site specific land use activities (e.g. mines) be allowed within traditional calving and post-calving areas subject to stringent regulations to ensure the accessibility and quality of these areas as key pieces of caribou habitat.

Darby, W.R. 1979. Recommended boundaries for land use protection areas for the Beverly and Kaminuriak herds. N.W.T. Wildlife Service unpublished report. 32 pp.

This paper is a report to the Department of Indian Affairs and Northern Development outlining recommended caribou protection areas for the Beverly and Kaminuriak herds. The report is to accompany a series of 20 maps (scale 1:250,000) outlining the protection area boundaries. All literature dealing with calving and post-calving areas is summarized and presented in a series of 3 maps. Two possible protection areas are suggested for each herd. Protection area A is the traditional calving and post-calving area based on scientific data. Protection Area B is the area that could potentially experience calving or post-calving activity. Detailed justifications for the placement of boundaries are given.

Darby, W.R. 1980. Beverly and Kaminuriak caribou monitoring and land use controls, 1979. N.W.T. Wildlife Service Progress Report Number 3. 74 pp.

In 1979, the Department of Indian Affairs and Northern Development (DIAND) implemented a revised system of land use controls to protect the Beverly and Kaminuriak populations of barren-ground caribou (Rangifer tarandus groenlandicus) during calving, post-calving and other sensitive periods. The zones and conditions were more flexible than those used in 1978. However, an interim injunction, dated 24 April 1978, required the Crown to specify special permit conditions when issuing land use permits and mineral exploration permits in the Baker Lake area, Northwest Territories. A monitoring program conducted by the N.W.T. Wildlife Service from April to September 1979 recorded caribou movements, advised DIAND land use personnel on caribou-related matters, and evaluated the effectiveness of 1979 controls. Caribou distribution and movements were recorded during aerial reconnaissance and systematic surveys. Beverly caribou were late migrating northwards, and their distribution became elongated in late May. Most calving occurred near Sand Lake in the northern portion of the area under land use restrictions, but some cows calved to the west in the Thelon Game Sanctuary. During July, most Beverly cows and calves moved through the Thelon Game Sanctuary west of the area of land use restrictions. Kaminuriak cows calved west of the pertinent zone, but this seemed to be a result both of late migration and the fact that all cows were headed for the northern portion of their traditional calving ground. With some exceptions, land use conditions associated with the zones are appropriate. Recommendations for controls and monitoring are given.

Dauphine, T.C. 1966. Barren-ground caribou body weights, heart girths, metatarsus lengths, kidney fat indices, abdominal fat weights and back fat thicknesses, given by sex, age, and season. Canadian Wildlife Service unpublished report. 12 pp.

This report contains raw data published later. see Dauphine, T.C. 1976

Dauphine, T.C. 1968. Growth and physical condition - Kaminuriak caribou herd. Canadian Wildlife Service unpublished report. 9 pp.

see Dauphine, T.C. 1976.

Dauphine, T.C. 1971. Physical variables as an index to condition in barren-ground caribou. Transcript of the Northeast Section of the Wildlife Society (U.S.A. - Canada). 28:91-108.

The Canadian Wildlife Service obtained measurements of body size and fat deposits from a population of barren-ground caribou in northern Canada. The measurements were analyzed for patterns of fluctuation and for sensitivity to seasonal changes in the physical "condition" (fat reserves) of the caribou. Ninety-seven adult males (58 months and older) and 314 females (27 months or older) were collected in eleven seasonal samples over a 28 month period. A graph of each fat index plotted against body weight, and a comparison of correlation coefficients (r) among the indices, indicated that fat deposits in prime (autumn) caribou mobilized in the sequence: "back" (subcutaneous) fat, "kidney" (perinephric) fat, "abdominal" (omental and mesenteric) fat, and femur marrow fat. The exhaustion of the back fat, and the first use of the marrow fat, coincided with the cessation of body weight decline and with a 50 percent decline in the two visceral fat indices. Only the two visceral deposits fluctuated throughout the full range of condition. A comparison of the results of variance ratio (F) tests on seasonal differences indicated that the kidney fat measurement was more sensitive than the other fat indices to overall seasonal change. Abdominal fat followed kidney fat in sensitivity. Back and marrow fat indices equaled or exceeded the two visceral deposits in sensitivity to change within their limited range of fluctuation. Body weight proved to be the most sensitive index of seasonal change but its usefulness at low levels of fat reserves was limited by the propensity to stabilize at a minimum level despite continued fat mobilization.

Dauphine, T.C. 1975. Kidney weight fluctuations affecting the kidney fat index in caribou. Journal of Wildlife Management 39(2): 379-386.

Kidneys and perirenal fat were weighed from 878 caribou (Rangifer tarandus) collected over a 2-year period in northern Canada. Comparison of seasonal trends in the "kidney fat index" (perirenal fat weight/kidney weight x 100) and perirenal fat weight for each sex and age group revealed substantial differences in timing and amount of change. The index was distorted by a 70 to 80 percent increase in kidney weight which prevailed during summer and early autumn. Consequently, kidney weight was an unsuitable correction for body size in an index intended to mirror seasonal changes in the amount of perirenal fat.

Dauphine, T.C. 1976. Biology of the Kaminuriak population of barren-ground caribou. Part 4: Growth, reproduction and energy reserves. Canadian Wildlife Service Report Series Number 38. 69 pp.

943 Kaminuriak caribou were examined for weight, morphological measurements, quantity of stored fat and condition of female reproductive organs. Mature females averaged 90 kg (maximum 113 kg), and males averaged 147 kg (maximum 172 kg). Winter weight loss was 11% for females and 30% for males (mainly during the rut). Maximum fat deposits in September decreased to April for males and June for females. Full recovery of fat deposits during summer was critical for reproduction, growth and winter survival. 50% of females ovulate at 1 1/2 years, 48% at 2 1/2 years and 90% at 3 1/2+ years. Data suggests a gradual exhaustion of female body condition during successive pregnancies followed by a recovery (barren) year and renewed breeding. The author suggests that fluctuations in cohort survival may be related to the amount of food available for pregnant females on the winter range.

Dauphine, T.C. and R.L. McClure. 1974. Synchronous mating in Canadian barren-ground caribou. Journal of Wildlife Management 38(1):54-66.

The dates of the 1966 and 1967 mating seasons for the Kaminuriak barren-ground caribou (Rangifer tarandus groenlandicus) population were estimated by examination of the reproductive organs of 129 females collected from Manitoba and the District of Keewatin, N.W.T., in September, November and December. Ovulation and pregnancy were diagnosed from the size and microscopic appearance of ovarian corpora lutea and follicles. Dates of conception were determined by estimating the age of embryos with a growth curve (crown-rump length) predicted from the growth rates of three other species of Cervidae. Conceptions were highly synchronous with 80 percent of 64 occurring in the first 11 days (19-29 October) of a 4- to 5-week mating season. The females' ages, body weights, and fat measurements were not significantly ($P > 0.05$) correlated with their conception dates. The synchronous occurrence of conceptions, confirmed by observations of rutting behaviour and the timing of births in the study and in other caribou populations, appears to be important to calf survival.

Dauphine, T.C., D.R. Miller, F.L. Miller and G.R. Parker. 1970. Minimum requirements for the management of barren-ground caribou populations. Report of Caribou Management Subcommittee, Technical committee for Caribou Preservation. 17 pp.

A report recommending management principles and requirements for the barren-ground caribou. Management principles outlined are that 1) management should be based on resource units not political boundaries, 2) harvest levels should allow populations to increase until utilizer demands are satisfied or the carrying capacity of the range is reached, 3) management of herds which occur in more than one political region should be co-ordinated by the agencies involved and 4) the cost of management should be shared by the agencies which benefit from these activities. Results of the Manitoba-Keewatin caribou project are presented: sex ratio (58 adult males:100 adult females), age ratio (juveniles and subadults comprise 51.5% of the population), natality (70% of adult females reproduce), annual calf survival (10%), causes of mortality (hunter kill 5%, natural causes 5%), current herd stability (recruitment equaled mortality), and range carrying capacity (range could support more caribou). These population characteristics were the basis for the following recommendations on minimum management requirements, 1) a sample of the hunter kill should be aged and sexed by collecting lower jaws, 2) an annual aerial inventory should be conducted, 3) the total annual kill should be determined by canvassing hunters, and 4) continuous attempts should be made to determine non-hunting limiting factors to caribou population growth. An estimate of annual costs is included.

de Vos, A. 1960. Behaviour of barren-ground caribou on their calving grounds. Journal of Wildlife Management 24(3): 250-258.

Studies were made of the behaviour of barren ground caribou on their calving grounds in Mackenzie and Keewatin Districts, Northwest Territories, between 22 May and 6 July 1958. An absence of leadership was noticeable. Bands ranging in size from two to five were most frequently observed. Most bands on the calving grounds consisted largely of pregnant females. The majority of calves were born in "calving bands." The peak of calving was estimated to have occurred around 12 June. As calving progressed, migratory behaviour was gradually replaced by a drifting movement. By late June, caribou became increasingly restless. The attachment between a cow and her calf gradually lessened after birth. Calves 4 days old and older moved widely through a band. Daily activity reached morning and afternoon peaks. An undisturbed band seemed to have a pattern of activity and resting periods during the calving season. Calves bedded more than cows. Vocal activity increased with the state of excitation and indecision. Limited calf mortality apparently resulted from cows

killing strange calves. The flushing distance of alerted caribou varied greatly with environmental conditions and band size. Cows with calves were more alarmed by disturbances than were calfless individuals.

Engen, E. 1964. A brief report on the construction of three barren-ground caribou range exclosures in the Horseshoe Lake area of northern Manitoba. Manitoba Game Branch unpublished report. 6 pp.

Not available for review.

Engen, E. 1965. A report on the construction of three barren-ground caribou range exclosures in the Lac Brochet area of northern Manitoba. Manitoba Game Branch unpublished report. 6 pp.

Not available for review.

Engen, E. 1966. The 1966 barren-ground caribou tagging project in Manitoba. Canadian Wildlife Service unpublished report. 14 pp.

Twenty-five Kaminuriak caribou were tagged in the Little Duck Lake area in 1966. Twenty-three were adult males and two were adult females. In addition to the ear tagging, biologists placed bright florescent "Saflag" vinyl collars around the necks of ten caribou. Four inch wide green collars with large black letters on either side were attached to nine adult males and a three inch wide pink collar with a black number "1" on either side was attached to an adult female caribou. Eight adult males and one adult female also wore Manitoba ear tags.

Fischer, D.A. and E.A. Duncan. 1975. Ecological studies of caribou and muskoxen in the arctic archipelago and Northern Keewatin. Renewable Resources Consulting Services Ltd. Polar Gas Environmental Program. 192 pp.

Research on caribou and muskoxen population numbers, distribution, habitat use and behaviour was conducted during 1974 and 1975 in the central Canadian Arctic. Population estimates from aerial surveys indicated 1600 caribou. Habitat studies indicate caribou select areas with a high frequency of willow in summer and utilize uplands in winter for lichens.

Fischer, C.A., D.C. Thomas, R.L. Wooley and P.S. Thompson. 1977. Ecological studies of caribou on the Boothia Peninsula and in the District of Keewatin, NWT, 1976, with observations on the reaction of caribou and muskoxen to aircraft disturbance, 1974-1976. Prepared for Polar Gas Project, Renewable Resource Consulting Services Ltd. 239 pp.

Studies to determine distribution, numbers, and habitat use of caribou in the south-central Canadian Arctic were conducted during 1976. In March 1976, large numbers of caribou were seen at the northeast end of Baker Lake (between Hayes River and Baker Lake). These animals (>20,000) were considered to be Kaminuriak caribou. By June 1976, 250 were seen in this area and no movement between Baker Lake and Hayes River in April and May was seen. However in late March the concentration of the Kaminuriak herd was located from 10 km east of Nuvutuak Point on the north shore of Baker Lake to Ragged Point on Chesterfield Inlet, including Christopher Island and Bowell Islands. This group moved south and east by mid-April and by the second week of May were on the calving grounds. A post-calving survey of the Kaminuriak caribou herd resulted in a total population estimate of 42,376 adults. Fischer et al. recorded a possible decline of the Kaminuriak herd from an estimated 63,000 in 1972 to 40,000 in 1976. The exact cause(s) could not be determined. A threefold increase in the harvest by five Inuit communities had been recorded. Reactions of caribou to overflights were recorded. Distance of the aircraft from the animal was the most important variable affecting response level. For altitudes of 61 m to 121 m, the percentage of strong responses exhibited by caribou were 29%, 17%, and 14% for horizontal distances of ≤ 365 m, 366 to 730 m and ≥ 731 m, respectively. Large groups were more reactive than small groups or individuals. Groups with calves were slightly more reactive than groups without calves. The activity of caribou at the time of the overflight influenced the response with bedded or feeding caribou reacting less frequently and intensively than travelling caribou. Caribou were most sensitive to aircraft in late winter. Studies of habitat use by caribou on Boothia Peninsula and in the north-central District of Keewatin were carried out during the period from June to August. The diet was marked by a high frequency of lichens, with moderate use of willows, forbs and sedges. Caribou were not limited by a lack of forage. Mean group sizes were consistently larger in the southern portion of the study area than in the north and were largest during the post-calving period and smallest during the calving period.

Fleck, E.S. and A. Gunn. 1982. Characteristics of three barren-ground caribou calving grounds in the Northwest Territories. N.W.T. Wildlife Service Progress Report Number 7. 158 pp.

Potential effects of human activities on barren-ground caribou on the Bathurst, Beverly and Kaminuriak calving grounds are unknown. In April, 1980, the Department of Indian Affairs and Northern Development sponsored the N.W.T. Wildlife Service in a 3-year disturbance study on calving grounds. The first year of the study concentrated on histories of the use of calving grounds, topography, snowmelt patterns, vegetation and abundance of predators. Historically, the general location of the calving grounds has not changed. Varied topography is a characteristic of all three calving grounds. The geographical limits of the more varied topography approximately align with the borders of the Beverly and Kaminuriak calving grounds. The three calving grounds are located in the northern portion of each herd's range and remain snow-covered longer than more southerly portions of their ranges. Snowmelt begins and ends earlier on the Kaminuriak and southern portion of the Beverly calving grounds (early June) than on the Bathurst and northern portion of the Beverly calving grounds (mid-June). Willows and dwarf birch shrubs characterize the vegetation on the Kaminuriak and southern portion of the Beverly calving grounds. Lichen communities dominate the vegetation on the northern portion of the Beverly calving grounds. The number of wolf dens is low on the calving grounds compared to areas near treeline. None of the environmental characteristics examined clearly isolate the calving grounds from their surrounding areas. The general location of traditional calving grounds is likely the influence of several interacting factors including plant phenology and predator avoidance. Traditional behaviour is likely important in explaining the choice of calving ground location.

Fuller, W.A. 1948. Summary of preliminary caribou investigations in southern Mackenzie District. Canadian Wildlife Service unpublished report. 16 pp.

Using aerial observations and accounts of local pilots and trappers an attempt was made to determine the distribution and movements of barren-ground caribou. Northern Saskatchewan and areas north and east of Great Slave Lake were reported on. Regularity, direction and size of migrations are discussed as are the difficulties involved in aerial observations and photography.

Fuller, W.A. 1951. Report on post mortum examination of caribou east of Fort Smith, N.W.T., December 12-22, 1950. Canadian Wildlife Service unpublished report. 2 pp.

This report describes the post mortem examinations of seven (Beverly) caribou shot by hunters and the skull measurements of six. The lymphatic system, teeth, and alveolar processes were examined in detail while lungs, liver, spleen, and masseter muscles received cursory attention. No pathological conditions

were discovered. The skull measurements taken were length of upper cheek tooth row and distance between lateral surrades of upper cheek tooth row. The ratio of the two measurements was variable, making these criteria unreliable as a technique for distinguishing reindeer and caribou.

Gates, C. 1981. Recruitment to the Kaminuriak caribou herd. N.W.T. Wildlife Service field note. 6 pp.

This report estimates the recruitment to the Kaminuriak herd in 1981. The survey was ground based. Animals were classified as antlered, antlerless and calves. Recruitment was calculated as 18.4% after allowing for 24% of the bulls as missing. Recently a number of models of population trends for the Kaminuriak herd have been developed for use as management tools. These models use a recruitment rate of 10% (determined during the 1960's) and a harvest rate of 4,600 caribou. Both of these figures may be underestimates so they may balance out, providing a population trend which approximates empirical measurements. However, changes in environmental conditions or harvest regulations will cause the models to err considerably. The author concludes that recruitment data is critical to management programs therefore annual surveys should be conducted to determine this variable parameter.

Gibbs, H.C. 1958. Report on disease investigation of barren-ground caribou, July 1957-August 1958. Canadian Wildlife Service unpublished report. 12 pp.

This paper reports normal haematological values for caribou and 4 aspects of caribou disease; 1) serological survey (tests were negative), 2) bacteriological studies (no significant cultures were found), 3) parasitological studies (11 species found, none produced clinical effects) and 4) pathological conditions (12 found, but only fly predation is considered important). It is concluded that disease, while present in caribou herds, is probably not a major factor in the perceived decrease of these herds.

Gunn, A. and F.L. Miller. 1980. Responses of Peary caribou cow-calf pairs to helicopter harassment in the Canadian High Arctic. pp. 497-507. In: Reimers, E., E. Gaare and S. Skjenneberg (eds.), Proceedings of the 2nd International Reindeer/Caribou Symposium, Røros, Norway, 1979. Direktoratet for vilt og ferskvannsfisk, Trondheim. 799 pp.

The authors simulated the slinging of loads by helicopter by flying sets of six passes at 240-370 metres above ground level over groups of Peary caribou on Prince of Wales Island, Northwest Territories. They were interested in the responses of cow-calf

pairs as they had previously noted these caribou's high responsiveness relative to other group types during helicopter harassment. Ground observers continuously recorded the behaviour of 20 cow-calf pairs before, during and after sets of 6 passes in July-August, 1977. The authors obtained 368 responses or activities from cow-calf pairs from each of four phases of the 92 passes. Calves responded to 86.7% of the 91 phases during which cows responded, and calves also responded during 28 phases when their cow was foraging or bedded. Of the 123 locomotory responses 19.5% and 20.3% were attributable to regrouping of the cow-calf pair and the pair rejoining their group, respectively. Only 2.2% of the cow-calf pairs were trotting as the helicopter departed and within 1 minute the pair still in sight had stopped trotting and was foraging. Calves tended to alert more and respond sooner than their maternal cows. The calves were also more likely to rejoin their maternal cows than the cows to seek out their calves.

Gunn, A. and R. Decker. 1982. Survey of the calving grounds of the Beverly caribou herd, 1980. N.W.T. Wildlife Service File Report Number 20. 27 pp.

The Beverly caribou herd was estimated to number 105,000 caribou over 1 year of age from a census of the calving ground, 7-8 June 1980. The estimate of total population size signifies the continued downward trend of the population. Calving was north of the Thelon River and covered an area of 5,300 km². The western edge of the calving ground had to be subjectively delineated because of the influx of young bulls and yearlings onto the calving ground and this subjective decision may have reduced the population estimate. Ground segregations on 13 and 14 June also emphasized the high proportion of non-breeders as breeding cows were only 69% of caribou on the calving ground compared to 81% in June 1978. The second problem with the census which likely reduced the estimate was the disparity between the left (inexperienced) and the right (experienced) observer.

Hanson, W.C., F. W. Whicker and J.F. Upscomb. 1975. Lichen forage ingestion rates of free-roaming caribou estimated with fallout Cesium-137. pp. 71-79. In: Luick, J.R., P.C. Lent, D.R. Klein and R.G. White (eds.), Proceedings of the First International Reindeer and Caribou Symposium. University of Alaska, Fairbanks, Alaska. 551 pp.

Lichen forage ingestion rates of free-roaming caribou herds in northern Alaska during 1963-1970 were estimated by applying a two-compartment, eight parameter cesium-137 kinetics model to measured fallout Cs-137 concentrations in lichen and caribou. Estimates for winter equilibrium periods (January-April) for each year ranged from 3.7 to 6.9 kg dry weight lichens per day for adult female caribou. Further refinement of these estimates were

obtained by calculating probabilistic distributions of intake rates by stochastic processes based upon the mean and standard error intervals of the eight parameters during 1965 and 1968. A computer program generated 1,000 randomly sampled values within each of the eight parameters during 1965 and 1968. Results substantiate the contention that lichen forage ingestion rates by free-roaming caribou are significantly greater than previously held.

Harper, F. 1955. The barren-ground caribou of Keewatin. Miscellaneous Publication Number 6. Museum of Natural History, University of Kansas. 164 pp.

Descriptive account of various aspects of caribou biology including migration, factors affecting distribution, relations to predators and other species and habits and morphology. Present and historical hunting practices are discussed. Little quantitative data is presented except in the taxonomy section. Results consist of a synthesis of the historical literature and six months observation and collecting in 1947 at Nueltin Lake (centre of the Kaminuriak herd range). The report includes a 25 page annotated bibliography of literature cited.

Hart, J.S., O. Heroux, W.H. Cottle and C.A. Mills. 1961. The influence of climate on metabolic and thermal responses of infant caribou. Canadian Journal of Zoology 39: 845-856.

Metabolic and thermal responses of infant caribou to climate were measured during the June calving period on the barrens in the area of Mosquito Lake and Beverly Lake, N.W.T. (Beverly herd range). It was found that temperature regulation was well established at birth and that the calves were very sensitive metabolically to cold, wind and precipitation. The metabolic rate was doubled by a lowering of temperature to about 0°C, but cold combined with wind and precipitation elevated the metabolic rate to over five times the resting value. Calves which were exposed without protection to such conditions eventually became hypothermic and died. Weather conditions during storms on the barrens are sufficiently severe to produce some mortality in animals exposed without protection. The possibilities for prediction of mortality from wind chill and estimated fur heat loss are discussed.

Hawkins, R. 1973a. A proposal to modify the approach to the Kaminuriak calving ground census. N.W.T. Wildlife Service unpublished report. 5 pp.

The author proposes to fly the survey in lateral strips (1/4 mile wide) at regular intervals, as opposed to blocks at random intervals. Advantages of the strip census technique over block technique are:

- 1) reduced navigational problems;
- 2) more efficient use of time in survey;
- 3) reduced risk of animal movement between sample areas;
- 4) useful comparative data would be obtained; and
- 5) you view the entire calving ground, giving the observers some assurance to the reliability of the sample.

Hawkins, R. 1973b. Tagging report - Beverly Lake herd, barren-ground caribou. N.W.T. Wildlife Service unpublished report. 71 pp.

Daily record of the tagging operation at Box Crossing including movements, herd composition, and natural influences on migration, weather conditions, tag recoveries, and wildlife sightings. Problems associated with field operations and personnel are discussed. Recommendations on tagging equipment and projects are made. Extensive appendices present all tagging data.

Hawkins, R. 1973c. Annual report, 1972/73 Baker Lake. N.W.T. Wildlife Service unpublished report. 12 pp.

This report estimates caribou kill based on monthly verbal reports and GHL returns, incorporating a 20% error for each estimate. Estimates of Beverly, Kaminuriak and Melville caribou kill from July - December 1972 and January - June 1973 were: Beverly, 1034; Kaminuriak, 218; and Melville, 156.

Hawkins, R. 1974. Annual report, 1973-74, Baker Lake. N.W.T. Wildlife Service unpublished report. 5 pp.

This paper reports the Baker Lake winter kill for 1973-74 for all game species. Total caribou kill was 2392 animals. The Beverly herd provided 65.4% of the kill while the Kaminuriak and "Melville" herds (animals northeast of Baker Lake) provided 9.6% and 25% respectively. Breakdowns by month and by individual hunters are provided.

Hawkins, R. and J.L. Howard. 1974. Barren-ground caribou calving ground survey, Kaminuriak population, 1974. N.W.T. Wildlife Service unpublished report. 41 pp.

This paper reports on the 1974 aerial survey of the Kaminuriak calving ground caribou population. The total population is estimated at 44,891 animals, with 4,714 yearlings, 25,588 breeding females, and 17,912 calves. The calving area was 2,352 square miles for a density of 12.7 caribou/square mile. The strip census method was used. Criticisms of the survey are that: 1) it was conducted too early, 2) more preliminary reconnaissance should have been flown, 3) the investigators should have taken a cow:calf

count and 4) calculation of the "blind spot" under the plane was arbitrary. It was suggested that the narrows at the east end of Baker Lake should continue to be monitored and that all blocks on the calving ground be numbered, as blocks with over 50% water cover should be excluded. Discrepancies between this and previous surveys (17,999 caribou in 1973) are probably due to 1) insufficient reconnaissance flights in previous surveys, 2) bad weather and lack of time available to conduct previous surveys and 3) a lack of knowledge of the herd's location prior to calving in 1974.

Heard, D. 1980. Results of the 1980 Kaminuriak caribou herd calving ground census. N.W.T. Wildlife Service unpublished report. 20 pp.

The author censused the Kaminuriak caribou herd between 31 May and 8 June 1980. The objective of the census was to test the hypothesis that the number of breeding females on the calving ground in 1980 had decreased to 11,500 animals, down from 14,800 in 1977. The estimate of the number of caribou one year of age or older on the calving ground was $20,551 \pm 1,256$ (S.E.) of which $12,961 \pm 4,610$ were breeding females. The size of the entire herd was estimated at $38,666 \pm 14,197$. The data support the hypothesis that the herd is declining and the assumptions upon which that prediction was based. Until the number of caribou killed by hunters is substantially reduced, the author predicts that the herd will continue to decline.

Heard, D. 1981. An estimate of the size and structure of the Kaminuriak caribou herd in 1977. N.W.T. Wildlife Service File Report Number 17. 37 pp.

The size of the calving ground segment of the Kaminuriak caribou herd was estimated at about 27,000 animals in June 1968. Most surveys since 1968 have not produced an accurate population estimate; however, subsequent surveys that were accurate indicated that the herd has declined since 1968. The author conducted a survey of the calving ground between 2 and 12 June 1977. The sample units in the survey were line transects. The calving ground was divided into three strata within which sampling effort varied according to density. Post-calving groups were segregated by observers on the ground between 15 and 17 June. Caribou were segregated in September, from the air in 1976 and 1977 and from the ground in 1977. The calving ground population was estimated at $16,503 \pm 1,936$ (S.E.) caribou over 1 year of age. The total population was estimated at 44,095 caribou excluding calves. Ninety percent of the non-calf animals on the calving ground were breeding females. The peak of calving was 7 June in the north half of the calving ground, and 14 June in the south half. Fall segregations indicated that calves (3 - month old caribou) made up 23% of the total population in September 1976, and at least 20% in

September 1977. Most of the problems affecting previous surveys were avoided in this study. The 1977 population estimate is the most precise obtained to date. This estimate supports the hypothesis that the Kaminuriak caribou herd has declined since 1968.

Heard, D.C. 1982a. Composition of the Beverly caribou herd in the fall of 1980. N.W.T. Wildlife Service File Report Number 26. 14 pp.

The objective of this work was to determine the sex ratio and calf to female ratio in the Beverly caribou herd in October 1980. Of the 1,580 caribou over one year old classified from the ground, 56.7% were female - slightly less than observed during the last classification count conducted in 1978. From the ratio of 51 calves per 100 females, the author estimated that 72% of the calves born in June 1980 were still alive during these counts. This calf to female ratio is identical to the mean value observed in other populations in other years but greater than observed in the Beverly herd in 1978. The number of caribou estimated on the 1980 calving ground was extrapolated to a total pre-calving herd estimate of 97,000 caribou.

Heard, D.C. 1982b. Hunting patterns and the distribution of the Beverly, Bathurst and Kaminuriak caribou herds based on tag returns. N.W.T. Wildlife Service Report. 46 pp.

Over 10,000 barren-ground caribou (Rangifer tarandus groenlandicus) in the Beverly, Bathurst and Kaminuriak caribou herds have been marked with ear tags, neck collars or both since 1959. The objective of the marking program was to learn more about herd movements and seasonal distribution, to document interchange of caribou among herds, and to collect information on the numbers, distribution, sex and age of caribou shot by hunters. Kaminuriak herd tags returned before 1966 and Beverly and Bathurst tags returned before July 1970 have been published. This paper analyzes the subsequent tagging and return data and compares the results with those already published. Since the 1966 and 1970 analyses, over 1300 caribou have been tagged and 180 tags (25% of all returns) have been recovered. The overall tag return rates are 7.2%, 5.0% and 6.4% for the Beverly, Bathurst and Kaminuriak herds respectively. The recent tag recoveries document the same hunting trends as interpreted from the earlier returns. More males were shot than expected (based on the number tagged) and more caribou were shot in winter than in summer. Tag return locations indicated that the ranges of all three herds were, with one exception, distinct and stable over time. Part of the winter range of the Kaminuriak and Beverly herds overlapped throughout the tag return period. There was no evidence to suggest that there was any major shift of caribou from one herd to another.

Heard, D.C. (in press) Hunting patterns and the distribution of the Beverly, Bathurst and Kaminuriak caribou herds based on tag returns. *Acta Zoologica Fennica*.

see Heard, D.C. 1982b.

Heard, D.C. and G.W. Calef. In prep. The decline of the Kaminuriak caribou herd 1968 to 1980. N.W.T. Wildlife Service Rep. 29 pp.

The Kaminuriak caribou herd declined from an estimated 120,000 animals in 1950 to 63,000 in 1968 and to 39,000 by 1980. The range used by the herd during this period also decreased and caribou density remained relatively constant. Despite the range reduction and a change in winter ranges, this herd has used essentially the same calving ground since 1966. There is no evidence for any major emigration from this herd. The authors suggest that since 1968 the herd declined because adult mortality, made up of an annual natural mortality of 8.5% plus a hunter kill of 3031 caribou per year, exceeded the average annual recruitment of 10%. A study of the Kaminuriak herd between 1966 and 1968 led to the conclusion that the herd should remain constant in size. The authors suggest that this study failed to predict the subsequent decline because natural mortality was underestimated. Reduction of human harvest and reduction of the wolf population are the only practical methods available to stop the decline of this herd.

Heard, D.C. and R. Decker. 1980. An estimate of the size and structure of the Beverly caribou herd, 1978-79. N.W.T. Wildlife Service unpublished report. 39 pp.

In June 1978, the authors estimated the number of caribou on the calving ground of the Beverly herd at $52,540 \pm 4,797$. Eighty-one percent of those caribou were females that had produced a calf. Calving ground classification counts indicated that 30% of the calves died within three weeks of birth. Most (17/28) appeared to have been killed by wolves but cold stormy weather during calving may have predisposed calves to an early death. During fall classification counts conducted in October 1978 females were estimated to comprise 59% of the adult population. Survival of the 1976, 1977 and 1978 calf cohorts from birth to one year was 0.18, 0.39 and 0.22, respectively. Average herd production for these years was 13%. The size of the entire Beverly caribou herd has declined significantly ($p < 0.01$) from 210,000 in 1971 to 130,000 in 1978.

Holleman, D.F., R.G. White, J.R. Luick and R.O. Stephenson. 1980. Energy flow through the lichen-caribou-wolf food chain during winter in northern Alaska. pp. 202-206. In: Reimers, E., E. Gaare and S. Skjenneberg (eds.), Proceedings of the 2nd International Reindeer/Caribou Symposium, Røros, Norway, 1979. Direktoratet for vilt og ferskvannsfisk, Trondheim. 799 pp.

The fallout radiocesium method was used to estimate energy flow through the lichen-caribou-wolf food chain during winter in northern Alaska. Lichen dry matter intake estimated for free-ranging caribou ranged from 3.0 to 7.0 kg/day for an 80 kg caribou. The mean lichen intake rate was 4.9 ± 0.8 kg/day which corresponded to a metabolizable energy intake of approximately 38 MJ/day. Estimates of caribou intake by wolves ranged from 2.2 to 3.1 kg/day of wet muscle for a 40 kg wolf. The mean intake was 2.8 ± 0.2 kg/day or a metabolizable energy intake of 20 MJ/day. The estimated metabolizable energy intakes were compared with expected energy requirements for free-ranging caribou and wolves. Nitrogen, phosphorus and calcium intakes were calculated.

Howard, J.L. 1961. Barren-ground caribou tagging at Duck Lake in August, 1961. Manitoba Game Branch Biologist Report. 9 pp.

This report includes a list of personnel, a general itinerary, number of caribou tagged per day, and tag numbers used. The calf percentage was estimated at 18-19%. The water crossing tagging technique was recommended due to its speed and efficiency. Aerial reconnaissance north of Manitoba would determine summer migration patterns. Appraisal of tagging by the Technical Committee for Caribou Conservation is also recommended.

Howard, J.L. 1962. Barren-ground caribou tagging at Duck Lake in August, 1962. Manitoba Game Branch Biologist Report. 9 pp.

Caribou arrived at Duck Lake (Kaminuriak herd range) on 16 August 1962. Two crews tagged successfully at the main crossing on Nejanilini Lake between 17 and 25 August. 479 caribou were marked with Hasco cattle ear tags and yellow Herculite #80 plastic ribbons, with a spray of blaze orange paint applied. One caribou tagged in 1961 was recaptured at the same site this year in good condition, but the yellow ribbon gone from her ear. The author's observations in the same area indicated very poor reproduction among the caribou.

Howard, J.L., H.J. Monaghan, W. Pepper and R.J. Robertson. 1974. Barren-ground caribou management steps, Beverly and Kaminuriak herds. N.W.T. Wildlife Service unpublished report. 4 pp.

This report outlines the steps necessary for meeting the minimum management requirements (Dauphine et al.) of the Beverly and Kaminuriak herds. These steps are; 1) calving ground surveys (to determine the number of adult females in both populations), 2) fall composition surveys (to determine sex ratio and summer calf survival), 3) late winter-spring composition surveys (to determine annual calf survival), 4) major population re-survey (total population estimate for both herds), 5) collection of harvest data (sex, age, and number of animals taken) and 6) marking projects (to test the feasibility of aerial spraying of caribou for movement studies). Total management costs are estimated to be \$49,850.

Jacobsen, R. 1975. Distribution of the Beverly barren-ground caribou herd in the 1974-75 ALUR study area. Canadian Wildlife Service unpublished report. 11 pp.

This preliminary report is a series of maps and descriptions of the general 1974-75 distribution of the Beverly and Bathurst herds in the ALUR study area. In March-April 1974, the Bathurst and Beverly herds intermingled north of the east arm of Great Slave Lake at the treeline. General movement was northeastward. In January 1975 large numbers of caribou were seen in the area around the east arm of Great Slave Lake. They are believed to be part of both Beverly and Bathurst herds and movement occurred in all directions.

Jakimchuk, R.D. 1979. An overview of five major herds of barren-ground caribou in Canada. In: A.W.F. Banfield and R.D. Jakimchuk (eds.) Analysis of the characteristics and behaviour of barren-ground caribou in Canada. Prepared for Polar Gas Project. 84 pp.

A review of the literature on five major caribou herds was carried out. The seasonal distribution, movements and population parameters are summarized and discussed. The most recent population estimates are: Bluenose, 92,000 in 1974; Bathurst, 150,000 in 1977; Beverly 124,000 in 1974; Kaminuriak 42,000 in 1976; Porcupine, 105,000 in 1977. The Bluenose herd is an increasing population and the Kaminuriak herd has declined markedly in the past decade. The Porcupine and Beverly herds are stable and the Bathurst herd was stable at last survey but is vulnerable to a decline. The five herds constitute about 80% of the current barren-ground caribou in Canada. Since 1975 the Kaminuriak herd has altered its traditional distribution and has wintered on the tundra near Baker Lake and Eskimo Point every year except the winter of 1977/78. The other herds maintain a seasonal pattern of wintering primarily in the taiga with major migrations to traditional calving grounds. Recent distributions east of the Mackenzie River show a general similarity with distributions first documented in the late 1940's and early 1950's. Available information on the biology and annual cycle of herds is variable.

The most intensively studied herds are the Kaminuriak and Porcupine herds, but all herds have been surveyed within the past five years. Available data suggest a relatively high productivity for the Porcupine, Bluenose and Bathurst herds and low recruitment for the Beverly and Kaminuriak herds in recent years. Human kill is currently highest for the Kaminuriak and Bathurst herds and lowest for the Beverly and Bluenose herds. Human kill of the Porcupine herd is moderate but near maximum levels to maintain stability.

Jakimchuk, R.D. 1980. Disturbance to barren-ground caribou: a review of the effects and implications of human developments and activities. In: A.W.F. Banfield and R.D. Jakimchuk (eds.) Analysis of the characteristics and behaviour of barren-ground caribou in Canada. Prepared for Polar Gas Project. 141 pp.

Cows with young calves are the groups most sensitive to human disturbance. Human activity, particularly vehicular motion, is avoided; the traditional behavioural response to wolf predation is thought to be a factor causing that reaction. Caribou show strong motivation to overcome obstacles during migration and are influenced by the leadership of older cows. Caribou respond to physical structures of berms, roadways and seismic lines by a paralleling movement before crossing. Population fluctuations appear to be independent of the presence of transportation facilities within their range. It is concluded that factors other than sensory disturbance, habitat alteration or obstruction of movements have affected the status of the caribou population.

Jingfors, K., A. Gunn and F.L. Miller. 1982. Behaviour and range use patterns of caribou on the Beverly calving ground N.W.T. N.W.T. Wildlife Service File Report Number 22. 118 pp.

The exploration for minerals on the tundra ranges of migratory barren-ground caribou (Rangifer tarandus groenlandicus) raised concerns about the potential effects of these activities on the well-being of caribou, especially cows and calves. As a result, the Department of Indian Affairs and Northern Development implemented the Caribou Protection Measures in 1978. These measures limited the activities of mining companies exploring for minerals just before and during the calving and post-calving periods of the Beverly and Kaminuriak herds (15 May - 31 July). As an initial step to evaluating the Caribou Protection Measures and to develop appropriate methodology for measuring some behavioural responses to man-induced disturbance, the authors field-tested a sampling design for recording undisturbed behaviour of cow-calf pairs on the Beverly calving ground in 1981. Activity budgets and the frequency of events that reflect the strength of the cow-calf bond and that may be influenced by or indicative of disturbance, such as nursing and aggressive acts were recorded

between 2-23 June. Patterns of range use in relation to snow melt and plant phenology were recorded. The authors emphasized rigorous definitions of behaviour categories and readily detectable classifications of range types under field conditions to reduce observer errors and to ensure repeatability. To be able to recognize behavioural responses to disturbance and to evaluate some of the short-term effects of human activities on cows and calves on the calving grounds, it is necessary to use the same study design during sampling periods involving exposure to foreign stimuli (helicopter landings and human activity on the ground).

Johnson, E.A. and J.S. Rowe. 1975. Fire in the subarctic winter ground of the Beverly caribou herd. *American Midland Naturalist* 94(1): 1-14.

This study documents the timing, prevalence and importance of fires in a 105,000 square kilometer area of the Northwest Territories, Canada, bounded by longitude 104° and 112° and latitude 60° to tree line. Lightning caused most of the fires and accounted for almost all of the area burned in a 7-year period. In this part of the subarctic, the fires appear to follow a seasonal pulse that progresses in June and July from the southwest toward tree line in the northeast, retreating in August. The normality of fire in this part of the northern boreal zone is beyond dispute. There is no conclusive proof that the fire regime has changed substantially in recent times from what it was previously. The implication is that endemic animals, such as caribou, are adjusted to recurring fires.

Kelsall, J.P. 1950a. Caribou conditions and caribou surveys. Letter to Dr. Lewis. Canadian Wildlife Service unpublished report. 3 pp.

This letter discusses a general overview of caribou conditions in the north during the winter of 1949-1950 and the early spring of 1950. The author considered the movements of caribou abnormal. Caribou were absent from Churchill, Duck Lake, Ennadai Lake, Snowbird Lake, Reliance, and Yellowknife where their appearance is considered normal. Also large numbers of caribou were seen in unusual places (Fort Smith area, Wood Buffalo Park and areas in Manitoba and Saskatchewan). The author concludes that it was a poor winter for obtaining distribution and movement data.

Kelsall, J.P. 1950b. Letter to Mr. Sloan, re: caribou. Canadian Wildlife Service unpublished report. 2 pp.

This communication deals with the author's appraisal of Banfield's proposed season changes for caribou hunting. Banfield recommended that the bull's only season be extended from 1 April to 15 May. He also suggested the elimination of the "skin taking" hunt and moving the general season opening to 15 August from 1 September.

The author feels that the result of increasing the spring hunt may be to legalize Eskimo caribou hunting which is already taking place. Eskimo harvest however, is probably not critical or wasteful as is the harvest by Indians below the treeline. The Indians do not need an increased season and the elimination of the "skin taking" season will increase the wastage of meat. Therefore, the author sees no need for changing the opening of the seasons. Since the author had not discussed the matter with Banfield he admits there may be good reasons for the changes of which he is unaware.

Kelsall, J.P. 1953a. Caribou calving. Canadian Wildlife Service unpublished report, C.W.S. -36-53, Edmonton. 30 pp.

Segregation of herds prior to calving and the accelerated movement of cows suggests that caribou have a traditional calving ground which they use each year. Calves are equipped with teeth to start eating solid food at the time of birth. Low calf percentages were attributed to bad weather: "It seems likely that the crucial conditions are high wind velocities, low air moisture content, temperatures low but not necessarily below freezing, and continuous or frequent precipitation." It is thought that insect infestation causes heavy calf mortality by fatigue and malnutrition.

Kelsall, J.P. 1953b. The aerial survey of barren-ground caribou. Canadian Wildlife Service unpublished report. 20 pp.

The author stated that extensive use of aircraft is necessary in caribou study because of enormous distances and difficult terrain to be covered. Most of the commonly used bush aircraft, and some military types, make satisfactory but not ideal, survey aircraft. Three methods may be used for censusing caribou from the air; an absolute range coverage with aerial photographs, an absolute visual count, and an aerial strip census. The first has not been used due to limitations of time and money; and the third has been used a great deal in caribou study. The aerial strip census technique contains so many variable factors that results cannot be proven statistically significant. Among the chief difficulties are the variable, non-random distribution of the caribou; the difficulty of accurately estimating the width of the survey strip; the accurate estimation of the size of the caribou range; the maintenance of a constant altitude; and the elimination of bias from the sample strips. Despite difficulties the aerial strip census is a useful method for enumerating caribou populations. Estimates derived from censuses are generally minimum estimates. Aerial surveys are the most satisfactory method for securing calf counts from which annual increment figures can be calculated and this work is expected to play an increasingly important part in caribou research and management. Aerial surveys provide the only logical method of keeping track of herd movements over a long

period and a large area. Aircraft are also used for the examination and assessment of caribou ranges at all seasons, for the location of caribou for a number of special purposes, and for transportation.

Kelsall, J.P. 1953c. Predation on barren-ground caribou. Canadian Wildlife Service unpublished report. 14 pp.

The author estimated a population of 8,000 wolves for the caribou ranges from observations during 43,624 miles of survey flying. He felt that the estimate by Clarke (1940) of 36,000 wolves in the same area was too high. A 5 per cent annual caribou loss to wolves totals between 33,000 and 50,000 caribou and would allow four to six caribou per wolf per year. Caribou carcasses and remains are very common throughout the caribou range but it is difficult to assign causes of death in most cases. Many caribou carcasses show signs of wolf utilization but this does not mean that the caribou were killed by wolves in all cases. Analysis shows that very few wolf scats do not contain at least caribou hair. This is due to the great amount of caribou debris throughout the caribou range, even when caribou are not present. Instances of promiscuous and apparently wasteful killing of caribou by wolves appear to occur occasionally. All instances seen during the study appeared to have been attempts to accumulate food in the vicinity of wolf dens. The author thought that the majority of wolf-killed caribou in winter are taken in forest where they are not seen from the air. He stated that wolf control on an extensive basis did not appear to be practical, or economically desirable, but felt that intensive and local wolf control during winter months on occupied caribou ranges would be worthwhile, at least on an experimental basis if continued for a few years.

Kelsall, J.P. 1955. Barren-ground caribou resurvey. Canadian Wildlife Service unpublished report.

Not available for review.

Kelsall, J.P. 1957a. Barren-ground caribou research program. Report Number 1. Canadian Wildlife Service unpublished report. 13 pp.

This report describes the preparations for, and the field operations of the Canadian Wildlife Service Beverly herd caribou research program in 1957. A general description of caribou movements, numbers and sex are given. The author estimates that calves comprise 8.1% of the total herd and that 2 year olds make up another 13.1%. Very few bulls were seen. Complete kill statistics were not gathered but the author feels that the winter hunt in Saskatchewan was too heavy. Data from the field camps was not included, but causes of calf mortality were mentioned as violent weather, the rigors of migration and wolf predation.

Kelsall, J.P. 1957b. Continued barren-ground caribou studies. Canadian Wildlife Service Wildlife Management Bulletin Series 1, Number 12. 148 pp.

This report summarizes data gathered on the Great Bear and Radium (Bluenose) and Rae and Yellowknife (Beverly) caribou herds from 1950 to 1953. The author described the annual movements, distribution and increment. Ground calf counts for the Rae (Beverly) herd were 8.8% in 1950-51, 6.7% in 1951-52 and 28.5% in 1952-53. The Rae and Yellowknife herds were estimated at 138,000, a decline from Banfield's (1954) estimate of 214,000. Human utilization was conservatively estimated at 8,105 caribou annually. Calving and post-calving movements, the behaviour of cows and calves, calf mortality factors, parasites, predation and other mortality factors are described. The author estimated 7,958 wolves on the caribou ranges. He describes the geology and topography of the winter range and summarizes a winter range study conducted in 1952 to assess the influence of forest fires.

Kelsall, J.P. 1957c. Caribou feeding habits on forested winter ranges. Canadian Wildlife Service unpublished report.

Not available for review.

Kelsall, J.P. 1958. Barren-ground caribou research program, cooperative investigation 1957-1958. Canadian Wildlife Service Report Number 3. 22 pp.

This paper reports on the continuing study of caribou herds west to the Mackenzie River and to Bathurst Inlet in the east. Movements and distribution are described. The author doubts that caribou maintain discrete herds. Weather conditions appear to have an important effect on caribou sexual activity. A 16.5% calf crop is reported. Reports of wolves, wolf kills, and accidental drownings are included.

Kelsall, J.P. 1960. Cooperative studies of barren-ground caribou, 1957-1958. Can. Dept. of Northern Affairs and Nat. Resources, Nat. Parks Branch, Canadian Wildlife Service Management Bulletin, Series 1, Number 15. 145 pp.

This survey was designed to evaluate caribou mortality based on the wintering herd in northern Saskatchewan (Beverly). The population was estimated at 100,000 caribou. The effects of climate and topography on caribou movement and distribution are discussed. Adverse weather conditions can cause heavy calf mortality. Predation is mentioned; wolves spend one third of their time hunting. Range, parasites, disease and accidents are discussed. The author believes that human utilization is the most important factor in the decimation of the herd and that the lack of control over native caribou hunting prevents the herd's recovery.

Kelsall, J.P. 1963. Barren ground caribou and their management. Canadian Audubon Magazine, November-December, 1963. reprint. 7 pp.

An article discussing the range distribution, migration patterns, and population of the barren ground caribou of mainland Canada. In 1949 an estimated 672,000 caribou were surveyed over an area of 36,000 square miles and human kill was reported at 100,000. As early as 1920 government and residents were concerned about the numbers of caribou being killed by natives and whites engaged in the fur trade. Studies in 1955 concluded that forest fires and wolf predation added to the declining population. Further discoveries such as unusual migration patterns, low calf crops, and human utilization exceeding annual calf crop led to another survey in 1955. The results were an estimated 278,900 animals over an area of 40,000 square miles. This caused increased interest in caribou management and research at all levels of government and public bodies. Legislation for the protection of caribou has improved, except for the Treaty Indian rights (which allow for unrestricted hunting) which are the greatest problem in reducing the loss of caribou.

Kelsall, J.P. 1964. The decline of the caribou. Oryx 7(5): 240-246.

Not available for review.

Kelsall, J.P. 1966. The barren-ground caribou tagging program in the Northwest Territories. Canadian Wildlife Service Report. 17 pp.

8,405 caribou from the Beverly, Bathurst and Kaminuriak herds have been tagged. 5,966 of them in the Northwest Territories. It is suspected that some Northwest Territories hunters are not returning tags. The author suggests an increased incentive to return tags. Animals should be accurately sexed when they are tagged, and there should be increased tagging in the west.

Kelsall, J.P. 1968. The migratory barren-ground caribou of Canada. Canadian Wildlife Service Monograph Number 3, Queen's Printer, Ottawa. 364 pp.

Definitive work on the mainland caribou herds of the north-central Canadian mainland. Includes the history, morphology, and biology of the barren-ground caribou. Considers aspects of caribou range and feeding biology, and details the annual movements of different herds. Decline of caribou and possible reasons for it are documented. Concludes that human predation is the major factor causing the caribou decline and suggests rectification measures.

Kelsall, J.P. 1970. Interactions between barren-ground caribou and muskrat. *Canadian Journal of Zoology* 48: 605.

Barren-ground caribou in the Beverly herd were observed to systematically explore, trample and eat the pushups constructed on ice in winter by muskrats for feeding. Muskrats may be inconvenienced or frozen out by this behaviour and the caribou may be attracted by the frozen but green vegetation of which pushups are constructed.

Kelsall, J.P. 1975. Warble fly distribution among some Canadian caribou. University of Alaska. Biology Papers, Special Report Number 1. pp. 509-517.

Observations suggest that warble fly larvae infestation on caribou can be judged from counts of breathing holes and scars on tanned hides. Using these criteria, assessment was made by sex of symmetrical, geographical and numerical distribution of warble larvae among nine Canadian caribou populations including the Beverly and Kaminuriak herds. Larvae tend to be equally distributed bilaterally and to be approximately twice as abundant on the posterior, as compared to anterior, half of the animals. Warble infestations and the number of warbles per animal tend to be greater on males within populations and to increase from north to south between populations. Morphology and behaviour of caribou may govern larvae distribution on individuals. Behaviour of herds and climate, particularly temperature, generally seems to account for differences in infestation observed between herds.

Kelsall, J.P. and J. Bisdee. 1979. The Porcupine caribou herd and its range. An annotated, cross-referenced bibliography. Canadian Wildlife Service unpublished report. 219 pp.

This annotated bibliography summarizes literature relevant to the Porcupine caribou herd and is cross indexed by author and topic.

Kelsall, J.P. and A.G. Loughrey. 1955. The barren-ground caribou resurvey. Canadian Wildlife Service unpublished report. 21 pp.

This is a report of an aerial survey designed to recensus barren-ground caribou populations, map caribou distribution and to count calves. The survey method was the same as Banfield's (1950) study. 44,048 miles were flown and 38,769 caribou were seen. Banfield flew 36,296 miles and saw 358,881 caribou. This indicated a substantial decline due, the authors believe, to human over-harvest, low calf crops, predation, and the loss of winter range through fire. The calf crop was estimated at 11% of the total population, which was calculated as 278,900 animals. The calf crop in the years 1948-53 averaged 17.4%. General notes on wolves and muskox were included.

Kelsall, J.P. and A.G. Loughrey. 1958. The barren-ground caribou, cooperative investigation 1957-1958. Report Number 2, C.W.S.-10-58, Edmonton, July 1-September 30. 50 pp.

This paper reports on the continuing study of the caribou herds between the Mackenzie River and Bathurst Inlet. The influence of winds and topography on caribou movements is described. Calving range, percentage of pregnant and non-pregnant females, cow/calf interrelationships and wolf predation is discussed. The utilization of caribou by humans in northern Saskatchewan and Alberta is reported in tabular form.

Kelsall, J.P., E.S. Telfer and T.R. Wright. 1977. The effects of fire on the ecology of the Boreal Forest, with particular reference to the Canadian north: a review and selected bibliography. Canadian Wildlife Service Occasional Paper Number 32. 58 pp.

This review analyzes literature relevant to effects of fire on the Boreal Forest, and on its related wildlife resources, with particular reference to the Canadian North. The selected bibliography contains the more recent and historically important references and is not all-inclusive. It was concluded that fire is the most important factor influencing the ecology of the northern Boreal Forest; that fire and the resulting forest mosaic are natural features of long standing; and that the Boreal Forest can be characterized as a fire dependent ecosystem. Trees, other plants, birds, mammals, and other animals of the forest have evolved in response and adaptation to the frequency, extent and intensity of fire. With some possible exceptions, a mosaic of varied successional stages in the Boreal Forest provides a richer habitat for a more varied and abundant fauna than does the monotypic spruce forest characteristic of unburned areas. Specific attention is given to fish, birds, and mammals, particularly to important species of game and furbearers, and to such characteristics of the northern forests as the presence of permafrost, the soils and the characteristics of unique vegetation. The basic characteristics of different types of fires are also described.

Klein, D.R. 1980. Reaction of caribou and reindeer to obstructions - a reassessment. pp. 519-527. In: E. Reimers, E. Gaare and S. Skjenneberg (eds.), Proceedings of the 2nd International Reindeer/Caribou Symposium, Røros, Norway, 1979. Direktoratet for vilt og ferskvannsfisk, Trondheim. 779 pp.

The past decade of accelerated oil and gas exploration and development in the North has focused attention on the effects of the construction of oil fields, roads, railroads, pipelines, and other developments on caribou and reindeer. Associated experience

with these projects and investigations provide the basis for specific conclusions. Roads, railroads, pipelines, powerlines, artificial or altered water courses or other man-made linear features can block, delay or deflect the movements of caribou and reindeer. The level and type of vehicular traffic and other human activities associated with these features, as well as the season of the year, however, are major factors influencing the reaction of caribou and reindeer. The sex and age of the animals and their group size also influence their reaction to obstructions and disturbances. Caribou and reindeer tend to habituate more readily to obstructions and disturbances if they are resident in the area where they occur rather than experiencing them only seasonally in relation to movement patterns. Variations in behavior exist between distinct races of Rangifer which may lead to differences in response to obstructions and disturbances. The consequences for caribou and reindeer of northern developments can be local overgrazing and trampling of winter range, range abandonment and disrupted migratory patterns, loss of access to calving grounds, insect relief areas or other range components, fracturing of large herds, discontinuance of interherd movement, increased energetic costs to the animals and associated physiological consequences, and overall reduction in herd productivity, population levels or potential herd productivity.

Klein D.R. 1982. Fire, lichen and caribou. *Journal of Range Management* 35(3): 390-395.

Continental populations of caribou (Rangifer tarandus groenlandicus) usually winter in the northern taiga. Fire is a natural feature of the ecology of the taiga but its effects on the winter range of caribou has been the subject of conflicting reports in the literature. Lichens which are an important component of the diet of caribou in winter, are associated with late successional stages in the post fire sequence; therefore their loss when old growth forests burn has been considered detrimental to caribou. On the other hand, several authors have suggested that lichens are not essential for caribou in winter and therefore their loss through forest fires does not seriously affect caribou. Recent nutritional investigations with reindeer and caribou have demonstrated the importance of lichens in their winter diet. Botanical studies have shown that fires are essential for long-term productivity of the boreal forests and they account for much of the habitat diversity that characterizes caribou winter range. Extremely old forest stands show reduced lichen productivity. The author concludes that, when viewed on a short-term basis of 50 years or less, fire may destroy lichens and other forage, thus reducing the taiga's potential to support caribou. Over long-time periods, often of a century or more, fire appears essential for maintaining ecological diversity and forage production for caribou.

Kuyt, E. 1972. Food habits of wolves on barren-ground caribou range. Canadian Wildlife Service Report, Series Number 21. 36 pp.

The food habits of tundra wolves were investigated mainly between 1960 and 1965, although some work continued until 1968. Studies were carried out in spring and summer in the Thelon Game Sanctuary, with supplementary winter work on caribou winter range north of Yellowknife and east of Fort Smith Northwest Territories. Northwest Territories tag recoveries showed that tundra wolves may migrate over 200 miles and that their movements are associated with those of the barren-ground caribou. During the winter, tundra wolves eat only caribou; during the spring and summer they vary their diet by eating small rodents, passerine birds, eggs and fish, particularly in areas temporarily devoid of caribou. Wolves prey on calves more than other age classes of caribou, but caribou of over 8 years are also heavily preyed on. Wolves kill at least four times as many female caribou as males. Caribou killed in winter are completely utilized by wolves; in summer, parts of carcasses are often left to scavengers. The initial point of attack is the neck, and the caribou is pulled down by the impact of the onrushing wolf. During maximum compression of wintering caribou populations, densities of one wolf per 6.9 square miles were reached. A captive wolf requires 3.23 pounds of bison meat and fat and 0.26 pounds of dog food daily. Mean growth curves illustrate the rapid early growth of cubs.

Land, E. and E. Bowden. 1971. Kaminuriak population of barren-ground caribou calving ground survey. N.W.T. Wildlife Service unpublished report. 15 pp.

This report summarizes a Kaminuriak caribou herd calving ground survey conducted from 3-8 June 1971. Seventeen 16 square mile blocks were censused and 13,957 caribou were counted, resulting in a total population estimate of 22,831. The authors felt that this estimate was unreliable as there was caribou movement between census blocks, the size of many groups of caribou had to be estimated, and the observed mixture of clumped and random distributions affected the validity of the statistical methods used to calculate the estimate. The authors estimated that between 80 and 85% of the females sighted had given birth and were attending calves. They supported the development of more objective survey methods.

Land, E. and R. Hawkins. 1973. Kaminuriak population of barren-ground caribou calving ground survey, May/June, 1973. N.W.T. Wildlife Service unpublished report. 24 pp.

An aerial survey was conducted on the calving ground of the Kaminuriak population of barren-ground caribou during late May and early June, 1973. The Kaminuriak caribou calved in June, largely between latitudes 63°15' and 63°50' and longitudes 93°45' and

95°00'. The peak of calving took place between June 1st and 7th. A stratified random block survey was employed. A transect survey was also conducted during the delineation of the calving ground. It is estimated that 11,900 adult cows and yearlings were present on the calving ground. This estimate is much lower than previous surveys. The following hypotheses should be tested: 1) that a social interaction between the Beverly and Kaminuriak populations (established through tagging) may vary to a significant degree from year to year, 2) that a portion of the Kaminuriak population calved in areas other than the traditional calving ground, and 3) that pressures of hunting and predation over the last two years has greatly reduced the total population.

Lawrie, A.H. 1948. Migration and distribution. Canadian Wildlife Service unpublished report. 29 pp.

This report summarizes the annual distribution and movements of the southern Keewatin (Kaminuriak) caribou herd.

Lawrie, A.H. 1950. Sociality and behaviour. Canadian Wildlife Service unpublished report. 24 pp.

A collection of observations on Kaminuriak caribou behaviour. The author concludes that though gregarious, caribou are not social. Herds are fortuitous aggregations of the basic social unit of the individual (or cow with calf) brought together by the interaction of movement with terrain and weather. No social behaviour such as leadership, defence or formation of harems was observed. Dominance encounters were observed only during the rut. The author felt that the caribou's gregarious but unstructured habits combined with its curiosity make them vulnerable to hunting.

Look, A.L. 1965. Report on Keewatin caribou herds, N.W.T. N.W.T. Wildlife Service unpublished report. 28 pp.

An estimated 271,677, 1+ Sackatchewan (Beverly) and Manitoba (Kaminuriak) caribou were counted by aerial survey from 15 April to 10 July 1965. The author stated that due to the reduction in range area from forest fires, the slow growth of lichens, and the trend of the Eskimos and Indians to no longer live off the land, there were more animals than the range could support. Recommendations given for management of the caribou are:

- 1) that adult bull caribou be included in animals taken on big game licences,
- 2) that people residing in isolated settlements be allowed to take three adult caribou on a special licence, and
- 3) that large freezers be built in each settlement so that natives can store meat for their use when the caribou are not in the area. Organized hunts should be supervised by a Game Officer and meat stored in the freezers for welfare purposes instead of buying canned meat. Periodic flights

should be made to locate the caribou herds so that the land-based Eskimos would not miss nearby caribou migrations.

Look, A.L. 1971. Caribou, Yellowknife and Snowdrift areas. N.W.T. Wildlife Service unpublished report. 1 pp.

This report summarizes observations on the distribution and movements of caribou east of the Great Slave Lake from August to December 1971. Caribou were into the treeline by the last part of August. Part of the (Beverly) herd stayed north of the east arm of Great Slave Lake. A large herd moved south past Artillery Lake to an area between there and the Slave River. They turned north and were south and east of Snowdrift by early January. The hunters reported seeing more wolves with caribou than they had for many years.

Loughrey, A.G. 1952. Caribou winter range study, 1951-1952. unpublished report, C.W.S.-52-52, Edmonton. 22 pp.

This study is a continuation of a 1951-1952 range study of the Rae, Radium, Great Bear Lake and Yellowknife herds. It includes a description of movements and winter range. Caribou feed extensively in spruce forest, and around margins of certain lakes. Fruticose lichens and sedges are the predominant plants taken. Some Equisetum species are poisonous to domestic stock, but do not affect caribou. Few wolves were seen during the aerial survey, but 18 were observed in 60 linear miles of ground survey. The discrepancy may be due to the tree cover. The estimated total population is 96,300 caribou. Average percent calves was 12.5.

Loughrey, A.G. 1955. Manitoba and Keewatin barren-ground caribou resurvey, 1955. Canadian Wildlife Service Report Number 52. 42 pp.

This report summarizes the results of aerial transect and photographic surveys conducted from 4 April to 8 June 1955. The author estimated the total Keewatin District, N.W.T. and Manitoba (Kaminuriak) caribou population to be 168,610. Calves composed 12.8 percent of 999 caribou classified on 24 March 1954, and 13.4 percent of 194 caribou classified from 10-12 April 1955. Total native kill from August 1954 to July 1955 for Indians (9,452) and Eskimos (14,250) was estimated at 23,702. A calculated wolf population in the Keewatin District was 1,145. The annual increment exceeded human utilization by 1 percent. The total annual decrement exceeded the annual increment by 9 percent of the total population. If wolf predation was eliminated the decrement would continue to exceed the increment by 4 percent. The author suggested that herd management principles be applied to populations that are discreet and occupy a discontinuous range.

When two or more herds occupy the same range he proposed that management be practised on a regional basis. The major factors responsible for the Kaminuriak herd's decline are in descending order of importance: human utilization, predation, accidents, disease and old age. The combined effects of these factors may vary from year to year, however, the annual effect has been a loss greater than the annual calf crop. The author recommended that immediate steps be taken to prevent a major decline:

- 1) a program of regional management should be initiated,
- 2) human utilization must be reduced,
- 3) a program of caribou conservation education among native hunters should be undertaken,
- 4) a predator control program should be initiated in southern Keewatin,
- 5) a study of caribou winter ranges should be commenced, and
- 6) a committee of the personnel actively engaged in caribou field investigations and management should be formed.

Loughrey, A.G. 1956. Caribou investigations in Keewatin and Manitoba, August 15 - October 15, 1956. Canadian Wildlife Service unpublished report Number 53. 36 pp.

The Churchill, Duck Lake, and Brochet (Kaminuriak) caribou herds were followed from their summer range to the rutting season. Churchill was the only area that was surveyed by air, giving an estimated 35,200 animals. Annual increment based on data from ground, aerial and photograph counts showed the average calf crop to be 7.2 per cent of 6,776 caribou classified. Physical condition and behaviour of sexes prior to the rut were observed and caribou group behaviour and wolf predation were recorded. Estimated loss from human utilization exceeded annual increment by 10.6 per cent. Requirements for caribou management are estimates of: 1) herd or regional population status, 2) annual increment for each herd and 3) annual decrement for each herd.

Loughrey, A.G. 1957. Caribou investigations in Keewatin and Manitoba, May 7-30, 1957. Canadian Wildlife Service unpublished report Number 295. 10 pp.

This report summarizes caribou investigations conducted from 7-30 May 1957. The spring migration routes and wintering areas of the Churchill and Duck Lake (both Kaminuriak) herds were determined. Calf percentages were estimated at 5.4 percent of 2,316 animals classified and 3.6 percent of 1,369 animals for the Churchill and Duck Lake herds, respectively. Overwinter calf mortality was estimated at 28 percent and 57.6 percent of the Churchill and Duck Lake herds, respectively. One wolf was observed for every 312 miles flown.

Luick, J.R., P.C. Lent, D.R. Klein and R.G. White (eds.),
 Proceedings of the First International Reindeer and
 Caribou Symposium. 9-11 August, 1972. Biological
 Papers of the University of Alaska. Special Report No.
 1. 551 pp.

A collection of papers on aspects of reindeer and caribou biology.
 Papers specific to the Kaminuriak and Beverly herds are referenced
 in this bibliography by author.

MacPherson, A.H. n.d. An estimate of the number of animals
 required by a Caribou Eskimo family in the course of a
 year. Memorandum to Dr. Stevens. Canadian Wildlife
 Service unpublished report. 1 pp.

This communication estimates the number of caribou taken annually
 by a Caribou Eskimo family (6 people, 5 dogs) at 100-150 animals.
 The figures were obtained from a conversation with a single eskimo
 near Baker Lake. The kill from November to March is between 10
 and 20 caribou. The animals are used mainly for skins during this
 period. Caribou are not usually taken in April and May because of
 the poor condition of the flesh and hides. About 50 caribou are
 killed in June as it is the prime time for drying meat. The kill
 is only 8 in July and August because of rain and blowflies. In
 September and October about 65 caribou are harvested because of
 the good condition of the hides and meat. Caribou is the staple
 dog food. Wasteful hunters would take more animals than outlined
 above.

MacPherson, A.H. 1967. Progress report No. 1: Manitoba-Keewatin
 barren-ground caribou study, March 1, 1966 to February
 28, 1969. Twelfth meeting of the technical committee
 for caribou preservation. Canadian Wildlife Service
 unpublished report. 8 pp.

This report gives an account of field and laboratory activities in
 1966-67 and summarizes preliminary findings on the following
 subjects: 1) reproduction (87% of adult females were pregnant or
 bore young), 2) nutritive condition (fat stores are lowest in late
 winter especially in young animals and pregnant females), 3) sex,
 age and weight (breeding female to calf ratio is 1:0.25), 4) herd
 movements (herd leaves Manitoba May 30, reaches Kaminuriak Lake
 June 7, heads north again June 18 and on November 1, re-enters
 Manitoba), 5) tagging and tag returns (11 caribou were tagged at
 Duck Lake, Manitoba) 6) numbers and plans for photographic counts
 (post-calving herd estimated at 50,000 animals), 7) kill estimates
 (2,700 caribou taken in N.W.T. and the total harvest of the
 Manitoba-Keewatin herd is 4,000 animals) and 8) winter range
 investigations.

MacPherson, A.H. and G.R. Parker. 1970. Managing barren-ground caribou populations in the N.W.T., Manitoba, Saskatchewan, and Alberta. Canadian Wildlife Service unpublished report. 23 pp.

This paper describes the 4 major herds (Beverly, Bathurst, Bluenose and Kaminuriak) and outlines their successive inventories, population constraints and management. The census data to date indicates static or increasing recent population levels in the Beverly, Bathurst and Bluenose herds while the Kaminuriak herd has declined. Population constraints include a low reproductive rate, fire on the winter range, wolf predation and the human kill. The total annual mainland caribou harvest (averaged from 1964-68) is estimated at 17,780 animals. The authors conclude that: 1) caribou management has had a low rate of success, 2) the Kaminuriak herd is being over harvested while the other 3 populations are harvested below the maximum allowable harvest rate of 5% of the population, 3) another 2400 animals could be harvested from the 4 herds on the average if the object was to remove a number equal to the annual increment, 4) since increments are so variable close monitoring of the resource is essential, 5) wolf control is unsatisfactory except in emergencies, 6) the collection of harvest data needs to be improved, 7) the number of subsistence hunters should be investigated and 8) the above conclusions extrapolated to the other herds are based on Kaminuriak herd population parameters.

Malfair, J.R. 1963. Caribou survey-eastern Keewatin. June 4 to 17, 1963. Typescript report to the Department of Northern Affairs and National Resources, Arctic Division, Ottawa, 3 pp.

This report summarizes a Kaminuriak herd calving ground survey conducted from 4-17 June 1963. The author delineated the pre-calving and calving distributions. He estimated 30,000 caribou on the calving ground but felt that his estimate was subject to a large margin of error. Calving began on 8 June and peaked on 11 June, terminating shortly thereafter. Approximately 85% of cows were productive. Calving ground mortality was negligible. The calving grounds were inhabited almost exclusively by cows with the exception of 34 yearlings observed during the ground survey.

McEwan, E.H. 1959. Barren-ground caribou studies, September, 1958 to June 1959. unpublished report C.W.S.-3-59, Edmonton. 42 pp.

The purpose of this study was to collect data on reproduction, mortality, herd composition and annual increment for the mainland caribou herds. The aerial transect method was used. The total observed number of animals was approximately 22,000 over an area of 4,800 square miles. The ratio of calves to cows was 85:100 on

the calving grounds. The greatest percentage of mortality occurred from mid-June to the end of July amounting to 29.4%. 344 wolves were poisoned from mid-December 1958 to late April 1959, and as a result caribou loss attributable to predation was reduced by half. Human utilization was about 9,500 animals and total decrement losses amounted to about 16,900. The population was estimated at 200,000 animals including the study herd (Beverly) numbering about 84,000.

McEwan, E.H. 1960a. Barren-ground caribou studies, July 1959 to August 1960. unpublished report C.W.S.-8-60. 65 pp.

This project was to initiate tagging programs and to determine the fertility rate, calving success, calf survival and annual increment/decrement for barren-ground caribou. Population size, composition, distribution and movements were also determined. There were 225,000 to 235,000 caribou in major wintering concentrations of mainland herds. The study herd (Beverly) was composed of 38.5% adult cows and 14.5% adult bulls. Annual increment was 24,000 to 26,000 yearlings. Calf production was 30,000 to 35,000 calves. A description of the tagging program is included. The author recommends that calf production and population composition data should continue to be collected and that wasteful hunting practices be discouraged. The importance of the tagging projects should be widely publicized in order to ensure a high rate of tag recoveries and resightings.

McEwan, E.H. 1960b. Preliminary studies on the reproductive biology of the barren-ground caribou. Canadian Wildlife Service unpublished report number 862. 21 pp.

This report summarizes studies conducted from 1957 to 1958 on the reproductive physiology of the Beverly caribou herd. Males and females reached sexual maturity at 17 months and 16-17 months respectively. Age at first reproduction was 4-6 years and 2 1/2 years for males and females respectively. The author suggested that inclement weather during the rut could result in low productivity. He recommended further studies on range conditions and hormonal changes associated with the reproductive cycle. Tables summarize measurements of male reproductive organs by age and season, and observed calf to cow ratios during June 1959.

McEwan, E.H. 1963. Reproduction of barren ground caribou Rangifer tarandus groenlandicus (L.) with relation to migration. Ph.D. thesis. McGill University, Montreal, Quebec. 99 pp.

In a study of the seasonal reproduction and movements of the barren ground caribou Rangifer tarandus groenlandicus (Linnaeus), it has been shown that cemental annuli, formed in the incisor teeth, are reliable indicators of age. The males are sexually

mature at 17 to 18 months of age; the first conception in the majority of females occurs during the third and fourth breeding season after birth. Mature bulls are in breeding condition from mid-September until early December. The rutting period extends from mid-October to the first week in November, mainly from October 20 to 25. The blastocyst implants about 27 to 29 days after mating. The corpus luteum attains its maximum size and vascularity at the time of implantation; retrogressive changes commence about 2 months prepartum. Following parturition, the corpus luteum regresses rapidly in size, forming a pigmented scar. Although two ovulations may occur, only one embryo implants and develops; this is considered to be an adaptation related to the social and nomadic habits of the species which favour the selection of highly precocious young at birth. The gestation period is approximately 227 days, and calves are born from June 1 to 20. About 80% of the parturitions occur in a 4-day interval. Inclement weather conditions during the peak of calving results in heavy postnatal mortality. The movements of caribou are nomadic and migratory, and are related to their feeding and reproductive requirements.

McEwan, E.H. 1968. Growth and development of the barren-ground caribou. II post natal growth rates. Canadian Journal of Zoology 46:1023-1029.

The growth curves of minimum body weights of fast-growing caribou reared in captivity and slow-growing wild caribou are compared. Captive animals exhibit a cyclical pattern of growth characteristic of other cervid species. The differences in the declining growth constants of wild caribou compared to captive caribou are attributable to environmental factors and activity, resulting in higher maintenance costs.

McEwan, E.H. 1971. Twinning in caribou. Journal of Mammalogy 52(2):479.

A penned female caribou (Rangifer tarandus), which was bred on 26 October 1967, gave birth to twin female calves on 24 May 1970. One calf weighed 2.5 kilograms and either was born dead or died soon after birth; the other calf, weighing 3.0 kilograms, lived for 12 hours. It was too weak to suckle successfully and resisted attempts to be fed by bottle. Both calves were premature in terms of weight in that the normal birth weight of single calves is about 5 kilograms. This is the first time twins have been reported for this species. Kelsall (The migratory barren-ground caribou of Canada, 190 pp. 1968) reported that female caribou usually produced only one young per pregnancy. Although more than one ovum may be shed, no evidence of advanced development of a second embryo ever has been found previously.

McEwan, E.H. and P.E. Whitehead. 1970. Seasonal changes in the energy and nitrogen intake in reindeer and caribou. Canadian Journal of Zoology 48: 905-913.

Caloric intake of captive reindeer and captive Beverly herd caribou was 35-45% lower in winter than in the summer growth period. The relation between heat production and body weight also exhibited a cyclical pattern. Heat production per unit of metabolic weight decreased by 25% (mid-August to mid-November). From calorimetry studies the relative proportion of protein and fat deposition from weaning to 12 months of age were estimated. The amount of digestible nitrogen required was comparable to that reported for cattle and sheep.

McEwan, E.H. and P.E. Whitehead. 1972. Reproduction in female reindeer and caribou. Canadian Journal of Zoology 50(1):43-46.

Reindeer and caribou are polyestrous and undergo estrous cycles of two lengths, a short cycle of 10 to 12 days and a long cycle of 24 days. The duration of pregnancy in free-roaming animals was found to be considerably longer than in animals reared in captivity, which may be due to prenatal under-nourishment. The estimated digestible energy consumed during the late pregnancy of penned animals amounted to about 6,000 kcal/day.

McEwan, E.H. and A.J. Wood. 1966. Growth and development of the barren-ground caribou. I Heart girth, hind foot length and body weight relationships. Canadian Journal of Zoology 44:401-411.

The changes in body weight and body proportions associated with growth in well-nourished captive barren-ground caribou (Rangifer tarandus groenlandicus) are described. Corresponding changes in free ranging wild caribou from the same population are compared with those obtained from the captive specimens. Body weight, hind foot length and body weight:heart girth ratios are examined as possible parameters for expressing the extent of developmental restriction imposed on the wild caribou by their nutritional environment.

Miller, D.R. 1970. Biology of the Kaminuriak population of barren-ground caribou. Canadian Wildlife Service Preliminary Report, Series Number 4. 97 pp.

The winter range of the barren-ground caribou in northwestern Manitoba was studied to learn the amount of potential forage available, and how weather, in particular snow conditions, affected the foraging of caribou. Potential forage was determined from measuring standing crop and per cent of green plants and lichens in study plots. Caribou were watched feeding, and plants

were collected from feeding craters and enclosures. Further evidence and confirmation of observed feeding habits were collected by an analysis of rumen content. Climatic measurements, especially of snow depth and crust hardness, explained sudden changes observed in caribou diet. The diet changed from predominantly terrestrial lichens and grass-like plants in early winter to arboreal lichens and woody browse in late winter when the snow crust prevented caribou from digging craters. As the snow thawed the caribou fed heavily on exposed plants and lichens, especially along the spring migration routes. Otherwise there was no evidence that the caribou were exerting pressure on their winter range forage. Aerial photographs, evidence of rates of lichen recovery and knowledge of feeding habits allowed some general conclusions to be drawn about the capability of the winter range to support caribou. In particular it is suggested that forest fires are beneficial in that they increase the heterogeneity of the plant cover, and favour the growth of some lichens which occur in early successional stages. The evidence suggests that there is a plentiful supply of forage in the area despite caribou use and fires. It is the snow cover rather than scarcity of forage that limits the capacity of the taiga to support caribou.

Miller, D.R. 1974. Seasonal changes in the feeding behaviour of barren-ground caribou on the taiga winter range. pp. 744-755. In: V. Geist and F. Walther (eds.), The behaviour of ungulates and its relation to management. International Union for Conservation of Nature and Natural Resources. New Series 24. Morges, Switzerland. 940 pp.

Barren-ground caribou populations in Canada remained stable during the past decade following a marked decline. The Kaminuriak caribou population was chosen for a study of whether the capacity of the taiga winter range limits caribou populations and of what effect wildfires have on this capacity. Caribou feeding patterns on the taiga were adapted to forage availability which changed with depth and hardness of snow. As forage availability changed during early, mid- and late winter and spring periods, caribou responded by moving to more suitable pastures. Caribou concentrate on sedge and horsetail forage in early winter, terrestrial forage in protected tree cover during mid-winter, arboreal in the presence of a sun crust in late winter; and terrestrial on bare hillsides and exposed flats in spring. Forage near treeless areas where caribou could escape wolves was favoured in mid- and late winter. The diversity of cover types is partly maintained on the taiga range by wildfires. A complete snow cover protects forage supplies at any one site against heavy use. In spring, however, forage supplies were depleted by caribou on sites from which the snow first disappeared. Correlation of daily and seasonal caribou feeding patterns with measurements of snow depth and hardness, and use and availability of forage illustrated the pertinence of behaviour observations in the assessment of range capacity.

Miller, D.R. 1975. Observations of wolf predation on barren-ground caribou in winter. pp. 209-220. In: J.R. Luick, P.C. Lent, D.R. Klein and R.G. White (eds.), Proceedings of the First International Reindeer and Caribou Symposium. University of Alaska, Fairbanks, Alaska. 551 pp.

An aerial survey in January 1968 produced an estimate of 258 wolves among 51,000 caribou that wintered in the Hara-Charcoal Lakes region of northeastern Saskatchewan (Beverly and Kaminuriak winter range). Ground studies of caribou were conducted at Hara Lake February 17 to 27 and again April 19 to May 7. cursory observations during February included 15 sightings of wolves and 13 of wolf-killed caribou. Systematic coverage of the 20-square-mile surface of Hara Lake during April-May provided observations of 211 wolves and 147 wolf-killed caribou. Two men with dog teams covered half the lake area daily marking the locations of kills and collecting the skull, mandible and femur or tibia. Physical condition of caribou prey was determined from the lipid content of bone marrow. Condition, sex and age comparisons of the wolf-killed caribou were compared with those of a sample shot non-selectively. Wolves killed an average of three caribou daily at Hara Lake during April-May observations and, on the basis of old kills, two daily during March and early April. Fawns were selected prey and there was a suggestion that caribou eight years and older were also selected prey. Fawns in relatively poor physical condition appeared more vulnerable to wolf attacks than healthy fawns. Observed wolf attacks demonstrated that caribou which failed to synchronize movements with other band members were vulnerable and that caribou used their antlers for defence when brought to bay. Wolves migrated north over Hara Lake in late April, coincident with the caribou migration.

Miller, D.R. 1976a. Biology of the Kaminuriak population of barren-ground caribou. Part 3: Taiga winter range relationships and diet. Canadian Wildlife Service Report, Series Number 36. 41 pp.

Lichens form approximately 50% of winter diet for caribou. That apparent preference is related more to availability than to selection. Snow cover was found to be the main factor altering diet. Estimated lichens on Kaminuriak range could support 360,000 caribou (5 x actual population). Vegetation damage was done by trampling, counteracted by snow cover and herd movements. The author concluded that range was probably not limiting for the Kaminuriak herd at present and fires act to increase heterogeneity of forest and plant cover, improving range for caribou.

Miller, D.R. 1976b. Wildfire and caribou on the taiga ecosystem of northcentral Canada. PhD thesis, University of Idaho. 131 pp.

Caribou numbers declined in northcentral Canada during the mid-twentieth century and effects of wildfire on the taiga winter range were considered as a potential factor causing the decline. No supporting evidence was found for this hypothesis either during a study of the taiga winter range of the Kaminuriak barren-ground caribou population in northwestern Manitoba and northeastern Saskatchewan, or of the Beverly population in northcentral Saskatchewan and southern Mackenzie District, Northwest Territories. Comparison of caribou use on the two taiga ranges showed similar preferences for feeding sites and forage despite differences in wildfire rates. Landforms were generally used according to occurrence and forage use was closely associated with availability. Cladina species of lichens predominated in the diet of caribou on both taiga ranges and were the most abundant forage available. Stereocaulon, Peltigera, and to a lesser extent Cetraria species were selected lichen forage. Cladonia species were common constituents in caribou rumens and common in terricolous lichen communities. Caribou showed no preference for feeding in stands greater than 90 years old versus stands 40 to 90 years old. Standing crops of terricolous lichens in moderate-aged stands were not significantly different from older-aged stands. Large lichen standing crops were dominated by seral Stereocaulon species and were generally in stands less than 110 years old. Caribou seemingly did not select climax lichen species Cladina alpestris and C. rangiferina over seral lichen species. Wildfires burned three times more taiga range annually in northcentral Saskatchewan than in northwestern Manitoba. One large fire on the Athabasca Plain accounted for most of the differential burn rate between the two taiga ranges. Reburn of seral stands, especially in the Athabasca Plain area, further inflated the annual burn rate. Forest stands in northcentral Saskatchewan over 70 years old burn annually at a rate approaching a 200-year rotation. Wintering caribou use a range differently after it has burned. They use recent burns as travel routes during migration and for local movement when snow conditions are favorable. Unburned islands within the burn area are used as feeding sites. Forest stands adjacent to recent burns become more accessible for feeding. Deflection of major caribou movements by large recent burns appears unlikely. Without wildfire the taiga ecosystem would be less suitable for supporting wintering barren-ground caribou in northcentral Canada. Periodic wildfire helps maintain vegetative heterogeneity and lichen productivity. Caribou distribution, movements and forage use in the taiga depend on existing snow characteristics which are influenced by wildfire history and its perpetual effect on the vegetative complex.

Miller, D.R. 1980. Wildfire effects on barren-ground caribou wintering on the taiga of northcentral Canada: a reassessment. pp. 84-98. In: E. Reimers, E. Gaare and S. Skjenneberg (eds.), Proceedings of the 2nd International Reindeer/Caribou Symposium, Røros, Norway, 1979. Direktoratet for vilt og ferskvannsfisk, Trondheim.

Range relationships of barren-ground caribou wintering on the taiga of northcentral Canada were studied from 1966 to 1974. Wildfire aspects were emphasized after 1970. Coloured aerial photographs were used to quantify differences in landforms and wildfire history. Field studies were conducted in northcentral Saskatchewan ranges of the Beverly population and northwestern Manitoba ranges of the Kaminuriak population. Wildfires annually burned 0.7% of the land surface in Saskatchewan and 0.2% in Manitoba. Caribou wintering on both taiga ranges showed no preferences for feeding in stands older than 90 years postfire compared with stands 40 to 90 years old nor for climax lichen species over subclimax species. In both winter ranges standing crops of terricolous lichens in stands over 40 years postfire did not correlate with age either at sites caribou selected for feeding, sites selected for vegetative studies or sites fenced against caribou use. Burned areas served a different role to wintering caribou than unburned areas. Periodic wildfires help maintain vegetative heterogeneity and terricolous lichen productivity which affects caribou distribution, movements and forage availability.

Miller, D.R. and J.D. Robertson. 1967. Results of tagging at Little Duck Lake, Manitoba. *Journal of Wildlife Management* 31:150-159.

Herculite streamers attached to cattle eartags were used to tag 2,438 barren ground caribou (Rangifer tarandus) at Little Duck Lake, Manitoba (Kaminuriak herd range) from 1959 to 1965. Eighty-two tags were recovered, 8 tagged caribou were observed, and 3 were recaptured at Duck Lake. Tags were recovered from 2-63 months after application and between 62 and 328 miles from the tagging site. Fifty-six winter tag recoveries were spread over the herd's entire range while the 26 summer recoveries were exclusively from the Keewatin District of the Northwest Territories. Tag recoveries have shown that the Manitoba-Keewatin caribou herd shares a portion of its winter range with the adjacent Saskatchewan herd but the two herds appear to use separate calving grounds and summer ranges. Herd movements have been variable and involve widely separated subgroups. Since a large portion of the herd's range receives little or no hunting pressure, the herd's seasonal distribution and specific movement patterns could not be determined from the tag recoveries.

Miller, F.L. 1962. Preliminary findings based on sex, age and weight data obtained from 310 barren-ground caribou. Canadian Wildlife Service unpublished report. 11 pp.

This paper is a collection of tabular and graphical data obtained from 310 barren-ground caribou. Parameters measured were: 1) weight by sex and age groups, 2) herd composition, 3) breeding female to calf ratio, 4) male to female ratios by age group, 5) winter weight loss by sex and age groups, 6) antlered animal to

antlerless animal ratio by sex and age groups, 7) fecundity, and 8) fetus weights. A review of histological aging techniques using caribou teeth is included.

Miller, F.L. 1972a. Distribution and movements of barren-ground caribou from the Kaminuriak population during calving and post-calving periods, 1970. Canadian Wildlife Service unpublished report number 1412.

Miller reported that the 1970 calving grounds were basically the same as from 1966 to 1969. Post-calving aggregations formed and started moving north in mid-June. Three groups of caribou moved from the calving grounds. One moved to within 10 km upstream of Kazan Falls but did not cross the river. This group paralleled the river towards Thirty Mile Lake and then moved south. The second group moved to Bissett and Martell Lakes and came within 10 km of Kazan River. None were reported to have crossed the river. The third group moved south along Kaminuriak Lake. Miller recorded caribou refusing to cross between North and South Henik Lakes, possibly as a result of noise and activity at Arctic Lodge. Also Inuit reported caribou moving north across Bowell and Christopher Islands but this move was not substantiated. Miller hypothesized that post-calving aggregations are important for reuniting groups of females, young, and bands of bulls and also for recruiting yearlings and two-year olds into these groups.

Miller, F.L. 1972b. Eruption and attrition of mandibular teeth in barren-ground caribou. Journal of Wildlife Management 36(2): 606-612.

The mandibular tooth rows of 356 Kaminuriak barren-ground caribou (Rangifer tarandus groenlandicus) were examined to determine at what ages their incisiform and molariform teeth erupt. The approximate ages of eruption were: i1, 9 to 13 months; i2, 11 to 15 months; i3, 11-15 months; c1, 11 to 16 months; p2, 21 to 28 months; p3, 21 to 28 months; p4, 21 to 28 months; m1, 3-5 months; m2, 10 to 15 months; and m3, 15 to 28 months. All permanent mandibular teeth were erupted by 29 months of age. The degree of attrition was recorded from the various age-classes that were examined.

Miller, F.L. 1974a. The biology of the Kaminuriak population of barren-ground caribou. Part 2: Dentition as an indication of age and sex; composition and socialization of the population. Canadian Wildlife Service Report, Series Number 31. 87 pp.

999 caribou were collected from the Kaminuriak and Beverly herds for obtaining age composition data. Ages were estimated from tooth eruption and placement, dental measurements and microscopic examination of the annuli in the cementum of mandibular teeth.

Male and female birth and mortality rates are equal until the prime of life (4-6 years) when male mortality increases.

Miller, F.L. 1974b. Age determination of caribou by annulations in dental cementum. *Journal of Wildlife Management* 38(1):47-53.

Cementum was deposited on the unerupted first incisor by the fifth month of life, and the first annulus was present by the tenth month. Mandibular teeth were decalcified, sectioned and stained. Cemental annuli in sagittal tooth sections were easier to read than cross sections. Ages were assigned to 902 caribou in this manner.

Miller, F.L., F.W. Anderka, C. Vithayasae, and R.L. McClure. 1975. Distribution, movements and socialization of barren-ground caribou radio-tracked on their calving and post-calving areas. pp. 423-435 In: Luick, J.R., P.C. Lent, D.R. Klein and R.G. White (eds.), *Proceedings of the First International Reindeer and Caribou Symposium*. University of Alaska, Fairbanks, Alaska. Biol. Papers of the Univ. of Alaska, Special Report Number 1, Fairbanks.

see Anderka et al. 1973.

Miller, F.L., D.R. Behrand and G.D. Tessier. 1971. Live capture of barren-ground caribou with tangle nets. *Transactions of the Northeast Section of the Wildlife Society* 28: 83-90.

Barren-ground caribou (Rangifer tarandus groenlandicus) were live-captured in tangle nets in northern Manitoba in April 1970. Groups of animals were located on frozen lakes by aerial reconnaissance. Nets were set on their back trails in adjacent forest. The caribou were then herded into the nets by taxiing aircraft. Eighty caribou were captured in seven days, totalling 190 man-hours of effort. Success per caribou captured or unit of effort was most closely related to the nature of the netting sites. Only 1.8 man-hours per animal captured were required at the best sites. Netting success was also closely related to the configuration of the set, obovate and oblanceolate designs proving most effective. A total cost estimate per caribou captured was \$60. Tangle netting may also provide the means for live-capture of other cervids under certain conditions.

Miller, F.L. and E. Broughton. 1971a. Polydactylism in a barren-ground caribou from northwestern Manitoba. *Journal of Wildlife Diseases* 7: 307-309.

A polydactylous right front foot was collected from a 5-year old female barren-ground caribou (Rangifer tarandus groenlandicus) in northwestern Manitoba (59°21'N, 110°13'W, Kaminuriak herd range). The authors determined by gross visual and radiographic examination that the foot had a complete extra digit in the position of the ancestral 1st digit. This is the first account of a polydactylous foot in the genus Rangifer.

Miller, F.L. and E. Broughton. 1971b. Investigation of observed anomalies in barren-ground caribou, Eskimo Point, Rankin Inlet areas, N.W.T. Canadian Wildlife Service unpublished report. 3 pp.

Brief report relating the findings of pathological investigations of five apparently lame caribou. Gun shot wounds, foot rot, and joint misalignment are reported. A greater number of animals are required to determine the cause of a high incidence of sick caribou reported by Eskimos on the west coast of Hudson Bay.

Miller, F.L. and E. Broughton. 1973. Behaviour associated with mortality and stress in maternal - filial pairs of barren-ground caribou. Canadian Field-Naturalist 87(1): 21-25.

During June and July 1970 observations on the maternal-filial bond in barren-ground caribou (Rangifer tarandus groenlandicus) from the Kaminuriak population were made on the calving ground and summer range in the central Keewatin District, Northwest Territories. Information on the persistence of maternal or filial attraction was obtained from five live cows with live calves, four live cows with dead calves, one dead cow and a live calf, and two dead cows with dead calves. The barren-ground caribou's practice of synchronized calving, followed within days by rapid movement from the calving ground in large postcalving aggregations, demands a strong maternal-filial bond. A strong bond minimizes the possibility of permanent separation in large postcalving groups at a time when the calf needs frequent nourishment and the care of its dam.

Miller, F.L. and E. Broughton. 1974. Calf mortality on the calving ground of Kaminuriak caribou, during 1970. Canadian Wildlife Service Report, Series Number 26. 26 pp.

This paper deals with calf mortality in the Kaminuriak herd. The principle factor which limits population growth is high calf loss during the first month of life. Helicopters were used to locate dead calves. Post mortems were performed: 18 of 57 dead calves found were killed by wolves, 12 were abandoned, 5 were stillbirths, 4 had died from pneumonia, 4 from malnutrition, 3 were injured, 5 from pathological causes, and 5 from natural

undetected causes. Calf abandonment is related to young females calving for the first time and to calving during post-calving movements. The authors suggest study of wolf-caribou relationships.

Miller, F.L., E. Broughton and A. Gunn. 1982a. An investigation of mortality of migratory barren-ground caribou with emphasis on predation. Canadian Wildlife Service unpublished report. 5 pp.

This paper reports findings on calving and post-calving mortality for the 1981-82 season. Predation by wolves and native hunters are two important contributors to juvenile caribou mortality and this study is an attempt to determine the predator's impact on the Beverly herd calves. Helicopter searches found 79 calves and 7 cows dead on the calving grounds. Wolves killed 23 calves, one was taken by a grizzly bear, 16 died of neonatal atelectasis, 3 died when abandoned, 2 died from pneumonia, 2 died from trauma, and one died from shock. Cause of death in the remaining 31 calves was uncertain. 4 of the 7 cows died from birthing complications; 2 by grizzly bear predation and one by wolf predation. Of 8,094 Beverly caribou counted in the fall 3,603 were adult females, 1,977 were calves, 565 were yearlings, 987 were prime bulls and 962 were young bulls. Of 3,250 Beverly caribou counted in the spring 1,615 were adult females, 761 were calves, 319 were yearlings and 555 were males.

Miller, F.L., E. Broughton and A. Gunn. 1982b. Mortality of newborn migratory barren-ground caribou calves of the Beverly herd. Canadian Wildlife Service unpublished report. 3 pp.

Helicopter searches for dead caribou (Rangifer tarandus groenlandicus) were conducted on the Beverly herd calving ground in the Northwest Territories between 3 and 27 June 1982. One hundred and seven calves and six cows were found and necropsied. The causes of death were determined with certainty for 90 calves: wolf (Canis lupus) predation, 69; fetal or neonatal atelectasis, 6; separation or abandonment, 5; patho-physiological, 5; pneumonia, 4; and malnutrition, 1.

Miller, F.L., A.J. Cowley, L.P.E. Choquette and E. Broughton. 1975. Radiographic examination of mandibular lesions in barren-ground caribou. Journal of Wildlife Diseases 11: 465-470.

Dental anomalies were observed in 43 of 1,226 barren-ground caribou (Rangifer tarandus groenlandicus) taken between 1966 and 1968. In five of those 43 animals, the mandibles had deformities which radiography showed to be the result of dental abscesses in four cases and probably of a trauma in the other. The absence of

actinomycotic lesions of the jaw bones of these 1,226 animals and of more than 500 examined previously, indicates that "lumpy jaw" is rare in barren-ground caribou. The authors suggest the use of radiography to determine the nature of bone growth on skeletal remains in the absence of soft tissues for examination for Actinomyces, either microscopically or by culture methods.

Miller, F.L., C.J. Jonkel and G.D. Tessier. 1972. Group cohesion and leadership response by barren-ground caribou to man-made barriers. *Arctic* 25:193-202.

Barren-ground caribou (Rangifer tarandus groenlandicus) of the Kaminuriak population of the Canadian mainland west of Hudson Bay make annual migrations of several hundred kilometers to and from their calving ground. A man-made barrier to corral caribou for marking and release failed because caribou would not leave the frozen water course at the entrance to the corral, nor would they readily deviate from learned travel routes. Some caribou delayed their migration northward until they found ways to circumvent the barrier. Other caribou overcame the man-made obstacle and continued on their set course. Any disruption of caribou movement could be detrimental to cow and calf survival because of increased dangers along new routes chosen and the delay of pregnant cows in reaching the calving grounds.

Miller, F.L. and R.L. McClure. 1973. Determining age and sex of barren-ground caribou from dental variables. *Transactions of the Northeast Section of the Wildlife Society* 30:79-100.

see Miller, F.L. 1974b

Miller, F.L. and G.R. Parker. 1968. Placental remnants in the rumens of maternal caribou. *Journal of Mammalogy* short communication 49(4):978.

Eight maternal barren-ground caribou were collected in the District of Keewatin, N.W.T. (63°31'N, 93°43'W). Placental tissue was found in the rumens of all eight of the cows. The age of their calves did not appear to correlate to the amount of placental remains in their rumens. The authors concluded that placental tissues may remain in the rumen for several weeks or more.

Miller, F.L. and G.D. Tessier. 1971. Dental anomalies in caribou, Rangifer tarandus. *Journal of Mammalogy* 52(1): 164-174.

The dentitions of 43 of 1226 caribou (Rangifer tarandus) skulls examined had anomalies. Of the 43, 13 had supernumerary teeth, 25

had missing teeth and five had extreme variations in root development and abnormal dentary patterns. These anomalies appear to be genetically produced and further study from the standpoint of evolutionary origin might be fruitful.

Miller, S. 1972. Ground observations of caribou of the Beverly caribou herd. N.W.T. Wildlife Service unpublished report. 2 pp.

Of 603 caribou classified 7-10 June 1972, 522 were adult females, 30 were calves, and 51 were yearlings. The low number of calves was probably due to the peak of calving occurring later than 10 June.

Moshenko, D.J. 1972. Caribou tagging project - Beverly Lake herd. N.W.T. Wildlife Service unpublished report. 9 pp.

This report summarizes personnel, camp location, equipment, and methods used for the July 1972 caribou eartagging project at Box Crossing and Sandy Island, Thelon River. A detailed list of tags applied is included. Data on tagged individuals includes date, time, location, tag number, sex and age class. Problems encountered, recommendations, and a cost breakdown are also presented.

Moshenko, D.J. 1974. Beverly Lake caribou calving ground survey. N.W.T. Wildlife Service unpublished report. 17 pp.

An estimated 77,820 caribou were calculated from the block survey method. The total calving area was 384 square miles, compared to 83,384 caribou calculated from a strip survey method with a calving area of 206 square miles. Herd composition was; 70,738 adult cows, 11,636 yearlings, 35,900 adult breeding bulls, and 5,518 other (young bulls and non-breeding females). 49,354 calves were produced in 1974. The herd may not be a declining population as the decreased total population figure compared to previous surveys (Rippen 1971, 164,403 and Thomas 1967, 159,000) may be caused from the following problems encountered:

- 1) the pilot was unable to maintain proper transect lines during the survey, due to the snow-covered ground and poor landmark recognition,
- 2) the inexperience of the observers to estimate numbers in large groups of caribou, and
- 3) the major switch of the calving grounds to the north.

Moyles, D.L.J. 1978. Studies of the Kaminuriak caribou herd - a literature review. Prepared for Pan Ocean Oil Ltd. September 1978.

This literature review provides a description of Kaminuriak herd movements especially in the Kazan River and Christopher Island areas. It also discusses the causes and effects of harassment and the reaction of caribou to aircraft, roads and other obstacles. The author discusses the implications of exploration and development in the Kazan River and Christopher Island area to caribou. A bibliography is included in the report.

Neiland, K.A. 1970. Weight of dried marrow as indicator of fat in caribou femurs. *Journal of Wildlife Management* 34(4): 904-907.

Analyses of 34 femur marrow samples from barren-ground caribou (Rangifer tarandus groenlandicus) revealed that this tissue is a three-component system comprised of water, fat and non-fat residue. Both the water and fat, and residue and fat are linearly and inversely related. Because the residue amounts to only 2-6 percent of the net weight, the dry weight of the marrow, except at low fat levels, is essentially equal to the weight of fat in the marrow. For maximum accuracy at low fat levels, the dry weight:fat inequality can be corrected by subtracting the average residue value for that fat level from the dry weight. Such corrected dry weights adequately measure femur fat content at all fat levels for many studies concerned with marrow fat reserves.

Parker, G.R. 1967. The 1967 barren-ground caribou tagging project, Aberdeen Lake, N.W.T. 28 June - 12 July 1967. Canadian Wildlife Service unpublished report. 13 pp.

A total of 830 barren-ground caribou (Beverly herd) were ear-tagged on the Thelon River, 5 miles west of Aberdeen Lake between 27 June and 12 July 1967. Of the total of 830 ear-tagged caribou, 520 of these were collared, 225 being bulls and the remaining 295 cows. The collars were made from bright yellow Herculite material, 4 inches in width. Collars were made in two sizes, cow collars being 22 inches in length, bull collars 30 inches. These sizes were determined from neck measurements taken from 400 caribou collected during the research program carried out on the Manitoba (Kaminuriak) herd. Tags were aluminum Hasco cattle ear-tags size 49, approximately 1 3/8 inches by 5/16 inches in size. The number series for the tags was 20001 - 20845. Green Herculite streamers 4 inches in length were placed on each tag.

Parker, G.R. 1968. Population dynamics of Kaminuriak barren-ground caribou populations. Canadian Wildlife Service unpublished report. 15 pp.

see Parker 1972c.

Parker, G.R. 1969. Obtaining kill data for research and management Manitoba-Keewatin barren-ground caribou study. Canadian Wildlife Service unpublished report. 8 pp.

In the spring of 1967 there were two possible sources of community caribou kill figures. One was the annual report by the Territorial Government, which utilized returns from general hunting licences. The other source was the annual R.C.M. Police reports summarizing the game conditions within their area of jurisdiction. The author recommends that the data be broken down by sex, age, kill date, and kill location. A method is outlined for obtaining data directly from the settlements by employing natives. The use and feasibility of a jaw return system is discussed.

Parker, G.R. 1971. Trends in the population of barren-ground caribou of mainland Canada over the last two decades. Dept. of Fisheries and Forests, Canadian Wildlife Service Occasional Paper Number 10. 9 pp.

Aerial surveys by the Canadian Wildlife Service in 1967 and 1968 produced an estimate of 385,000 barren-ground caribou for the four major populations of mainland Canada. A direct comparison of this estimate to results of the 1955 aerial survey of the same populations suggests an increase of approximately 50 percent during the 12 years between surveys. Closer examination of both surveys, with standardization of treatment of raw data, shows that the final estimates from both aerial surveys are similar and that a direct comparison of estimates is misleading. Contrary to a major increase, it appears the total number of barren-ground caribou in northern Canada changed only slightly during the period 1955 to 1967.

Parker, G.R. 1972a. Research and management of barren-ground caribou in northern Canada. Canadian Geographic Journal June:200-207.

This paper includes descriptions of the the four major herds (Bathurst, Beverly, Bluenose and Kaminuriak) of barren-ground caribou, the history of caribou study, and the future of the caribou's co-existence with man. There was a circumpolar decline in Rangifer tarandus populations at the turn of the century but this appears to have halted by the 1950's. The exodus of Indians and Eskimos from the land and into communities reduced hunter kill and helped to end the decline. In the early 1960's caribou eartagging studies were started and in 1967 an intensive research program on the Kaminuriak herd was initiated by the Canadian Wildlife Service. The main factor in limiting caribou numbers was found to be calf mortality on the breeding grounds. Harvest regulations have been relaxed in recent years but with an increasing human population stricter controls may be necessary.

With man intensifying his search for oil and mineral resources in the north, the disturbance to critical areas may cause shifts in range utilization and increase calf mortality on the calving grounds. The author recommends that both renewable and non-renewable resources continue to be inventoried and the extraction of these resources be accomplished with as little damage to the environment as possible.

Parker, G.R. 1972b. Distribution of barren-ground caribou harvest in northcentral Canada. Canadian Wildlife Service Occasional Paper Number 15. 20 pp.

A total of 6,857 barren-ground caribou were ear-tagged in the Northwest Territories from 1960 to 1967. Total recovery rates for the populations that calve at Beverly Lake and Bathurst Inlet were 7.2 and 4.4 per cent respectively. The difference in recovery rates suggests hunting pressure on the Beverly Lake population is significantly greater than on the Bathurst Inlet population. A significantly greater mortality of males from hunting is evident from a male:female relative recovery rate of 1.25. The average interval between tagging and shooting was 1.7 years and the greatest interval was 7.3 years. Approximately two-thirds of the tag recoveries were from the Northwest Territories and one-third from the Province of Saskatchewan. Indian hunters have returned a much greater number of tags than Eskimo hunters. Tags returned by Indians were usually winter recoveries within the taiga while most of those returned by Eskimos were summer recoveries north of the treeline. Application of the Lincoln Index produced varying annual population estimates for the Beverly population but the mean was similar to results from aerial surveys in 1967, i.e., about 150,000 caribou. The recovery of tagged caribou together, several years after tagging, suggests long-term social bonds, particularly between adult males. Populations of barren-ground caribou on mainland Canada have well-defined range limits but adjacent populations appear to exchange approximately 5 caribou per 1,000 annually.

Parker, G.R. 1972c. Biology of the Kaminuriak population of barren-ground caribou. Part I: Total numbers, mortality, recruitment and seasonal distribution. Canadian Wildlife Service Report, Series Number 20. 93 pp.

An average of 47,571 caribou were counted on 6 separate linear transect surveys from December to April 1967-68. A quadrat sampling method used on the calving grounds in June resulted in a total population estimate of 72,561. 545 caribou were classified during calving and approximately 80 percent of cows were with calves. In July a census was taken using aerial photography. 23 of 32 herds were photographed. 36,334 caribou were counted from the photographs. Visual estimates of the 23 herds made prior to photography overestimated later counts from the photographs by an

average of 17 percent. Visual estimates for the nine herds not photographed were reduced by 17 percent. The adjusted total was 50,403. Herd composition determined from the photographs was: calves 10,416, adult bulls 6,068, yearlings 2,687, and unclassified adults 31,232. From the 31,232 unclassified adults, 10,416 were adult cows with calves, 18,004 were adult cows having lost calves, and 2,812 were 2-year-olds and non-breeding adult cows. The adult male:adult female ratio in September 1968 was 57:100 for 3,073 caribou classified. Of 10,000 caribou classified in late winter and spring of 1968 approximately 6,500 animals were yearlings. July classification surveys south of Baker Lake indicated that large numbers of adult males and yearlings were not surveyed. Therefore, the total population estimate (75,875) was increased to incorporate the missing herd segments. Human kill by natives from four communities was 3,190 for 1967-68. In 1966-67 the proportion of calves fell from 10.5 percent in January to 7 percent in May and in 1967-68 from 15.9 percent in September to 10.3 percent in May. In June 1968 it was determined from a calving ground survey that there were 28,420 adult breeding cows.

Parker, G.R. 1972d. The barren-ground caribou tagging program in the Northwest Territories. Canadian Wildlife Service unpublished report. 34 pp.

see Parker 1972b.

Parker, G.R. 1973. Distribution and density of wolves within barren-ground caribou range in northern mainland Canada. *Journal of Mammalogy* 54(2):341-348.

Observations of wolves (Canis lupus) were recorded during aerial surveys of barren-ground caribou (Rangifer tarandus groenlandicus) from May 1966 to October 1968 over portions of northern Manitoba, northeastern Saskatchewan, and southeastern District of Keewatin, Northwest Territories. These observations were made over the entire range of the Kaminuriak population of caribou. There was a close association between the distribution of wolves and caribou. The average size of wolf packs was larger in autumn and winter (3.0) than in summer (1.7) and there was little change in the monthly mean sizes of packs from October to April. The area used by caribou wintering in northwestern Manitoba and northeastern Saskatchewan decreased from 3594 square miles in January to 682 square miles in April 1968, with a consequent increase in caribou density from 14 to 68.5 per square mile. A corresponding increase in wolf density during that period within the same area was not detected. Wolf densities appeared to maximize at approximately one wolf per 7 to 8 square miles and remain stable. Estimated wolf numbers in the area of high caribou density decreased from 258 in January to 60 in April.

Parker, G.R. 1974. Kaminuriak caribou calving ground surveys. Canadian Wildlife Service unpublished report. 4 pp.

This memorandum contains the author's views on ways to improve the Kaminuriak calving ground surveys. The random plot method is an improvement over the transect methods as it allows statistical analyses of results and eliminates doubt as to whether caribou are on or off transect. However, the random plot method is more difficult to execute, so if precision of the survey is not being measured, a transect survey is acceptable. Stratification of the survey area would improve the survey and coverage should be 25%. Any survey is subject to such hazards as bad weather, poor migration and observer fatigue. The 1973 survey of the Kaminuriak calving grounds was 45,000 animals lower than the 1968 survey. Mortality probably did not account for the discrepancy as annual harvest remained stable and no unusual numbers of diseased caribou were reported. Emigration is possible but without ear-tagging is difficult to detect. The author believes the discrepancy is due to the survey being done before all animals were on the calving grounds. Therefore it is recommended that winter surveys and checks on spring migration be made to eliminate this possibility in the future.

Parker, G.R. 1975. A review of aerial surveys used for estimating the numbers of barren-ground caribou in northern Canada. Polar Record. 17:627-638.

This paper is a review of the major types of aerial surveys used to estimate total numbers of barren-ground caribou. In the total count method all caribou within a herd are counted which is a simple but logistically and economically impractical method. In a strip transect (stratified or non-stratified) survey all animals are counted within a strip of constant width. This is the most popular method though still subject to human error. In a random plot survey a number of quadrats are randomly selected and the number of caribou within are counted. This method is statistically sound but difficult to execute. Aerial photography is used as an aid for estimating numbers in large groups and for segregating sex and age classes. A history of aerial surveys is included from Banfield's (1948) survey (670,000 mainland caribou) to Land and Hawkins' (1973) Kaminuraik calving ground survey. The vastness of the range, high operational costs, small management staff, and inaccurate kill statistics make normal ungulate management studies of growth, nutrition and reproductive assessments impractical for caribou. Aerial surveys will continue to be important management techniques.

Pruitt, W.O. 1958. Investigation of the ecology of the barren-ground caribou (Rangifer arcticus), 1957-1958. unpublished report C.W.S.-52-58, Edmonton. 118 pp.

This paper reports on a study of mainland caribou herds. Topics covered include the physical environment, topography, meteorology and a detailed study of snow influences. The author suggests reclassifying the caribou as a chionophile (highly adapted to snow

instead of a chionoephore (adapted to snow). The threshold of sensitivity of caribou to snow hardness is approximately 50 gm/km² for fresh snow and 500 gm/km² for lake (hard packed) snow. The density threshold appears to be approximately 0.19 to 0.20 for fresh snow and 0.25 to 0.30 for lake snow. Thickness threshold is 60 cm. Population statistics for northern Manitoba, northern Saskatchewan, and the Northwest Territories are included. General behaviour postures, and behaviour related to snow, spring migration and fawning are described. Caribou-wolf relations are discussed. The author criticizes the Chipewyan Indians for wasting caribou meat.

Pruitt, W.O. 1959. Snow as a factor in the winter ecology of the barren-ground caribou (Rangifer arcticus). Arctic 12(3): 159-179.

During the winter of 1957-1958 114 snow observation stations were established in parts of northern Saskatchewan and the southern Northwest Territories. Approximately 8,850 miles were flown at low altitudes over the region. During these flights the positions of bands and wintering individuals of barren ground caribou (Rangifer arcticus) were plotted on topographic maps. Numerous ground observations were made of caribou behaviour in relation to snow conditions. The areas of heavy caribou concentration were characterized by snow cover that was quite soft, light, and thin. The areas of no caribou were characterized by snow cover that was sometimes soft but also could be very hard, dense, and thick. Caribou appear to have a threshold of sensitivity to the hardness, density and thickness of the snow cover. The threshold of hardness sensitivity appears to be approximately 50 gm/sq cm for forest snow and 500 gm/sq cm for lake snow. The density threshold appears to be approximately 0.19 or 0.20 for forest snow and 0.25 or 0.30 for lake snow. The thickness threshold appears to be approximately 60 cm. When these thresholds are exceeded caribou react by moving until they encounter snow of smaller hardness, density or thickness. Caribou will dig feeding craters only twice in a given unit of snow after which it becomes so hard that they seek undisturbed snow for feeding. Some of the relationships of snow to the evolution, behaviour, species survival and management of caribou are discussed. Various aspects of necessary future research and improvements in techniques are enumerated and discussed.

Pruitt, W.O. 1960. Behaviour of the barren-ground caribou. University of Alaska Biology Papers, Number 3. 43 pp.

A one-year field study of the barren-ground caribou (Rangifer arcticus) in northern Manitoba, northern Saskatchewan and the Northwest Territories, Canada included many aspects of behaviour in relation to environment as well as to other individuals. Because their extensive yearly migration encompass a wide variety of habitat types, regional synchrony of physiological and

behavioural rhythms was judged to be of special importance to species survival. Threat (muzzle extended, antlers back), attack (head lowered antlers presented), head bobbing (releases following in fawn), alarm (one hind leg spread, head erect), postures and the excitation jump (rearing, pivoting, interdigital glands discharge) are described, illustrated and discussed in terms of the releaser concept. Nival factors and food supply govern winter activity and migrations. The search for suitable snow and the location of forage under the snow is described in terms of an appetite-consummatory behaviour sequence. The role of the threat posture as part of male courtship display is discussed. Fawning behaviour is described. Gravid females congregate in maternity bands which frequent characteristic topographic and nival situations. Does with young fawns congregate in nursery bands. Nursery bands coalesce and become an important social aggregation in summer. Miscellaneous observations are presented on: significance of antlers in social contact, profound sleep, reaction to insect attacks, dependence on scent, and behaviour at a "lick."

Pruitt, W.O. 1961. On post-natal mortality in barren-ground caribou. *Journal of Mammalogy* 42(4):550-551.

Observations of caribou births and calf mortality were made at Fawn Lake, N.W.T., 1958. 29 calves were born in four, 8 hour observation samples (one 8 hour sample on four consecutive days). It was calculated that 87 calves were born over the 4 days. 4 calves were found dead at the end of the observation period so the mortality rate was 4.5%. Weather conditions were near-blizzard.

Reimers, E., E. Gaare and S. Skjenneberg (eds.). 1980. Proceedings of the 2nd International Reindeer/Caribou Symposium, Røros, Norway, 1979. Direktoratet for vilt og ferskvannsfisk, Trondheim. 779 pp.

A collection of papers on range ecology, nutrition, reproduction, physiology, veterinary medicine, behaviour, population dynamics, management, and status of Rangifer in 1979. Papers specific to the Kaminuriak and Beverly herds are referenced in this bibliography by author.

Riddle, C.F. 1965. Caribou observations. N.W.T. Wildlife Service unpublished report. 3 pp.

Notes containing raw data from a survey conducted in the Damant Lake area (Beverly herd range), 19 August to 15 September, 1965. Of 1,174 caribou classified 25% were bulls, 28% were cows, 12% were yearlings, 8% were calves and 27% were unknown. The percentage of calves to known cows was 28%. There are general notes on the weather and wildlife sightings.

Rippen, B. 1971. Beverly Lake caribou calving ground survey. N.W.T. Wildlife Service unpublished report. 11 pp.

An aerial survey was conducted on the Beverly calving ground following the method outlined by Dauphine et al. (1971) to determine the number of adult cows. There were 93,945 adult cows estimated on the calving grounds. Herd composition was calculated using vital statistics from the Bathurst and Kaminuriak herds: 1) total caribou (164,403), 2) adult cows (93,945), 3) yearlings (16,440), 4) adult breeding bulls (27,244), 5) others (26,774) and 6) calves produced in 1971 (65,762). Difficulties involved in this aerial census are discussed; poor weather conditions, movement of caribou in response to the aircraft and the fact that the characteristics of 2 other herds were applied to the Beverly herd. The following recommendations are made for future surveys: 1) one aircraft to be used to locate the calving herd and determine the stage of calving, 2) two aircraft be used to fly transects. The use of two aircraft would cut costs and reduce the problems of inclement weather and caribou movements between transects.

Robertson, J.D. 1961. Caribou tagging. Beaver 292: 24-29.

This report documents the rationale and method of tagging swimming caribou. In September 1959, 112 caribou were tagged as they swam Duck Lake, Manitoba (Kaminuriak herd range). Caribou were approached in a canoe powered by a 10 horsepower outboard and brought close to the boat with the aid of a large shepherd's crook. Animals were held firmly by the antlers while an ear tag was attached.

Robertson, J.D. 1977. Disappearance of the barren-ground caribou from Manitoba. Manitoba Fish and Wildlife Service unpublished report. 31 pp.

This report documents the first time in recorded history that barren-ground caribou did not winter in northern Manitoba. This final stage in their gradual disappearance is a disaster to the Chipewyans whose culture is based on harvesting caribou. Over 144,000 square miles of habitat, capable only of sustaining caribou, today is devoid of any caribou - a loss in excess of \$5,000,000 in potential to northern Manitoba. Research has determined that the Manitoba-Keewatin (Kaminuriak) caribou herd has no serious physical limiting factors. Maintenance of habitat and harvest rates are two important limiting factors that man must control. A coordinated management approach with Saskatchewan and the Northwest Territories is required. Harvest of the Manitoba-Keewatin herd must be stopped until the herd is returned to a healthy state and occupies wintering range in Manitoba. Barren-ground caribou management must be elevated to a high priority in Manitoba.

Robertson, R.J. 1975. Kaminuriak barren-ground caribou herd. August 1974 - February 1975. Manitoba Department of Lands and Forests and Wildlife Resources. Northern Regional Status Report Number 865. 9 pp.

This report summarizes surveys conducted on the Kaminuriak caribou herd from August 1974 to February 1975 to determine recruitment, fall composition, hunter kill and the feasibility of using aerial dye-spraying techniques for marking caribou. The total Kaminuriak population was estimated at 61,500. Over 300 caribou were killed by Tadoule Lake hunters in late November 1974. Estimates of 11.5% calves (1,903 caribou classified) and 7.5% calves (4,836 caribou classified) were obtained in late January and early February 1975. The investigation of dye-spraying techniques was cancelled due to lack of funds. Beverly and Kaminuriak herd movements from November 1974 to January 1975 are summarized.

Ruttan, R.A. 1962a. Caribou tagging operations, Thelon River, N.W.T. Canadian Wildlife Service unpublished report, Number 973.

This report summarizes the second tagging operation of southward migrating Saskatchewan (Beverly) caribou at Box Crossing on the Thelon River. 618 caribou were tagged on the right ear with streamers from 6 July to 4 August, 1962. A table summarizing tag numbers and the sex and age of tagged caribou, and an itinerary are presented.

Ruttan, R.A. 1962b. Observations on barren-ground caribou in Manitoba, August 1962. Canadian Wildlife Service unpublished report, Number 974. 13 pp.

Aerial surveys were conducted on August 8, 9, 10, 19 and 20 for the purpose of determining; 1) the location and migration progress of the Kaminuriak herd, 2) calf percentage, 3) distribution during migration and 4) estimates of total population. The greatest density was observed northwest of the crossing point on Nejanilini Lake. An average of 7.4 caribou per square mile was observed. Calf counts obtained averaged 3.9 percent from aerial surveys and 1.14 percent from ground observations. The writer felt that this difference may have been caused by an inability to separate calves from yearlings during the aerial surveys. The estimated total population is 26,400. Recommendations given are: 1) collections of the lower jaws of caribou killed by natives should be made for age analysis, 2) increased effort should be made to determine sex and age composition of the Manitoba (Kaminuriak) herd by aerial and ground observations, 3) pregnancy, birth rate and calf survival studies should be initiated and 4) population studies should continue to be part of the tagging program.

Ruttan, R.A. 1963. The co-operative barren-ground caribou program, 1974-1963. Canadian Wildlife Service unpublished report. 22 pp.

Not available for review.

Ruttan, R.A. 1965a. Manitoba barren-ground caribou. Canadian Wildlife Service unpublished report. 16 pp.

This paper outlines the history of caribou research in Manitoba, the utilization and decline of the herd and the current situation. Banfield (1954) estimated an annual kill of 40,992 caribou in the Manitoba and Keewatin area and estimated the total herd to number 145,000 animals. In 1962, 5,000 to 6,000 caribou were taken in the same area and the total herd was estimated at 40,000 animals. Present range includes the region west of Hudson Bay from Baker Lake on the north to York Factory on the south. The winter range is forested areas (and adjacent tundra) within these boundaries. The author feels that the herd is increasing but that more research is necessary for sound management.

Ruttan, R.A. 1965b. Progress report on the Northwest Territories barren-ground caribou tagging program. Canadian Wildlife Service Report submitted to the Technical Committee for Caribou Preservation, Feb. 23-24, 1965. 55 pp.

4,197 caribou were ear tagged from 1960 to 1964. Recovery of the tags from the Saskatchewan (Beverly) herd has revealed two major ranges, one is the summer range, occupied from late June until early October, in the Aberdeen-Baker Lake area. The other is located in southeastern Mackenzie and northern Saskatchewan and is occupied from September to May. 68.3 percent of tag recoveries were from summer range. Tag returns indicate that a higher percentage of males are killed than would be expected. Local observers have suggested that hunters are reluctant to report tags from females because of fear of prosecution. There was overlap on the winter range of the Saskatchewan (Beverly) and Manitoba (Kaminuriak) herds. About 35 of the tags have been recovered.

Ruttan, R.A. 1966. Summary of the 1965 Contwoyto Lake tagging operation. Letter to J.P. Kelsall. Canadian Wildlife Service unpublished report. 2 pp.

This report summarizes tagging operations conducted at Contwoyto Lake from 28 July to 28 August 1965. 289 caribou were marked with green enamelled tags with "A" superimposed. A table summarizing tag numbers and the sex and age of tagged caribou is presented.

Ruttan, R.A. 1967. Seasonal distribution and population estimates of the major barren-ground caribou herds 1955-1967. Canadian Wildlife Service unpublished report. 12 pp.

A description of the seasonal distribution, migration patterns and past and present numerical status of the four major N.W.T. mainland caribou herds. A previous census in 1967 by Thomas and Parker underestimated the size of the mainland caribou populations. Those investigators counted the caribou as they left the forest cover en route to calving grounds. The author stated that their counts were premature and many pregnant cows were missed. Previous population estimates are given for the Manitoba or Keewatin (Kaminuriak) herd; in 1950 (30,000), 1955 and 1965 (150,000) and 1967 (35,000). Uncertainty over the distribution of the Saskatchewan (Beverly) herd resulted in fluctuating population estimates however, the author felt that the population had shown an upward trend. He estimated 200,000 Beverly caribou in 1965. The author stated that the four major herds existed in well defined ranges and migrated over established routes at predictable times. He suggested that the populations were at dangerously high levels. He recommended that the populations be reduced to safer levels and that better use be made of this resource which he felt was being wasted through neglect.

Ruttan, R.A. 1968. Barren-ground caribou management. Canadian Wildlife Service unpublished report. 6 pp.

Three types of management programs are outlined. An emergency program entails immediate reductions in herd sizes to prevent overpopulation. The short-range program involves a census of the major herds, ear-tagging operations, and implementation of improved harvest and utilization methods. The long-range program is an extension of the preceding program and involves herd composition analysis (sex and age), productivity estimates, forest fire control programs, and cessation of wolf control programs. All three are similar in that they involve an increase in hunting, relaxation of restrictive policies, and an increase in game branch activities. Provincial and territorial co-operation is urged.

Ruttan, R.A. 1969. Tagging-Bathurst Inlet. Barren-ground caribou, August, 1969. Canadian Wildlife Service unpublished report. 5 pp.

This report summarizes a tagging operation conducted at Pellatt and Contwoyto Lakes in August 1969. 70 Bathurst herd caribou were tagged. A table summarizing tag numbers and the sex and age of tagged caribou is presented along with recommendations for future tagging programs.

Schofield, E. 1975. Some considerations on the possible effects of local and global sources of air pollution on lichens grazed by reindeers and caribou. pp. 90-94. In: J.R. Luick, P.C. Lent, D.R. Klein and R.G. White (eds.), Proceedings of the First International Reindeer and Caribou Symposium. University of Alaska, Special Report No. 1. 551 pp.

Considerable evidence shows that local sources of air pollution eliminate most lichens from the immediate vicinities of urban and industrialized areas in temperate regions. Pollutants (eg., SO₂) appear to be transported hundreds of kilometers from Britain and central Europe to Scandinavia. While there appear to be no reliable data or observations that link pollutants transported on a global scale to the deterioration of lichens (primarily because the possibility has not been pursued), all of the ingredients necessary for lichen damage are present. Scattered comments and circumstantial evidence in the literature suggest that global pollution, in addition to local pollution, will adversely affect lichens grazed by reindeer and caribou. The accelerated industrialization of the Arctic makes this possibility of more than academic interest.

Scotter, G.W. 1962. Effects of forest fires on the winter range of barren-ground caribou. Canadian Wildlife Service unpublished report. 7 pp.

This report presents data on range productivity, rate of forest destruction by fires and lichen growth rates in northern Saskatchewan. Range productivity is given as pounds per acre of air-dry forage by age class and vegetation type. Average annual destruction of forest by fire is 14,966 acres. Average annual growth rates for the lichen (Cladonia alpestris) are 4.3 mm (Dodge Lake), 4.7 mm (McKeever Lake), 3.4 mm (Newnham Lake), 3.9 mm (Chipman Lake) and 3.4 mm (Taltson River area). Average annual growth rates for C. rangiferina are 4.8 mm (Dodge Lake), 5.7 mm (McKeever Lake), 4.7 mm (Newnham Lake), 4.4 mm (Chipman Lake) and 4.1 mm (Taltson River area). The average annual growth rate for C. mitis is 3.6 mm (Taltson Lake area).

Scotter, G.W. 1963a. Study of the winter range of barren-ground caribou with special reference to the effects of forest fires. Canadian Wildlife Service Progress Report Number 2. 116 pp.

see Scotter, G.W. 1968.

Scotter, G.W. 1963b. Effects of forest fires on soil properties in northern Saskatchewan. Forestry Chronicle, December 1963:412-421.

The effects of forest fires on some physical and chemical soil properties in the Black Lake region of northern Saskatchewan were determined on four burned-over areas, and results were compared with corresponding mature forested areas. Formerly, two of the burns supported jack pine forests and the other two supported black spruce forests. Temperatures, water infiltration rates, and erosion were the physical soil properties considered. Temperatures at the 1-inch and 3-inch depths in the burned-over soils averaged 10.5° F and 9.7° F respectively, higher than soil temperatures under mature forests. Water infiltration rates, compared at one location only, were not impaired. Erosion following fire was slight. Soil nutrients and soil pH were the chemical properties considered. Total exchange capacity decreased on three of the four burns, when compared with mature forests. Exchangeable hydrogen was reduced and available phosphorus increased on each of the burned-over soils. Exchangeable calcium increased on three of the four burned-over soils. No conclusions could be reached for alterations in total nitrogen, exchangeable magnesium, potassium, and sodium. On the burned-over areas acidity decreased at 1-inch depths and 3-inch depths. Forest fires influence both chemical and physical soil properties on the winter range of barren-ground caribou in northern Saskatchewan. These alterations may be important in changing the habitat to one less favourable for the generation and growth of preferred food plants.

Scotter, G.W. 1964. Effects of forest fires on the winter range of barren-ground caribou in northern Saskatchewan. Canadian Wildlife Service Wildlife Management Bulletin, Series 1, Number 18. 111 pp.

This booklet is a discussion of post fire changes in range productivity and wildlife utilization. Acreage burned in the study area (59° - 60° N, by 104° - 106° W) has increased 1.4 times in the last 60 years. Fire increases the water infiltration rates and summer temperatures in soil as well as altering the soil's chemical structure. The most obvious effect of fires is the reduction in quality and quantity of forage. This is a temporary reduction except for "reindeer lichens" which take a century or more to regenerate. Arboreal lichens may be major items in the winter diet of caribou particularly under severe weather conditions. Caribou prefer climax forests which harbour these lichens. From the results of this study it is impossible to tell the effect of forest fires on caribou population declines. But if the effect of fire on "reindeer lichens" is similar everywhere then forest fires probably were a principle factor in the caribou population decline.

Scotter, G.W. 1965a. Study of the winter range of barren-ground caribou, with special reference to the effects of forest fires, 1965. Canadian Wildlife Service Progress Report Number 3. 81 pp.

This paper reports on the 1963 study on caribou winter range in the Cochrane River region of Manitoba. It was found that jackpine and birch regenerate first after a fire and then are slowly replaced by the black spruce and lichens which are the caribou's preferred range. Air dry forage accumulation was 104 pounds per acre (for 1-10 year age class), 503 lbs/acre (11-30 yrs.), 649 lbs/acre (31-50 yrs.), 879 lbs/acre (51-75 yrs.), 1032 lbs/acre (76-120 yrs.) and 1072 lbs/acre (120 plus yrs.). Pounds of lichen accumulation were 150, 31, 511, 652 and 768 in the same year classes. Growth rates for the 3 major forage lichens were determined; Cladonia alpestris (3.9 mm/yr); C. mitis (3.8 mm/yr); C. rangiferina (4.4 mm/yr). Average podetium weights are; C. alpestris 0.0328 grams, C. mitis 0.0328 grams, and C. rangiferina 0.0261 grams. Protein and phosphorous content increased in shrubs from burnt over areas while crude fiber content decreased. Climatic and nutrient aspects should be considered when evaluating range carrying capacity.

Scotter, G.W. 1965b. Chemical composition of forage lichens from northern Saskatchewan as related to use by barren-ground caribou. Canadian Journal of Plant Science 45:246-250.

As part of a study stimulated by the decline in numbers of the barren-ground caribou in northern Canada, the quality of their winter forage plants was studied. Twenty-five lichens and eight vascular plants, comprising the important forage species on the winter range of the animals, were collected in June, September, and March. They were analyzed for crude protein, ether extract, crude fiber, ash, calcium, and phosphorus. In general, lichens were found to be low in protein, calcium, and phosphorus in relation to the estimated nutrient requirements of the caribou. They do however, appear to supply a major part of the energy needs of this species. An attempt has been made to list the groups of lichen species studied in the order of animal preference. Seasonal fluctuations in chemical composition are indicated.

Scotter, G.W. 1966. Sieve mesh size as related to volumetric and gravimetric analysis of caribou rumen contents. Canadian Field-Naturalist 80(4): 238-241.

A study was undertaken to determine which of three sieve mesh sizes could best be employed to determine the percentage composition of forage samples from the rumens of six barren-ground caribou. The second purpose was to compare the results obtained using wet volume and air-dry weight as methods of measurement. Of the meshes tested the smallest with openings of 2.00 mm, appeared to provide the best results. Gravimetric procedures offered advantages over volumetric ones.

Scotter, G.W. 1967. The winter diet of barren-ground caribou in northern Canada. Canadian Field-Naturalist 81(1): 33-39.

A study of the winter food of barren-ground caribou in northern Canada was conducted as part of an intensive research program. Analyses of 20 rumen samples were made by washing 250 ml of rumen contents through a gang of three sieves with openings of 4.76 mm, 2.83 mm and 2.00 mm. Forage particles from each sieve were separated and weighed. The weights of each species or forage group were combined to give an aggregate percentage composition. This helps to reduce error caused by unequal representation of food items in the three sieves. The data indicate that terrestrial lichens are the most abundant plants in the winter diet of barren-ground caribou, constituting more than 50 per cent of the food intake. Although lichens dominate the winter diet, caribou are rather catholic in their feeding habits and many items are included in addition to lichens. A number of woody plants, several grass and grass-like plants, and many species of bryophytes composed 19.8, 2.9 and 3.1 per cent of the diet, respectively. Some of the limitations of rumen analyses, such as differential digestion rates of some plants, are discussed. Although caribou stomach analyses are not highly accurate, they still provide an index to food habits not subject to some of the limitations of other methods. The value of rumen analyses may be improved by using them in connection with other methods of diet determination such as feeding crater studies.

Scotter, G.W. 1967. Effects of fire on barren-ground caribou and their forest habitat in northern Canada. Transactions of the 32nd North American Wildlife Conference: 246-254.

see Scotter, G.W. 1970.

Scotter, G.W. 1968. Effects of forest fires on the lichen winter ranges of barren-ground caribou in Northern Canada. Ph.D. thesis, University of Utah State. 143 pp.

The devastation of the winter habitat by forest fires has been suggested as a possible cause of the caribou decline. Four areas in northern Canada were selected for studying the effects of fire on lichen rangelands. A literature review, forest cover maps, fire control records, and examinations of the forests themselves indicate that fire is a natural phenomenon and not a new factor in the ecology of the region. During a period that extended from 1961 through 1964 there were 1,250 known forest fires that burned over 5,005,872 acres of potential winter range. The cover-map data on forest age classes suggested that the amount of destruction in recent years has increased. The standing crop of usable forage was determined for six forest age classes. The average standing crop of usable air-dried forage was higher than

the standing crop of high-value lichens in the same age classes. This difference of lichens is critical because of their slow succession, their slow growth rates, and their importance as winter forage for barren-ground caribou. Burning did not affect all game populations alike. In forests over 120 years old, 722 caribou pellet groups per acre were found compared with only 18 per acre on the 1 to 10-year age class. There were 49 moose pellet groups per acre in the 11 to 30-year age class and only three per acre in forests over 120 years old. Moose apparently preferred habitats in early stages of succession while barren-ground caribou favored those in later stages of succession. Because of the effects of fire on the standing crop of forage and plant succession, there can be little doubt that forest fires were one of the principle causes of the decline in caribou numbers. More prevention and control of forest fires would seem essential to increasing caribou numbers to a high level.

Scotter, G.W. 1970. Wildfires in relation to the habitat of barren-ground caribou in the taiga of northern Canada. Annual Proceedings of the Tall Timbers Fire Ecology Conference 10:85-106.

The author states that although damage by fire to winter range of barren-ground caribou occurred before the white man came to North America, the increased rate of forest destruction by fire accompanying settlement and exploitation, as well as possible changes in the summer weather pattern, has contributed to a loss of potential habitat. Fires adversely affect the standing crop of both terrestrial and arboreal forage utilized by the caribou. Lichens appear to be more seriously affected by fire than other forage plants because of their delay in re-establishment and slow growth rates. Fire appears to reduce the quantity of winter range for barren-ground caribou and improve it for moose on upland forests. Based on pellet group data collected during this study, the biomass of caribou per acre of mature forest appears higher than that of moose on early subclimax forests on upland sites. Data are insufficient to determine the extent to which forest fires have influenced directly the recent decline of the barren-ground caribou population. With the effect of fire on the standing crop of forage, plant succession and animal use, the author concludes that forest fires may have been one of the principle causes of the decline. The present winter range will not permit an increase in numbers to the level of 60 or 70 years ago. The reduced potential carrying capacity of the winter range does not appear to be the factor limiting the caribou population to the present low levels. It may well have been the cause of the reduction of caribou numbers until men, wolves, and other factors were effective in maintaining the population at low levels.

Scotter, G.W. 1971. Fire, vegetation, soil, and barren-ground caribou relations in northern Canada. Proceedings-Fire in the northern environment - a symposium. pp. 209-230.

see Scotter, G.W. 1968.

Scotter, G.W. 1978. Fire and caribou in northern Canada. Proceedings of Fire Ecology in Resource Management Workshop, December 1977. Information Report NOR-X-210. 2 pp.

The devastation of the winter habitat by forest fires has been suggested as a possible cause of the decline of barren-ground caribou. Four areas in northern Canada were selected for studying the effects of fire on lichen rangelands. A literature review, forest cover maps, fire control records, and examination of the forests themselves indicate that fire is a natural phenomenon and not a new factor in the ecology of the region. During a period that extended from 1961 through 1964, there were 1,250 known forest fires that burned-over 5,005,872 acres of potential winter range. The cover-map data on forest age classes suggested that the amount of destruction in recent years has increased. The standing crop of usable forage and high-value lichens was determined for six forest age classes. Destruction of the extremely slow-growing arboreal lichens by fire must be considered a serious loss of caribou winter forage. Burning did not affect all game populations alike, as shown by the densities per acre of barren-ground caribou and moose pellet groups. In forests over 120 years old, 722 caribou pellet groups per acre were found compared with only 18 per acre on the 1- to 10-year age class. There were 49 moose pellet groups per acre in the 11- to 30-year age class and only three per acre in forests over 120 years old. Moose apparently preferred habitats in early stages of succession, but barren-ground caribou favored those in later stages of succession.

Simmons, N.M., D.C. Heard and G.W. Calef. 1979. Kaminuriak caribou herd: interjurisdictional management problems. N.W.T. Wildlife Service Progress Report Number 2. Paper presented at the 44th Annual North American Wildlife National Resource Conference, Toronto, Ontario, March 24-28, 1979. 30 pp.

The Kaminuriak barren-ground caribou herd of the Keewatin Region, Northwest Territories, has declined at a rate exceeding 4% annually because natural mortality and mortality caused by hunting have exceeded annual increments. The decline has spanned at least a decade. Kaminuriak caribou have been an important food source to Inuit, Indians, and Metis of Manitoba, Saskatchewan, and the Northwest Territories, but in recent years a reduction in range size has deprived native hunters in Manitoba of caribou. Five

government agencies have been involved in the management of this herd, and inconsistent research efforts and jurisdictional problems have resulted. The keys to proper management of Kaminuriak caribou are regular, effective, standardized programs of monitoring caribou population dynamics, improved communications with native hunters, and involvement of native hunters in caribou management efforts. Considerable progress has been made in all of these areas in the past two years. Action must be taken immediately to reduce the numbers of caribou killed by hunters and wolves, or the Kaminuriak herd will be condemned to continued decline possibly to extinction.

Stager, J. 1977. Baker Lake, N.W.T., a background report of social and economic development. unpublished manuscript prepared for Polar Gas. 203 pp.

This study was commissioned by Polar Gas Co. Ltd. for the purpose of establishing a socio-economic data source as a basis for predicting future development in Baker Lake, N.W.T. The economic analysis showed Baker Lake is undeniably salary oriented, yet 38% of the settlement's food comes from the land. The economic base is a complex structure oriented equally to the settlement and the land. Yet the land itself cannot be completely identified in economic terms. People still identify with "the land" which represents a symbolic tie with a traditional way of life. The conclusion of the report presents a number of recommendations to the client. These are that the company should provide training for village members and help build a solid economic infrastructure in the village by encouraging new investment.

Stephenson, D. and D. Heard. 1982. Capturing and marking of free-ranging mammals with special reference to caribou (Rangifer tarandus). N.W.T. Wildlife Service unpublished report. 19 pp.

This report describes capture and marking techniques and their effects on the behaviour, biology and movement of animals. Descriptions of marking techniques used on the Beverly, Kaminuriak, Bathurst and Baffin Island caribou populations are summarized.

Strong, J.T. 1975. Kaminuriak calving grounds - 1966-1974. N.W.T. Wildlife Service unpublished report. 3 pp.

This report presents maps showing the comparative sizes and locations of the Kaminuriak calving grounds for the years 1966-1968, 1972-1974.

Thomas, D.C. 1960a. A report on the tagging operation - Beverly-Aberdeen Lakes, 8 to 19 July, 1960. Also Mary Frances lake tagging report for 24 July to 1 August 1960. Canadian Wildlife Service unpublished report. 30 pp.

This report summarizes tagging operations conducted at Beverly and Aberdeen Lakes from 8 to 19 July and at Mary Frances Lake from 24 July to 1 August 1960. Fifty and 73 Beverly herd caribou were tagged at Beverly-Aberdeen Lakes and Mary Frances Lake respectively. Reconnaissance flights from 12 to 20 July to determine caribou movements relative to the tagging sites are summarized.

Thomas, D.C. 1960b. Caribou tagging at Contwoyto Lake, August 1960. Canadian Wildlife Service unpublished report. 17 pp.

This report summarizes tagging operations conducted at Contwoyto Lake from 3 to 20 August, 1960. 96 Bathurst herd caribou were tagged. Tag numbers and the sex and age of tagged caribou are presented. The report also summarizes observations of a caribou harvest by native hunters at a nearby camp. The native hunters killed 512 caribou.

Thomas, D.C. 1969. Population estimates of barren-ground caribou, 1967. Canadian Wildlife Service Report Series Number 9. 44 pp.

An aerial survey of barren-ground caribou in the Mackenzie District and adjacent portions of Alberta and Saskatchewan was conducted in 1967. It had four objectives: 1) to determine late winter distribution of caribou herds and their spring migration routes to the tundra; 2) to census all major herds; 3) to determine numbers of young in relation to older animals; and 4) to assess human use of caribou on their winter range. Surveys were flown for a total of 270 hours in March, April, and May, 1967. Four populations of caribou were described on the basis of their distribution and calving areas. Population estimates for three of the herds were 320,000 to 330,000 obtained by combining total counts, strip censuses, photographic counts, and a ratio method. The overall average recruitment rate was 11.0 per cent. The harvest has been reduced since the Eskimo's and Indian's dependence on the caribou has decreased.

Thomas, D.C. 1975. A short review of caribou in Canada. Annual Proceedings of the American Association of Zoological Parks and Aquariums. pp. 20-28.

In 1948-49, there were 670,000 barren-ground caribou east of the Mackenzie River on the Canadian mainland. The estimate in 1955 was approximately 280,000 and the populations were thought to have

reached a low of 200,000 in 1957. The pronounced decline occurred from 1949 to 1955 and probably continued until the late 1950's when an upward trend began. Surveys conducted in 1967-68 indicated there were about 386,000 caribou in the four major populations on the Canadian mainland. The populations contained an estimated 19,000 (Bluenose), 145,000 (Bathurst), 159,000 (Beverly) and 63,000 (Kaminuriak) caribou. With the addition of an estimated 40,000 to 60,000 caribou on the mainland north of Chesterfield Inlet and on Baffin, Southampton, and Coats Islands the total barren-ground caribou population in Canada east of the Mackenzie River was 400,000 to 500,000 in 1967-68. Management of barren-ground caribou in Canada revolves around; 1) trying to restrict hunting when populations are low and facilitating hunting when populations are high, 2) reduction of the wolf populations when caribou numbers reach a low level as in the late 1950's, and 3) protection of winter ranges through fire suppression.

Thomas, D.C. 1981. At the crossroads of caribou management in northern Canada. Canadian Wildlife Service, Western and Northern Region, Edmonton. Special Publication No. 10. 21 pp.

Several major populations of caribou in Canada and Alaska have declined sharply in this decade with overharvest a common denominator. A review of what is known about the causes of these declines, of past attempts to manage populations, and of demographic characteristics of the user groups leads to the conclusion that hunting must be curtailed soon or some populations in northern Canada will be reduced to an insignificant resource or extirpated. Action must be taken quickly to curb these caribou declines because recovery from population lows can take 1 to 3 decades. Meanwhile the population of the hunting villages is doubling every 16 to 20 years and land claims may delay implementation of restrictions. Solutions will be extremely difficult to achieve until all land claims are settled, but interim action is needed to save the Kaminuriak caribou population and to maintain adequate numbers in some of the others. Wolf control is needed to speed the recovery of the Kaminuriak and Beverly populations but without harvest quotas it will not save them. One approach to curbing the kill by hunters is an educational program with a goal of voluntary self-restraint (essentially self-management) by the user group. A second solution is some form of restriction imposed on the people by the management agencies with the involvement and support of hunter associations. The author feels that the first approach will not work in the short term and possibly not in the long run; but, in the present political climate, it is a prerequisite to attempted deployment of the second.

Thomas, D.C. and H.P.L. Kiliaan. 1982. A brief report on the March 1982 sample of barren-ground caribou from the Beverly herd. Canadian Wildlife Service unpublished report. 15 pp.

In March 1982, 132 caribou were sampled from the Beverly herd as it moved past Halliday Lake. Caribou 2 and 3 years old were over-represented in the sample and adult bulls (>3 yr) were under-represented. Condition of the caribou, as measured by weight and fat reserves, was good, compared with average in 1980 and excellent in 1981. The relatively high calf survival in 1981-82 reflects, in part, the excellent condition of the caribou before calving in 1981.

Thomas, D.C., G.R. Parker, J.P. Kelsall and A.G. Loughrey. 1968. Population estimates of barren-ground caribou on the Canadian mainland from 1955 to 1967. Canadian Wildlife Service Progress Note Number 3. 5 pp.

This note compares the latest to earliest estimates of caribou numbers. In 1949 Banfield estimated 668,000 caribou, in 1955, Kelsall and Loughrey estimated 278,000, and in 1967, Thomas and Parker estimated 357,500 excluding northern Keewatin. The reasons given for the drastic decline from 1949 to 1955 are; forest fires on winter range, low calf survival, and excessive human utilization. The mainland population can be expected to increase if human kill is reduced, there is a reduction in forest fires and there are good calf crops.

Thompson, D.C. and C.A. Fischer. 1979. Distribution and numbers of the Kaminuriak caribou herd in March and April, 1977. Arctic 32(3):266-274.

The distribution and abundance of the Kaminuriak caribou herd were documented through an aerial survey conducted in March and April 1977. It appears that the herd altered its traditional migration patterns and abandoned its southern wintering grounds in this year at least. The size of the herd was estimated at 30,770 animals, a significant decrease from 63,000 found in 1968. Available data though limited, suggest that the maximum allowable harvest of 5% of the herd has been exceeded in recent years. Although the possibility exists that some Kaminuriak caribou may have dispersed northward, it is considered most likely that the decline in the size of the herd is the result of overharvesting.

Thompson, D.C., G.H. Klassen and J. Cihlar. 1980. Caribou habitat mapping in the southern District of Keewatin, N.W.T.: An application of digital LANDSAT data. Journal of Applied Ecology 17 pp. 125-138. April, 1980.

In view of the significance of the Kaminuriak herd in the ecology of the region, a large scale study of habitat utilization of this herd was conducted in 1977. This paper focused on assessing the regional importance of broad areas within the southern District of Keewatin to caribou on a seasonal basis. Classification and

description of the area in terms of vegetation cover types was accomplished in the following manner: (a) sampling units were initially identified using LANDSAT imagery, (b) cover types were selected on the basis of past vegetation studies and each sampling unit was described quantitatively in terms of the proportion of each vegetation cover type it contained and (c) sampling units were clustered on the basis of having similar proportions of cover types. The relative intensity of use of each cover type by caribou was determined in the following manner; (a) the use of vegetation cover types by caribou was quantified in terms of the density of pellets each type contained and (b) the relative intensity of use of each cluster of sampling units was calculated on the basis of the proportion of each cover type within the cluster. Analysis of pellet-group counts by cover types showed definite trends in seasonal use by caribou. In winter, the Lichen Steppe and the Lichen-Heath tundra cover type received the greatest, and approximately equal, use by caribou, containing relative pellet-group densities of 36 percent and 35.8 percent respectively.

Thompson, D.C., G.H. Klassen and C.A. Fischer. 1978. Ecological studies of caribou in the southern district of Keewatin, 1977. Prepared for Polar Gas Project, Renewable Resources Consulting Service Ltd.

Studies to determine the distribution, abundance and habitat use of caribou of the Kaminuriak herd in southern Keewatin were conducted by aerial survey in March and April 1977. Aerial surveys revealed an estimated 30,770 animals. The greatest concentration was found near Chesterfield Inlet to the east end of Baker Lake. Field studies of habitat use were carried out during June and July. 54 sampling units were outlined by classification of LANDSAT images. Eight vegetation cover types were described and quantified by quadrat sampling. Cover type proportions were accumulated for each sampling unit and submitted to cluster analysis. The resulting four complexes displayed markedly different vegetation compositions. In winter the lichen-dominated cover types were preferentially selected and in summer the Dwarf Shrub-lichen tundra received the greatest use by caribou. Caribou feed heavily on lichens and mosses in winter. The use of sedges increases dramatically in summer, however, lichens continue to be a major dietary component.

Urquhart, D.R. in prep. The Beverly herd, part 3. 1933-1981. N.W.T. Wildlife Service Report. 262 pp.

This paper is a review and evaluation of information concerning the Beverly herd of barren-ground caribou in the Northwest Territories for the period 1933-1981. Topics covered include winter range, spring migration, calving grounds, summer movements and fall migration, seasonal distribution, reproduction, mortality, and population dynamics.

Walters, C.J., R. Hillborn and R. Peterman. 1975. Computer simulation of barren-ground caribou dynamics. *Ecological Modelling*, 1: 303-315.

This paper describes a simulation model of a Canadian caribou population. The model was constructed by an interdisciplinary team of field biologists, managers and systems ecologists. Population dynamics are represented in terms of age structure, with age-dependent survival and fecundity. Biomass dynamics of the major food species are also simulated, and the food dynamics interact with the caribou population through a foraging submodel that explicitly considers snow depth, seasonal migrations, and total area of useable winter habitat. The model was used to examine two hypotheses regarding the abundance of barren-ground caribou. It was shown that there is no reason to suspect that food supply currently limits the population size; instead, hunting pressure appears to be the critical variable. The implications of this finding for population management are discussed.

Wilk, A.W. 1958. Caribou studies. Canadian Wildlife Service unpublished report. 29 pp.

This report summarizes weather records, herd composition, antler condition and distribution data from a caribou survey conducted from 25 September to 15 December 1958. Males composed 26.9 percent, females 41.6 percent, fawns 27.6 percent, and yearlings 4.1 percent of 1,684 caribou classified. Immature males may have been included with the female class as they resemble cows. Wolf observations, rutting behaviour and herd locations are described daily in areas adjacent and south (to the Saskatchewan border) of Artillery Lake (Beverly winter range). Maps are appended showing flight lines and herd locations.

Williams, T.M. 1979. An evaluation of harvest estimates for the Beverly caribou herd from 1969-70 to 1978-79. N.W.T. Wildlife Service unpublished report. 53 pp.

The extent of hunter-induced mortality on the Beverly caribou herd was assessed. A literature review provided information on herd status, productivity, and natural and hunter induced mortality. Most of the data in the literature could not be compared effectively because of variations in extent and timing of surveys, lack of definition of herd boundaries, and variation in sampling techniques. Population censuses from 1954 to the present were summarized with a description of apparent herd status changes. The Beverly herd did not change appreciably in size between 1955 and 1970. Between 1971 and 1978 the herd appears to have declined. General Hunting Licence (GHL) returns were evaluated and were found to underestimate hunter kill. Six witnesses to native caribou hunts in northern Saskatchewan and the N.W.T. in 1978-79 were interviewed, and a subjective cripple loss estimate of 25% was derived from their reports. GHL kill data were

corrected for percentage of returned licences. A recently derived average annual estimate of productivity (12%) (based on the percentage of yearlings in the total population) and natural mortality (8.5%) were combined with corrected GHL kill data from 1967-70 to 1977-78. Average total mortality from 1969-70 to 1973-74 (10,186) was slightly less than estimated average productivity (12% of 160,000 animals, or 19,200) for the same period. Average total mortality (15,582) was greater than average productivity (12% of 124,000 animals or 14,880) from 1974-75 to 1977-78. Estimates of total mortality (18,710 and 20,230) for 1978-79 were based on an average N.W.T. kill figure of 2,616, and reported and estimated kill from northern Saskatchewan. At a 10.4% recruitment level for 1978-79 the Beverly herd was overharvested by the current level of harvest (14.8% and 16.1%). The author recommended that the accuracy of hunter kill data be improved, and that data on the effects of natural mortality factors on the Beverly herd be obtained. He stressed the importance of field studies to verify the extent of animal crippling and meat wastage.

Williams, T. M. and A. Gunn. 1982. Description of water crossings and their use by migratory barren-ground caribou in the Districts of Keewatin and Mackenzie, N.W.T. N.W.T. Wildlife Service File Report Number 27. 209 pp.

Migratory barren-ground caribou (Rangifer tarandus groenlandicus) swim or wade lakes and rivers at traditional water crossing sites. Land-use related activities are prohibited by the Department of Indian Affairs and Northern Development (DIAND) within a 5-km radius of each of the designated water crossings 15 May - 1 September on the ranges of the Beverly and Kaminuriak caribou herds in the Districts of Keewatin and Mackenzie, N.W.T. Locations of designated water crossings were confirmed from mapping trail patterns onto 1:60,000 aerial photographs in 1980. Frequency and period of use of traditional water crossings was described from a literature survey. Further descriptions of trails along the Thelon River and spring-summer use patterns were added in 1981. Of the 27 designated water crossings, 25 (40 sampling sites) were described from the ground. The descriptions of the designated water crossings suggest that caribou most frequently cross at narrows caused by peninsulas or other shoreline irregularities or where there is water turbulence or exposed rocks and gravel bars in the water. Recent declines in the sizes of the Beverly and Kaminurak herds have apparently altered the pattern of use of migration pathways and associated water crossings.

Yule, R.F. 1948. The disappearing caribou. Canadian Medical Association Journal 58: 287-288.

The author predicts that under current conditions the caribou will soon cease to be a major factor in the economic life of native hunters. He cites reports of oldtimers and personal observations that there are much fewer caribou in northern Manitoba than in previous years. He felt that three major reasons for the caribou decline were 1) indiscriminate slaughter by resident hunters, 2) feeding caribou to dogs and 3) wolf predation, especially on calves. The author predicts that the disappearance of caribou will result in a complete change in lifestyle for the northern Indians and inland bands of Eskimo.

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