THE IMPACT OF AN INTRODUCED POPULATION OF
ELK UPON THE BIOTA OF BANFF NATIONAL PARK

by

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ABSTRACT

In 1949, a study was carried out in Banff National Park to determine the relationship existing between introduced elk (*Cervus canadensis nelsoni*) and the other biota of the region; particular emphasis was placed upon possible competition with the indigenous moose (*Alces americana americana*). Subsequently, the historic relationships of the major floral and faunal species were further studied.

Elk were introduced into the Park in 1917 and 1919-20. They flourished and became so numerous that in 1943 their control by non-selective mechanical removal became necessary. This control has been continued to date but the condition of the main ranges is still unsatisfactory. Most elk winter ranges are heavily over-browsed and over-grazed and summer ranges are now beginning to suffer. Unorganized predator control has possibly worsened the situation.

Moose first entered the area (in recent times, at least) in 1916 and probably increased steadily to the late 1930's. They then apparently declined somewhat to reach a stable maximum by about 1943. Their reproductive rate appears to be excellent. They show no present apparent detrimental effect arising from the elk population, although the latter exerts a steady pressure by encroachment upon the drier portions of the moose range; and by almost complete removal of aspen, willow and dwarf birch reproduction in the Bow Valley and some adjacent areas. They will probably eventually affect the beaver-moose complex to the final detriment of these species.
Mule deer (*Odocoileus hemionus hemionus*) are indigenous to the Park, summering throughout the area but wintering, in the main, outside its confines. Destructive use, by elk, of much of the main Park winter range, below the 7 mile Beaver Dam in the Bow Valley, has depressed the resident deer population to a near static low. Herd increment appears to be low compared to other mountain regions such as in Utah.

Bighorn sheep (*Ovis canadensis canadensis*) have been in the Park area since earliest record, but have been dependent, for much of their range upon openings created by fires. Thus, Park policy of fire control has brought about containment of suitable bighorn sheep areas; these areas have, more recently, been invaded by elk. Bighorn have been numerous, and reached a possible maximum in the early 1930's. They then rapidly declined, possibly due to some epizootic. Recovery, if any, has been slow, probably due to the encroachment of the elk in recent years. Thus the sheep, suffering from debilitating parasitism and range impoverishment, are failing in the competition against the more aggressive and versatile elk, that apparently suffers less from parasitism and other biological limiting factors.

It is suggested that few of the components of the Park biota will eventually escape the influence of the elk. Man, as a member of the biotic community, by his actions and his very presence, influences that community often beyond the confines of his present perception.
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THE IMPACT OF AN INTRODUCED POPULATION OF ELK
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INTRODUCTION

In an annual report on the Canadian National Parks (Canada, 1944:79) it is stated that

"The Parks are hereby dedicated to the people of Canada for their benefit, education and enjoyment, subject to the Provisions of this Act and Regulations, and such Parks shall be maintained and made use of so as to leave them unimpaired for the enjoyment of future generations".

Thus Banff National Park, in common with most of our National Parks, has been dedicated to the maintenance of natural conditions, where indigenous flora and fauna may pursue their evolutionary course, and natural phenomena may be observed in the full play of seral progression and retrogression; in the ebb and flow of animal populations. But man, in his vision, forgot perhaps that he himself is an integral part of any biotic community, and his presence—even as an humble
student—must necessarily bring into play certain forces too frequently neglected in the common concept of natural conditions. If his numbers be few, and his activities be attuned to the natural complex, then he may, through interpretation of the past and study of the present, delve with some confidence into the future. But if his numbers be many, and his activities be merely those of a casual bystander, to be thrilled and amused, then he may well warp the evolutionary trend beyond the limits of present vision. Civilization has already taken its awful toll upon our rich flora and fauna. Its advent into our National Parks, with the consequent development of highways, golf courses, ski lifts, hotels and motels can scarcely fail to leave its mark. Fire, that great force of evolution, is contained and stamped out. Finally, indigenous life becomes inadequate, and exotic species are planted to further charm the jaded eye. Thus it is in Banff Park today, where hunting remains one of the few human activities still forbidden, and where elk plantings have released forces that cannot fail to influence the evolutionary pattern of plants and animals alike. It is, perhaps, time to take stock of the situation; to ask where we are going in our concept of National Parks. This study, having its beginning in a consideration of the moose-elk relationship in Banff Park, attempts to take us one step forward in our search for the truth.
SCOPE AND METHODS

On the authority of the then Dominion Wildlife Service, an investigation was carried out in 1949, during the months May to August inclusive, to determine what, if any, competition might exist between the moose and elk of Banff National Park; and to gain some insight into the implications of such competition should it be found to exist. The studies were mainly confined to the Bow Valley region west of Banff, but surveys were made of many other areas to gain a general knowledge of the problems existing in the Park, and to obtain comparative data by which to measure conditions found in the main study area. Such widespread observations could not fail to suggest the complex inter-relationships existing between four, at least, of the major big games species and their environments. Thus the dynamic aspects of the biota became the major interest (if not the major task) throughout the study.

The problem was approached from two aspects: study of the ranges and range conditions, and direct observations of the two major species concerned—to gain knowledge of local food and reproductive and life habits. In these latter studies greater emphasis was laid upon the moose since they were not only more readily observed in summer but were considered most likely to be affected by competition, judging
from population data. Daily records were kept of all wild-
life seen, and of visual estimates (supported by frequent
mechanical checks of browse height and branch utilization)
of browse and graze conditions on all ranges. Some quanti-
tative range determinations were carried out by means of
square metre quadrats. Pellet counts and observations were
used extensively to determine game species involved as the
animals themselves were frequently not present. Previous
floral studies were consulted for purposes of this investi-
gation, but over two hundred shrubs, grasses and forbs were
collected. Underwater plant species were obtained from moose
summer range by means of several hours of wading, knee to
neck deep, in lakes and marshes. Visual studies, with and
without aid of binoculars, were made of plants utilized by
single animals and by groups; by animals stationery and mov-
ing. These observations were made at times varying from day-
break to after sundown, to ensure the widest possible coverage
of behaviour pattern.

As before stated, chief emphasis was placed upon the Bow
Valley. But observations were made in some detail in the
Cascade Valley, Spray Valley and Waterfowl Lake areas. Recon-
naissance surveys were made into the Carrot Creek, Johnston
Creek, Boom Lake, Helen Lake and Howse River—Saskatchewan
Crossing (including Owen Creek) regions. Numerous other short
trips were taken, to round out knowledge of the Park and to
cross-check game movements and range use comparisons. In all,
these studies involved over 3,500 miles of travel by station wagon, 300-400 miles by foot, and some travel by horse and by rubber boat.

The elk were subjected to scrutiny first; to ascertain their food habits during the spring when new grass was not readily available. At the same time, a general survey of range conditions was made. Then, as the elk groups commenced to break up preparatory to calving, and to the final movement toward summer range, attention was turned more to the study of moose and further, more detailed, study of the ranges. As the summer progressed, studies were divided between moose and elk, with observations on sheep, deer and goat carried on concurrently.

Finally, the various Wardens in the Park were contacted and their observations, opinions and suggestions noted. The old-time wardens were questioned to obtain history of the region. Many of the available diaries were scanned and moose and elk occurrences noted. In particular, consolidated reports of all big game and predators, prepared by Special Warden H. U. Green, were studied to provide basis for comparison, and more particularly to gain an insight into the ecological complexities of the biota of the Park. Reference has been to Mr. Green's reports since this survey, to bring some of the data up-to-date.
THE PROBLEM AREA

HISTORY

The Rocky Mountains, for which the Rocky Mountains Park was named, originally were named Assin-wati by the Crees; this was translated in 1752 to the French Montagnes des Roches (Williams, 1929:7). But it was not until nearly a half a century later that explorers first entered the region now known as Banff National Park. In November, 1800, David Thompson and Duncan McGillivray ascended the Bow River to "The Gap", within about fifteen miles of the present Banff townsite, but did not proceed farther west. In 1840, Reverend R. T. Rundle, while working with the Stoney Indians, spent a part of June and July camped in front of what is now Mount Rundle, and in 1841 Sir George Simpson passed through the Banff area and proceeded to the Columbia Valley by way of Healy Creek and Simpson Pass. Next record is for 1845, when Father P. J. DeSmet crossed White Man Pass from the south, camped at Canmore, and then followed the mountain trail to Rocky Mountain House. Exact details of his route are not presently available. (Warren, 1927:1-2.)

In 1858 Captain John Palliser headed an expedition into the Rockies, adjacent to and possibly into what is now the Park, while in search of an all-British wagon road to the Pacific coast. He split his party in three and one
member, Sir James Hector, a geologist, ascended the Bow River to its junction with the Vermilion (Altrude Creek?), ascended to the Divide and turned north to the Kicking Horse Pass. (Williams, 1929:11-12.) The following year the Earl of Southesk went into the area (probably to hunt, so it is recorded) and travelled over the Pipestone Pass (from the Clearwater or Siffleur?) to descend the Bow River. In 1880 the first surveyors entered the now Banff Park area. (Warren, 1927:1-2.)

White men first saw and recorded the now famous hot springs of Banff in 1883. So important was this find considered that in 1885, upon completion of the Canadian Pacific Railway, the Government set aside ten square miles surrounding the springs, to keep the area fit for a first class resort. Thus Banff Park had its genesis. In 1887, impressed by the beauty of the area, a group of influential men and politicians were instrumental in having set aside, by act of Parliament, the Rocky Mountains Park, a recreational and scenic area of 260 square miles (including the original ten square miles). In 1902 this was increased to 5,000 square miles, but was, in 1911, reduced again to 1,800 square miles by passage of the Forest Reserves and Parks Act of that year. For game protection purposes it was again increased, some time prior to 1921, to 2,751 square miles. (National Parks of Canada, 1938:5 and Williams, 1921:13-14.) In 1929, the name of the Park was changed to Banff National Park.
Finally, in 1930, the Park was extended from its north-west terminus at Bow Summit, to Sunwapta Pass, southern terminus of Jasper National Park—so creating a short common boundary. Thus the Park today embraces 2,585 square miles of territory entirely within the Rocky Mountains and situate immediately east of the Continental Divide. Its western boundary is largely shared with the eastern boundaries of Yoho and Kootenay National Parks.

GEOLOGY AND GEOGRAPHY

It is probable that this section of the Rockies lay under water during part of the Cambrian period, and again during the Ordovician period when an inland sea stretched from the region of the Selkirks to the Laurentians. During the ages silt was laid down, to form in some places a layer over 50,000 feet in thickness. In the Carboniferous period, pressure over millions of years caused upheaval, and again toward the end of the Mesozoic era another thrust from the west crumpled the area, folds were raised up and faults occurred. In some areas rocks from the west side were pushed up over the eastern formations, leaving grey limestones sloping to the west and steep escarpments falling away to the east. Older formations were, in places, thrust over new. Then followed the glacial period, when thousands
of feet of ice capped the area, grinding and moving. Finally the ice receded, leaving the contours pretty much as they are today, though erosion and avalanche have made some marks. (Williams, 1929:9-11.) Today there may be seen within the Park some trace of almost every geological system from the Pre-Cambrian to the Cretaceous inclusive, excepting only the Triassic (Allan, 1913:167). The coal beds at the eastern boundary of the Park are of Cretaceous origin.

The Park, as constituted today, is transected by several mountain ranges which, in the main, follow a northwest to southeast trend and lie parallel to the Continental Divide. The Palliser, Cascade and Sulphur ranges show westward-tilted fault block of Palaeozoic and Mesozoic rock—with east face jagged escarpment and west sweeping sheer strata. The Sawback range shows Carboniferous and Devonian rock folded into compressed anticline (weathered into spires and saw-toothed ridges). Many of the mountains west of the Sawback range show Carboniferous and Devonian rock, with the abrupt limestone cliffs rising to round or wedge-shaped summits. (National Parks Association, 1948:7.)

From the many glaciers still existent within the area and from along the inter-mountain valley systems arise the headwaters of the Bow, Red Deer, Clearwater and North Saskatchewan Rivers, all of which flow generally eastward from the Park through the foothills of Alberta. Two major tributaries, the Siffleur on the North Saskatchewan and the
Panther on the Red Deer, follow a somewhat similar pattern. Within the confines of the Park several rivers of importance and countless creeks contribute to these major drainage systems. Of particular note are the Cascade and Spray Rivers, and the Fortymile, Healy, Red Earth, Johnston and Pipestone Creeks flowing into the Bow River, and the Mistaya, Howse and Alexandra Rivers flowing into the North Saskatchewan.

CLIMATE

Climatically, the Park is in a comparatively low precipitation region just east of the Great Divide. It lies, however, astride the dividing line between moderately heavy and very light precipitation areas. The headwaters of the Bow, Red Deer, Clearwater and North Saskatchewan Rivers, the Continental Divide itself, and west central areas generally north to and including Bow Summit, receive moderately heavy summer rains and deep winter snows which encompass both mountains and valleys. Easterly, the precipitation becomes progressively less, with comparatively light snow falling in the major valleys below the headwaters. Some easterly portions of the Park experience near drought; the same condition obtains in the North Saskatchewan Valley. The Spray Valley is transitional, receiving considerably more total moisture, winter and summer, than the adjacent Bow Valley.
It is suggested by Clarke (1939:3) that immediately following the last glacial retreat, the region under study contained only two plant associations, tundra and grassland, with wet meadow intermediate. Then Engelmann spruce (*Picea Engelmanni*) and Alpine fir (*Abies lasiocarpa*) invading from the west, interposed themselves at the junction of the two formations, and gradually pushed out to occupy the deep snow valleys of the west (some marshland areas still remain). From the northwest, white spruce (*Picea glauca*), with poplar (*Populus tremuloides*) as a forerunner, invaded the grassland area of the east and pushed forward into the mountains to meet the Engelmann association, leaving small areas of original prairie still extant. Thus today three major floral associations occur—grassland, tundra (alpine) and forest, the latter falling into three subdivisions—boreal, sub-alpine and montane. Green (1951) states that there is reason to believe that the Bow Valley and its bordering mountain slopes supported dense stands of dominant white spruce, crowded to the banks of the Bow River, for at least 110 years prior to the turn of the Twentieth century. In the Lake Louise area, however, in 1896 the major floral association from the Bow River to timber line was Engelmann's spruce with an occasional black pine (*Pinus ponderosa*—was more probably *Pinus albicaulis*). There were a few deciduous trees and bushes
adjacent to the banks of the rivers and open sphagnum swamps caused by morainal dams, and in clearings created by snow avalanches. (Wilcox, 1896:58-60.) Other possible exceptions may have been small areas of original grassland such as still exist at Mile 13 (Hillsdale) west of Banff. Origin of the Douglas fir (*Pseudotsuga taxifolia var. glauca*) at low altitudes in the Bow Valley is not clear. Lodgepole pine (*Pinus contorta var. latifolia*) exists throughout the Park as a fire type, with a tendency for such areas to revert to grassland after repeated or heavy burnings.

In 1890 a fire almost completely destroyed the forest of the slopes south of the Bow River from opposite the Vermilion Lakes to beyond Baker Creek to the west. In 1903 fire destroyed the forest from East Gate to Anthracite, north side of the Bow, and in 1904 another fire burned the slopes and valley floor north of the Bow from Vermilion Lakes west to Baker Creek and north some distance up Johnston Creek. It was following these fires that aspen poplar became a substantial part of the forest association of this area, and willow (*Salix Bebbiana Sarg.*) took over suitable valley floor habitats. In 1912 fire swept up both sides of the Spray River from near Banff to about Mile 18. The Panther River district was burned in 1926, and in 1928 the west slopes of Goat Range fell before fire. 1930 the area Cuthead toward the Palliser was burned; 1934 the Brewster Creek area; 1936 from Flint's Park toward the Palliser and Cascade
Valley, and in 1940 the Howse River-North Saskatchewan River triangle and the northeast slope of Goat Range were burned. The first and second Kananaskis fires, in 1926 and 1935-36 probably affected the southern reaches of the Park. It is considered probable that the main North Saskatchewan Valley must have been burned within the last fifty years, though no such fire is recorded. Certainly other fires have occurred in the Park, but are not recorded or remembered. But these burns, now at various stages of grassland—lodgepole pine association and reforestation, have provided the main big game feeding areas in the past and still support the larger faunal species—for a portion of each year at least. They are complemented, and to some degree supplemented, by the many willow (Salix vestita Pursh.) areas provided by avalanche action, and by willow and other browse species now present in or about creeks, rivers and marshes. Alpine meadows, with associated willow (Salix saximontana Rydb.), provide the third major source of food supply.

FAUNA

The history of the fauna of the Park is unfortunately not well recorded, at least until very recent times. Annual reports on the Park made little mention of wild species until the late 1930's. Therefore, it is necessary to draw
rather broad inferences from the few data available; to build up a picture of faunal occurrence from which one can draw present comparisons and point up dynamic inter-relationships.

Comparatively little is known of Rocky Mountain goat (*Oreamnos americanus missoulae*) and caribou (*Rangifer montanus*), either past or present, in Banff Park. Sir George Simpson (1847:118) reported sheep and goats along his route (in the Park) up to Simpson Pass in 1841. The record of the Earl of Southesk hunting in through the Pipestone area in 1859 would suggest the presence of goat, caribou or grizzly bear (or all three) in that region. Wilcox, in his report published 1896 on his work in the Lake Louise area, recorded the presence of goat, black bear and mountain lions. (Wilcox, 1896:58-60.) Caribou have been recorded only as early as 1902, and as recently as 1943 (Cowan, 1943:13), 1946 and possibly 1948 (Green, 1948:7). The Park cannot be considered good caribou range, and in light of present knowledge, this species probably warrants little consideration in this discussion of dynamic ecological relationships. The same may be said for the goat. The situation might be completely changed when good data are available on both these species. Goat are presently distributed throughout the Park in a manner to suggest that most of the suitable ecological niches are in some degree utilized. However, data are lacking
regarding total numbers, and carrying capacity of range is unknown.

Rocky Mountain bighorn (*Ovis canadensis canadensis*) have been indigenous to the Rockies and the foothills since earliest records, and in the United States used to extend east throughout the rugged and broken grasslands to the Missouri River and into the Dakota badlands. With the advent of the white man their range was restricted from this probable optimum, and they were forced to a readjustment of habitat whereby once marginal areas, or at best summer range, high in the mountains became home range. The species, so confined to the east, was halted in the westerly movement wherever deep snows occurred at or east of the Continental Divide, and was forced to exploit alpine meadows, and grasslands, the latter produced by the ever-increasing burns that heralded the advent of the white men. The constant encroachment of forest species upon these burns, plus man's efforts at fire control (first organized in 1909 in Banff Park (Canada, 1911:6)) would aggravate this precarious existence. This, it would appear, has been the situation in Banff Park north of Simpson Pass (Clarke, 1942:3), where sheep have been recorded as early as 1841 (Simpson, 1847:113). They are largely confined to the eastern ranges, with some invasion of central areas north of and adjacent to the Bow Valley. They were present in considerable numbers, possibly maximum, until the late 1930's when the populations commenced
dwindling. The same situation apparently obtains today, with extinction, though improbable, a possibility.

There are no early records of mule deer (*Odocoileus hemionus hemionus*) in the Park area. One can only surmise that, since they are inhabitants of the borderland between forest and grassland, they have flourished or failed with the successive changes of floral associations within the Park. They will most certainly have been in the Bow Valley since the fires of 1890 and 1903, as they are known to have been in the foothills since earliest record. They are presently found throughout the Park in summer, from valley to timberline, but in winter move to areas of light snow—both within and without the Park boundaries. The Bow Valley is the most important winter concentration area within the Park. Whitetail deer, (*Odocoileus virginianus macrourus*) are scarce within the Park today, and are not recorded in any early data. Cowan (1943: 10) records a small band resident along the North Saskatchewan River, and a few others along the Banff-Jasper highway from Mile 92 to Mile 102. A few summer occurrences have been noted in recent years, but winter residence has not been established. Further colonization is not certain and will probably be controlled by future range conditions. (Ibid:10.) They can, in the main, be ignored in this study, since their influence upon the faunal complex is minor.

Moose (*Alces americana americana*) are indigenous to the area, but of recent origin in most reaches of the Park. In
1906, the Park Superintendent reported that

"......There is at present a good number of big game in the park, consisting chiefly of moose, elk, deer, bear, sheep, lynx and goat, as well as marten and beaver, besides an unlimited number of game birds,"

(Green, 1946:2). Since at that time the Park encompassed 5,000 square miles, (exact boundaries not known) it is possible the moose reported were in the North Saskatchewan drainage area. J. Naylor, retired Park Warden, states they were known in that region long before they were ever seen in the lower reaches of the Park. Another possibility is that they were in the Ya-Ha-Tinda district. However, the Park was reduced in size in 1911, and it was not until 1930 that the Saskatchewan area was again included. Thus, the 1916 report, by Park Warden U. U. LaCasse, was the first record of a moose in the Park as then constituted, and the first reported occurrence in the southern area. This animal came from the Kootenays over Vermilion Pass. The next record was in 1923, when a moose was seen by Wardens J. Naylor and W. Child, near the abandoned beaver dams adjacent to Altrude Creek and the Bow River. The same year, Warden P. G. Woodworth saw a moose while on patrol into the upper areas of the Park (Pipestone country?). He considered it a most remarkable sight.

From this time on moose spread out over the Park. The Bow Valley population colonized, no doubt, in all directions, but its eastern movement halted at the confluence of the Cascade and Bow Rivers, where suitable habitat ended. Moose
are presently found along all important water courses in the Park. The Bow drainage system is the major area involved in this study.

One cannot pass from consideration of the moose of the Park without some mention of the beaver. The two species have been associated ecologically throughout history, and the situation here is no exception. It is difficult to escape the conclusion that neither species could or would have colonized the area, other than transitorily, but for the fires at the turn of the century. The aspen and poplar association following the fires created an environment attractive to beaver. They, in turn, conditioned the environment to the needs of moose. Thus commenced a sequence of ecological events still seen today in the lower Bow Valley.

The first beaver were observed in 1921, near the mouth of Altrude Creek, where they had established a pond and lodge. Subsequent movement downstream took place, with colonization at Red Earth Creek, then Healy Creek, Sundance Creek and Vermilion Lakes and area. Unsuitability of habitat ended this movement in 1931 at the junction of Cascade and Bow Rivers. About 1924, population pressure in the Vermilion Lakes area was relieved by emigration up Fortymile Creek, but by 1934 that area had been eaten out, and the population dispersed—probably to fall prey to coyotes (and possibly to cougar). By 1949, beaver in the lower Bow Valley were largely confined to a small area at Vermilion Lakes, where some reserves of poplar still remained.
Thus a colonization, undoubtedly made possible by the fires of 1890, 1903 and 1904, thrived, ate itself out and waned to but a few lodges. As for the remainder of the Park, three new lodges were seen on the Spray and Bryant Rivers in 1942, but no other firmly established colonies are known. Itinerant beaver may occur from time to time.

The last big game species to be considered is the elk (Cervus canadensis nelsoni). It has been noted (under moose) that elk were reported within the Park in 1906. This is contrary to the statements of Mr. James Simpson and Mr. N.K. Luxton, both of whom state there were never elk in the Park, within their memory, prior to the first planting. Mr. Simpson, at least, has been in the area since before the turn of the century. It is possible that this conflict of opinion has arisen because of the shift in boundaries that took place, but it seems fairly definite that elk have never been indigenous to the Park, as now constituted, at least within the memory of living man. Sir George Simpson, however, during his passage through the area in 1841, recorded that one of his party killed a red deer two miles from the Bow Traverse, where they crossed the Bow River (Simpson, 1847:122). He further reported fresh tracks of red deer the second day down from Simpson Pass towards the Kootenay River (Ibid:121). It is not known if by this he referred to elk, but this seems probable since the term red deer, as applied to whitetail deer, is believed to be of more recent origin. Certainly
elk remains in many areas along the foothill country north of Morley, Alberta, indicate the species was common (and plentiful) immediately east of the Park. These remains were reported to Mr. H. U. Green by Mr. George McLean, an educated Stoney Indian of venerable years. He stated that in some places they covered several acres, and he discounted any theory of slaughter by Indians. A general die-off through disease and/or starvation seems more probable. This whole situation parallels the history of elk in the United States, where it is early recorded that elk frequented the upper Rocky Mountain ranges in summer, and where die-offs nearly extirpated the species.

Elk are known to have been in the Canal Flats-Invermere country about the middle of the 19th century, and were present in some numbers to the 1870's when a severe winter almost extirpated the population (from information given by Mr. M. Morigeau, Fairmont Springs, B. C.). They recovered slowly and by 1916-1920 were considered to be common again. They moved up and down the Kootenay drainage system, and undoubtedly approached, at least, the summits of the Divide and the Banff Park border. It is not unlikely that the elk sighted at Egypt Lake during the summer of 1945 (Green, 1946: 4) were from the Kootenay herd. Cowan also records some instances of elk crossing the west boundary of the Park (Cowan, 1943:14). However, since it was not until 1922 or 1923 that they were in sufficient numbers to warrant an open
season in British Columbia, it is unlikely that population pressure has been sufficient to bring about more than chance summer occupation of any part of Banff Park.

To the east of the Rockies elk were plentiful prior to 1891, and it seems probable that they were present in most suitable areas bordering the Park. The fire of 1890 should have provided outlet for pressure-induced colonization. But in 1891-92 a most severe winter was experienced and it is recorded that in Yellowstone National Park 5,000 of an estimated 25,000 elk died of starvation. Again in 1898-99 unusually severe winter conditions prevailed, and the elk along the eastern limits of the Rockies became virtually extinct. (Skinner, 1950:22.) Large gaps were left in a once almost continuous population. It is believed that such a gap existed immediately to the east of the Park.

In 1916 arrangements were made by park authorities to obtain elk from the National Park Service of the United States, and in February, 1917, a total of fifty-seven elk were received from Yellowstone Park. In June, 1918, forty-one were released. In January of 1919 or 1920 an additional 206 were obtained from the same source; twelve died en route. Fifty-three of these were released at Massive, twelve miles west of Banff, and 141 at Duthill, eight miles east of Banff. In all, 235 elk were released in the Bow Valley. (Green, 1946:2.) They flourished, and soon began to migrate. Cowan (1943:14) gives the following chronology of dispersal as indicated by first
appearances in the respective areas:

"Banff-Bow Valley, introduced 1917; Panther River—first seen 1927 (C. C. Fuller); Snow Creek Pass—first seen 1931 (W. Childs); Red Deer at Yaha Tinda Ranch, first seen 1933-34 (C. Murphy); Saskatchewan—first summering bulls 1936 (Davies); Indian Head cabin on Clearwater River—first seen 1942 (Chas. Phillips); Little Pipestone—first wintered 1942-43 (P. Woodworth); 9 miles north of Lake Louise on Jasper Highway—first wintered 1942-43 (P. Woodworth)."

By 1943 removal of surplus elk was considered necessary and since that date some elk have been slaughtered each winter. In spite of this elk continue to be plentiful. Main permanent concentrations, determined by winter range, appear to be along the Bow Valley from the East Gate to Louise, the Upper Spray Valley, the Upper Cascade Valley and the North Saskatchewan River. Other small local groups no doubt exist.

Nothing is known of the advent of the major predators in the Park, except in the case of wolves. Bear, both black (Ursus americanus americanus) and grizzly (Ursus horribil-is) are present, the former in some abundance. Simpson (1847: 121) records bear tracks on the south west slopes of Simpson Pass in 1844, but does not state for which species. Wilcox, in 1896, records black bear in the Lake Louise area (Wilcox, 1896:58-60). Cougar (Felis concolor missoulensis) appear to be of rare occurrence in the Park today, but were recorded also by Wilcox in 1896 (Ibid). They were considered over-abundant by park authorities in 1935, and Mr. E. R. Lee of Vancouver Island was employed to hunt them. During the
period 10 October, 1935, to 26 January, 1936, he killed nine cougar— one at Massive and eight along the Bow Valley between Banff and East Gate. (From Government files.) More recently, Green records a female and two kittens near the Aylmer Range in 1946, tracks of one adult near Johnston Creek Range in 1946, and tracks of two adults near Eisenhower Range in 1947 (Green, 1949:35). True status of the cougar in the Park is presently unknown. The coyote (Canis latrans) is plentifully represented and has probably been present as long as the valleys have been semi-open and have supported deer.

The tracks of wolves (Canis lupus occidentalis) are recorded by Simpson (1847:121) as occurring just over Simpson Pass into the Kootenay area, so presumably they ranged into the area now in Banff Park. However, according to Cowan, they made their first appearance, in recent times, in the winter of 1942-43 when two entered the Park in the Saskatchewan River area. In 1945 five or six wolves hunted the Clearwater Valley and denned just outside the Park. In 1943 a small resident population in the Ya-Ha-Tinda area worked along the Red Deer River to Scotch Camp, and ranged up the Panther River to Windy Cabin. In 1946, however, evidence was seen that a pair had denned in the Panther River Valley for at least eight years. (Cowan, 1947:145.) More recently, Warden E. Young reports that in 1948 there was a pack of fourteen wolves in the Ya-Ha-Tinda Ranch area. In 1944-45 three individuals passed through the Ghost River-Minnewanka Lake area, and in 1943,
1944 and 1945 single animals were seen at Bow Summit, Goat Creek, and in the Bow Valley eighteen miles west of Banff (Ibid). According to Mr. U. U. LaCasse, a retired Park Warden, wolves came into the Bow Valley in about 1942-43 and a group became established up Johnston Canyon or Creek shortly thereafter, operating up to the Pulsatilla Mountain area and down into the Bow Valley. The pack finally numbered nine according to his count. By 1949 wolves were reported on all major game ranges in the Park.

In considering, then, the general picture of the flora and fauna of the Park, it is seen that today the major concentrations of moose, elk, sheep and mule deer are to be found, for part of the year at least, upon the same ranges--ranges that are in the main the product of fire. The wolf and coyote, too, of necessity must frequent these same areas. It will be seen, therefore, that any one species or range is subject, in some measure, to the impact of a complex involving range, herbivore and predator; no one factor can be divorced from the consequences of its biological whole.
MOVEMENTS AND FOOD HABITS OF ELK

As stated earlier, elk plantings in Banff Park were most successful, and from a slow beginning the populations expanded until by 1936-37 (according to verbal reports obtained in 1949) the ranges adjacent to the areas of liberation were already heavily overgrazed. Conditions worsened until 1943, when the first elk slaughter was carried out. Non-selective removal has been carried out every winter since. But in 1949 the mature aspens "chawed" (barked by gnawing of elk) to heights of seven feet, and the deteriorated condition, or complete absence, of browse species bore mute testimony to past over-population by elk, and gave credence to the thought that all was not yet well ecologically.

Observations on elk movements and feeding habits were begun on 8 May, 1949, in the Bow Valley from Banff to Eisenhower, and continued daily until 16 May. Individual observations lasted from a few minutes to half an hour, and were carried out at varying periods of the day, though largely during late afternoon and evening. Elk numbering from one to thirty were observed. During this period, only one instance of browsing was noted; this the casual browsing of dwarf birch (*Betula glandulosa*) by one elk (of a group of...
thirty) during the evening of 11 May. A male elk was seen eating bark off a fallen poplar about 15:45 hours on 10 May. During 16 May, three bull elk fed in the typical moose habitat of First and Second Vermilion Lakes area, but were definitely grazing. Seventeen May, twenty-six elk were seen in the 17 Mile area, four of them out in the boggy, willow-type flat, but no feeding observations were possible. Practically all the adult bulls had left the winter range, and the females and young males were dispersed into small groups. From 17 May to 6 June, two hundred "elk minutes" of observation were accumulated; only grass and forbs were eaten by elk. By the end of this period migration to summer range was apparently completed, and only a few females and an occasional male remained on the winter range between Banff and Eisenhower.

On 17 June, a cow elk was seen south of the lake in the 17 Mile Flat region. During the five minutes it was observed, it searched out and thoroughly browsed a willow. Subsequent examination showed the area to be completely grazed out, with food almost unobtainable. It seemed almost certain that acute need forced this choice of food upon the animal, which appeared to be feeding a calf. The same day a cow and calf were seen in the typical moose area at Muleshoe Lake, but were observed only to graze during the ten minutes they were watched. On 25 June, in the late evening, two bulls and two cows were observed in the 17 Mile Flat area. The cows were watched closely for forty minutes and were seen to browse
willows both casually and deliberately during this period. Further observations were difficult, due to darkness, but judging from the positions of the animals' heads, it was considered that they browsed five to ten per cent of the time. Subsequent investigation indicated that sedges in the area were sufficiently high to invalidate part of this data.

The fourth of July, eight cows and four calves were observed grazing on the flat south of Second Vermilion Lake, and the same day ten adults and four calves were seen grazing near 12 Mile area west of Banff. On 25 July, twenty elk, believed to be females, were seen grazing between 10 Mile and 11 Mile in late evening. Three days later one cow was seen grazing in this area.

Throughout this period female elk were known to be on the valley floor of the Spray. Warden W. Child reported 29 June that he knew of a mixed herd between Goat Creek cabin and Banff. Cows were seen between Goat Creek cabin and 15 Mile cabin on 25 July, 29 July and 13 August, but no actual food observations could be made. A check of the area revealed no evidence of recent browsing of willow or dwarf birch. Throughout this period, of course, elk were observed upon the summer ranges of the Spray area. Observations by binocular indicated they were grazing. Similarly, elk were seen on the upper grass ranges of the Cascade region throughout the summer. Warden E. Carleton reported that a herd of twenty to thirty elk grazed frequently around a swamp in Flint's Park
area during the summer. On 13 August, twenty-five cows and calves were reported to be on the valley floor about half a mile inside Cascade gate, and on the 15th a mixed herd of 108 elk was seen in the willow flat on the valley floor south of Cuthead. It was not found possible to later visit this area to make food determinations.

Early on 22 August, a herd of twenty elk (two males, six calves and twelve cows) were observed for twenty minutes outside the cabin at Hillsdale. They were seen to browse the short willow quite deliberately. The two males were the most avid browsers, but the others browsed at least fifty per cent of the time. Later examination of the approximately two acres concerned showed that total available graze had been utilized forty to fifty per cent, and willows thirty to forty per cent. Willows utilized had fifty per cent of the leaders eaten back from four to ten inches. It was noted at this time that grasses and forbs were brown and very dry, the result of the dry season and normal fall curing.

Generally, it may be said that elk were seen or reported from almost every area of the Park throughout the summer. On 22 August, seven bulls were seen, in the upper reaches of Johnston Creek Valley, moving rapidly south toward the Bow—the first evidence of fall migration for the rut. The first bugling was reported about the middle of August but it was not until 29 August that it was heard regularly during the late
evenings and throughout the nights. This was later than the normal, according to competent observers.

No attempt was made to list all plant species utilized by the elk. Wildlife literature is rich with studies of elk food habits, and the range problems pursuant thereto. Green (1946:30-32) lists the main grasses, shrubs and forbs of the Bow Valley area, and notes those utilized by elk. Murie (1951:195-252), in his monumental book on elk, also deals in detail with elk foods and food habits. It was noted, however, that shrubby cinquefoil (*Potentilla fruticosa*) was completely untouched even in heavily overbrowsed areas. Bearberry (*Arctostaphylos uva-ursi*) and buffaloberry (*Shepherdia canaden sis*) showed little evidence of elk browsing, though cited by both Green and Murie as elk foods. Gaffney (1941:444) confirms this lack of use of these three plant species, except under extreme duress. The versatility of the elk is so great that such minor variations in food habit are probably of little importance, except where affecting plant indices. The observations regarding shrubby cinquefoil were considered significant in this latter respect, since this species fail completely to point up range conditions in Banff National Park (see Murie, 1951:231).
VITAL STATISTICS OF ELK

It is probable that, since the 1943 elk slaughter at least, better record has been kept of the Banff Park elk than of any other comparable herds on the continent. It was felt, therefore, that little further data were needed, other than casual day to day counts as opportunity provided. Such observations were somewhat spurred by early reports of wardens that the calf crop was very low, and some effort to tally Bow Valley elk was made. The records kept from the time the first calves were seen (see Table I) indicated a cow to calf ratio of 3:1. No attempt was made to relate calves to total number of elk seen. Warden W. Black estimated a ten per cent calf crop in the North Saskatchewan area, but gave no actual figures. It is not thought that any duplication in calf counts was made, but certainly some duplication in yearling counts occurred. Twenty-four yearlings in all were seen, but highest day counts fix the figure at twelve. In all about sixty elk remained on the Bow Valley winter range throughout the summer. Actually, little reliance is placed upon these summer counts made on the lower ranges, since dry cows may or may not be present, and calves are most difficult to see. Rather, the figures given by Green (unpublished records) for the years 1944-51 are considered best indication of herd increment and are noted in Table II. It is interesting to note that the calf to total herd ratio in 1949 was 1:3. This confirms the
Table I. Sight records of elk cows and calves in Bow Valley, Banff National Park, in 1949.

<table>
<thead>
<tr>
<th>Date</th>
<th>Number of adult females seen</th>
<th>Number of calves seen</th>
<th>Place</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 June</td>
<td>13</td>
<td>7</td>
<td>Muleshoe Lake</td>
<td>Not accurate due to distance</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td></td>
<td>12 Mile area</td>
<td>Observed closely</td>
</tr>
<tr>
<td>17 June</td>
<td>2</td>
<td>1</td>
<td>17 Mile Flat</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>1</td>
<td>Muleshoe Lake</td>
<td></td>
</tr>
<tr>
<td>4 July</td>
<td>8</td>
<td>4</td>
<td>Second Vermilion Lake</td>
<td>Seen at distance</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>4</td>
<td>12 Mile area</td>
<td>May have been more calves</td>
</tr>
<tr>
<td>18 July</td>
<td>4</td>
<td>4</td>
<td>17 Mile Flat</td>
<td>Observed closely</td>
</tr>
<tr>
<td>25 July</td>
<td>20 (†)</td>
<td></td>
<td>10-11 Mile area</td>
<td>In woods, may have been calves</td>
</tr>
<tr>
<td>28 July</td>
<td>1</td>
<td></td>
<td>11 Mile</td>
<td></td>
</tr>
<tr>
<td>13 August</td>
<td>1</td>
<td>1</td>
<td>Sheep Lick, Vermilion Lakes</td>
<td></td>
</tr>
<tr>
<td>22 August</td>
<td>12</td>
<td>6</td>
<td>Hillsdale</td>
<td>Close count</td>
</tr>
</tbody>
</table>
belief that many calves are missed in a summer count.

Table II. Elk calf and yearling counts (percentage of total herd) for Banff National Park.

<table>
<thead>
<tr>
<th>Year</th>
<th>Calves Percent of total herd</th>
<th>Yearlings Percent of total herd</th>
</tr>
</thead>
<tbody>
<tr>
<td>1944</td>
<td>23</td>
<td>13</td>
</tr>
<tr>
<td>1945</td>
<td>21</td>
<td>11</td>
</tr>
<tr>
<td>1946</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>1947</td>
<td>24</td>
<td>8</td>
</tr>
<tr>
<td>1948</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>1949</td>
<td>25</td>
<td>7</td>
</tr>
<tr>
<td>1950</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>1951</td>
<td>22</td>
<td>5</td>
</tr>
</tbody>
</table>

It is not intended to discuss further the implications of a 1:3 calf to total herd ratio. This rate compares very favorably with the figures given by Murie (1951:138-143). Cowan (1943:16) and Green (1946:10-11) also have discussed the reproductive success at some length. However, the considerable loss, shown in Table II, from calves to yearlings is significant, and as yet not satisfactorily explained. The answer may well fit in with the general unsatisfactory ecological changes pursuant to elk activities in the Park.
ELK LOSS FACTOR

Loss factors are very well discussed by Green in his work on elk of Banff Park (Green, 1946:11-15). He covers mechanical destruction, predators, calf and winter losses, and losses due to disease, parasitism, accident and general factors. To bring the losses due to non-selective removal up to date, Green's figures (Ibid. 12) are given in Table III, with additions from his notes. It is indicated that 1,459 elk were removed by the spring of 1950. Further reductions have been made, but the figures are not yet to hand.

Table III. Elk removed by slaughter from Banff National Park.

<table>
<thead>
<tr>
<th>Year</th>
<th>Number removed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1943 - 44</td>
<td>74</td>
</tr>
<tr>
<td>1944 - 45</td>
<td>200</td>
</tr>
<tr>
<td>1945 - 46</td>
<td>352</td>
</tr>
<tr>
<td>1946 - 47</td>
<td>321</td>
</tr>
<tr>
<td>1947 - 48</td>
<td>257</td>
</tr>
<tr>
<td>1948 - 49</td>
<td>93</td>
</tr>
<tr>
<td>1949 - 50</td>
<td>162</td>
</tr>
</tbody>
</table>
Wolf predation was considered important, and checks were made in 1949 to determine the occurrence of these predators. Warden W. Black saw two wolves in the North Saskatchewan area in August, and stated there were more in his district. He killed six in 1948. Wardens E. Young and J. Woledge reported a pack of fourteen was resident in the YaHaTinda area in 1948, and was presumably still present. On 2 July, a female and three pups were seen by Warden E. Carlton near Cuthead in the Cascade Valley, and two pups were killed. On 15 August one wolf was seen in the same area. Retired Warden U. U. LaCasse stated that there were nine wolves in the Johnston Creek area but during the summer of 1949 one was seen up the creek on 24 June (Woledge), four were seen in the same area 25 June (Young), two were seen near Pulsatilla Summit on 20 July (Woledge), and one comparatively fresh scat was seen on Edith Pass on 11 August. During June two tourists (women) reported two wolves seen from the highway near Johnston Creek. One old track, possibly a wolf's, was seen along Carrot Creek during the summer. Warden W. Child saw a wolf on 11 July at 15 Mile cabin in the Spray Valley.

Elk loss to wolves was a major interest in this study. Opinion was divided, among members of the Park staff, as to whether elk or moose fell more readily prey to wolves. One warden felt there was no difference, but that the lesser numbers of moose made their losses more significant. All felt
that predation upon elk was significant, however. Cowan stated in 1947 that elk contributed forty-seven per cent of the big game diet of wolves in Banff and Jasper Parks (Cowan, 1947:173). The wolves have increased in Banff Park since the time of his studies, so the general opinion regarding predation may be sound. However, no kills directly attributable to wolves were seen in 1949; the carcasses noted were beyond adequate interpretation as to cause of death.

This predator-prey relationship points up a possible interesting situation. Elk were planted in the Park prior to the advent of the wolf, when no major cursorial predator was present in significant numbers. In 1935 cougar control was carried out over one of the main elk concentration areas, and by 1942-43, when the first wolves made their appearance, the elk had already reached a population high requiring mechanical removal. No evidence has been seen in the records, or throughout this study, to suggest that wolves at any time affected detrimentally the elk population (see also Cowan, 1947:172); rather the effect may have been beneficial. Well meant but unofficial killing of wolves has tended to perpetuate this situation. Gaffney (1941:439), in a paper on elk in the Flathead, Montana, lists the almost complete extermination of cougars in that area as a contributing factor to elk overpopulation. In the North Saskatchewan region, however, where elk first became firmly established about 1940-41 and wolves entered the area in 1942-43, the elk herd seems to be
adjusted to its environment and showing only moderate population increase. It is too presumptuous to state that wolves have been solely responsible for this situation; but their presence has done no apparent harm and may indeed be beneficial. At the present time, in fact, any normal losses (other than by epizootics) may be considered beneficial to the elk populations generally in the Park.

ELK RANGES

It was apparent from the outset of the 1949 studies that the elk were their own worst enemies. In May it was estimated, without previous knowledge of the range, that the Banff-Hillsdale-Eisenhower area had a grass carryover of about twenty-five per cent on the valley floor. This was further utilized before the new growth carried the still resident elk, and final carryover generally was about twenty per cent. This figure agreed with Green's 1949 report on ranges, wherein a final carryover of twenty per cent was estimated (typewritten report made available). Hillsides, particularly south slopes, showed very heavy overuse. One such in the Hillsdale area showed ninety-five per cent plus usage for the first one third of the slope, and one hundred per cent usage on up, with roots and crowns of grass alone remaining. Hoof erosion varied from marked to slight along
the various slopes. Areas of pine grass (*Calamagrostis rubescens*) were relatively untouched.

On 12 May, a six foot wide 1,200 yard reconnaissance transect was made through Hillsdale meadow from the cabin to the railroad—thus including meadow and semi-open aspen areas. Three hundred and eleven elk pellet groups, or one to every 7.7 square feet, were counted. Only one dwarf birch out of every hundred was found without all terminal shoots eaten, all willows were completely browsed, and no aspen reproduction (saplings or seedlings) was noted. On 13 May two similar transects were run, one from Hillsdale cabin to Red Earth Creek road, and one from the road west to the far end of the south Hillsdale meadow. On the first transect of 1200 yards, through meadow, open aspen woods and 50-50 aspen and spruce, the count was again one group of pellets to every 7.7 square feet. Again all willows were browsed completely and aspen reproduction was wanting. The second transect, of 1600 yards, mainly through meadow, showed one group of droppings to every 2.4 square feet.

Square metre quadrates were clipped in the north and south Hillsdale meadows in May, as were several also along the highway to test elk pressure in wooded and/or pine grass areas. A comparable set was clipped in August, after completion of summer growth. The original quadrates in the north meadow were also reclipped to test the effects of one hundred per cent winter utilization upon the ensuing year's growth.
Totals registered are shown in Table IV. All weights are for air-dried condition. The figures shown for the plots along the highway confirm the belief that deep woods and pine grass associations were relatively unused by elk for feeding areas, since the fall clips still included a major portion of the past winter's carryover. If the original estimates of spring carryover were accurate (as there is reason to believe they were) then the growth in 1949 was down badly. This was believed to be the case, judged from visual observation. The yield from the re-clipped plots pointed up the harm to be done by drastic over-utilization. Clarke and associates, in an ecological and grazing capacity study on the prairies, recommend a forty-five per cent carryover of the principal forage species (Clarke et al, 1942:20). Hunter, in Colorado, believes that a twenty per cent carryover of grasses and weeds is sufficient (Hunter, 1945:238). The range observations made in Banff Park suggest that Hunter's figure allows no margin of safety, and that thirty per cent to forty per cent carryover at least is to be desired. Late rains in July brought some relief to the ranges, but by late August the grass areas were still in unsatisfactory condition. Generally, this situation applied to all grass ranges from Banff to Eldon; some areas were poorer than at Hillsdale.

The shrubs in the Hillsdale meadow area were extremely overbrowsed. Average height of dwarf birch was fifteen to eighteen inches, and of willows twelve to eighteen inches,
Table IV. Data on square metre quadrates clipped in Hillsdale area, Banff National Park.

<table>
<thead>
<tr>
<th>Area</th>
<th>Number of plots clipped</th>
<th>Spring clip (gms.)</th>
<th>Comparative fall clip (gms.)</th>
<th>Per cent spring carryover in terms of fall growth</th>
<th>Estimated per cent spring carryover</th>
</tr>
</thead>
<tbody>
<tr>
<td>Along highway</td>
<td>7</td>
<td>476.5</td>
<td>732.8</td>
<td>65.0</td>
<td>--</td>
</tr>
<tr>
<td>South meadow</td>
<td>10</td>
<td>999.1</td>
<td>2116.0</td>
<td>47.2</td>
<td>20</td>
</tr>
<tr>
<td>North meadow</td>
<td>10</td>
<td>1083.4</td>
<td>1788.1</td>
<td>60.5</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>1007.1</td>
<td></td>
<td></td>
<td>re-clip*</td>
</tr>
</tbody>
</table>

*Original ten plots in North meadow re-clipped to test effect of one hundred per cent utilization.

Most willows appeared to be nearing extinction—a situation universal throughout the area Banff to Eldon. Wet or semi-wet ground willows showed better growth, with heavily browsed live stems to heights of three to four feet; all growth above this was killed. It was estimated that browse utilization was eighty per cent to one hundred per cent.

It was noted, by pellet observations, that except in a few rare instances there appeared to be a distinct dividing line between areas of elk and moose utilization. This line occurred at the edge of all moist or boggy areas. Thus in
lownland meadows the usual overbrowsed condition common to elk range would prevail, yet small boggy willow patches would be completely untouched by elk; though heavily browsed by moose. This was particularly noted in the 10 to 12 Mile area west of Banff and in the 17 Mile meadow. In the latter case, the area completely surrounding the boggy meadow, and including the lake, was destructively browsed by elk yet the eastern two thirds of the meadow, covered generally by willows up to two feet in height and over two to three acres by willows five feet in height, was almost untouched, except by moose. Elk tracks were seen passing through this area but no direct evidence of browsing was seen.

Perhaps the most startling effect of elk upon this range was the almost complete removal of aspen reproduction throughout the Bow region. Aspen seedlings and saplings were to all intents and purposes completely absent from the immediate vicinity of all favored graze areas, and reproduction was inadequate to preserve the stands. It was noted that elk browsing grew progressively less as one moved back from "preferred" grazing areas. Check plots showed that sixty-six per cent of the aspens immediately adjacent to the Hillsdale meadow were "chawed", many of them to heights of seven feet. Two hundred yards back only fifty per cent were "chawed". August checks indicated that young seedlings did get up to a height of several inches by fall, but they presumably were eaten completely back again each winter and spring.
Overpopulation by elk brought about the original aspen deterioration in conjunction with extreme range overuse. It would appear that even reduced herds now remove all seedlings, probably incidentally while grazing. In the Queens Park area a considerable stand of aspens, apparently "chawed" at an age when they were just too big to be broken down, was observed to be going down under the winter snows. Little regrowth was seen in this area and it is evident it will not survive.

Re-examination of the browse species in August indicated nearly one hundred per cent recovery from the spring condition. However, this was still far below the potential. To check this, data were derived from the Index plot about ten miles west of Banff, and noted in Green's work on elk (1946:27) as Plot number 1, Sub-area A, Unit area 2--fenced in April, 1944, when utilization of dwarf birch and willow was eighty percent. The area enclosed mature aspen, so was typical of the area. When checked, the outside area showed the typical condition--dwarf birch and willow up to fourteen-twenty inches in height and aspen reproduction nil. Within the plot, five dwarf birch clumps averaged six feet in height and willows averaged three to five feet. Aspen reproduction was as follows: sixteen saplings averaging seven feet, nine averaging three to four feet and fifteen first year seedlings.

It is not known if Hunter (1945:238) is again bordering the critical point in range usage when he recommends a fifty per
cent carryover of current years browse growth. But the comparisons noted above clearly indicate the degrading effect of eighty per cent to one hundred per cent browse utilization.

Before leaving the discussion of this elk range, some mention must be made of another factor working in the north Hillsdale meadow. Ground squirrels (Citellus columbianus columbiaus) were found to be most numerous. Invasion by large rodents is a commonly accepted index of over-grazed range; this area proved no exception. Whether these ground squirrels will eventually benefit the range by eating the undesirable plant species, as is suggested by Bond (1945:233), is a moot question. By fall it was observed that every "gopher" hole was surrounded by an area eaten completely bare—for an average radius of three feet. It was estimated in 1949 that unless they were controlled, the carrying capacity of the north meadow would be lowered significantly. Under present circumstances, this would, it is believed, outweigh any possible good achieved.

The range from Banff to the East Gates was checked, and the situation found to be essentially the same as that already described—with recovery even less than at Hillsdale. Destructive browsing of willow growth was found at the entrance to the gorge leading to the Carrot Creek summer range. This, however, was believed to be due to a build up of elk prior to a rush through the gorge, or possibly because of delay engendered by unfavorable conditions within it. This
interpretation was strengthened by the fact that willows
(Salix subcoerulea Piper = Salix Drummondiana Barrat var.
subcoerulea Piper) and birch (Betula pumila L. var. glandu-
llifera Regel.) on up the creek north of the gorge were plen-
tiful and in good condition—they showed only moderate
browsing by moose (pellet diagnosis). The Carrot Creek sum-
mer range showed the destructive effect of "chawing" upon the
aspen, though graze conditions were fair. This suggested
that this area was used, on occasion at least, as a winter
range.

The Spray River elk ranges were inspected several
times during June, July and August. They were generally in
excellent condition, with the south-east section of the upper
range showing deterioration by late summer. Some of the
ridges of sharp repose also showed decline in range condition.
However, since this valley receives more precipitation than
the Bow area, there was no reason seen to consider the area
overpopulated. The valley floor carried only a limited
amount of forage, but no indication of summer browsing by the
then resident elk was seen. However, heavy winter browsing
of willow on the low, open flats, with utilization eighty per
cent to ninety per cent and average willow height eighteen to
twenty-four inches, was noted. It was impossible to deter-
mine whether this was the work of elk or moose, but it was
probably caused by both. Regrowth in August appeared to be
excellent, in terms of the spring condition.
Quite a different situation was evident on the Cascade ranges. These areas, chiefly invaded high-altitude sheep ranges, were seen to be in poor condition throughout the summer. Incipient erosion was quite evident. Since many of these ranges are on steep westerly slopes of the Palliser Range, erosion is to be expected after only moderate over-grazing. This, however, made the situation no less acute. Considerable browsing of the willows on the Cascade valley floor was noted, and questioning elicited the information that in the fall of 1948 elk were found on the valley floor during the slaughter—the first time this had been noted. Obviously, browsing must have occurred since graze species were limited. No serious harm was yet evident in 1949, but as noted earlier, elk in some numbers were again on the valley floor—this time in August. It must be anticipated that if this behaviour continues, serious harm to the browse species must certainly ensue. A check on 29 August, of the Flint's Park and Windy ranges to the north showed them to be brown and in poor condition, with much bare ground showing. Generally, the entire range area of the Cascade gave the impression of low carrying capacity and impaired vitality.

The North Saskatchewan elk ranges were given scanty check. Since the range lies in a low precipitation area, no lush growth was expected. However, the several short visual checks indicated no deterioration of range. Low willow growth on some of the river flats had been heavily browsed,
probably by both elk and moose. It is not believed that this indicated any problem. Aspen growth and reproduction appeared to be normal on the elk range, and "chawing" was negligible. Generally, the range showed no signs of overpopulation by elk.

In conclusion, the elk have shown a remarkable ability to pioneer into and to occupy practically all summer grazing ranges in the Park. With the exception of the North Saskatchewan range, where they have not yet reached a peak, and possibly the Spray range, they have subsequently abused these summer ranges to the point where progressive range deterioration is an accomplished fact.

MOVEMENTS AND FOOD HABITS OF MOOSE

Special emphasis was laid upon the study of the moose population in the Bow Valley from Banff west to the 17 Mile meadow, and considerable time was spent observing movements and food habits. Check studies were made in several other areas, for comparison purposes and to determine, if possible, influence of presence or absence of elk upon these factors.

Observations commenced 8 May, 1949, and on 12 May the first moose were seen, two cows and one new-born calf, in the Vermilion Lakes area. By 27 May the minimum number
(less calves) known to have been in the Banff to 17 Mile area was twenty-one. Yearlings constituted nineteen per cent of the total during this period (see Table VI), but the last yearling disappeared 18 May. It was remarked by Green that the cows drive the yearlings away just prior to calving, and these observations seemed to bear out the fact. This was further shown by fact that late in June Warden W. Child saw a dry cow still accompanied by a yearling, while on 4 July Green noted a cow, with a calf, vigorously attacking a yearling that apparently claimed relationship.

By 18 June the population in the Vermilion Lakes–7 Mile Beaver Dam–Muleshoe Lake area alone was eighteen (less calves) and on 20 June seventeen were counted—fourteen of them cows. By 2 July there were nineteen moose in the area—four of them definitely yearlings and three doubtful. Thus the yearlings had returned to the summer marshes and now constituted at least twenty-one per cent of the total. On 3 July there were fourteen moose present; by 8 July only seven were seen.

It became apparent that the fluctuations in numbers bore greater significance than mere inaccuracy in observation. This was the more obvious since two grey females were known to have been present in early May, missing in late May and present again by mid-June. By 8 July they were again absent. It was also noticed that the moose divided their feeding
time, in the valley, between wet vegetation and dry willow and dwarf birch. This was discussed with Special Warden H. U. Green, and it was concluded that the moose must be moving in and out of the Bow Valley. It appeared that they came in from dry feed areas, satiated themselves on wet food, and then returned to the upper dry feed areas. Further investigation showed that a party of geologists, while at the top of the col on Mt. Norquay on 4 July, had seen a bull moose on top of the ridge (coming out of Fortymile Creek) and moving down toward Vermilion Lakes. On 10 July a cow and calf were reported moving past the foot of the ski lift on Mt. Norquay—presumably in or out of Fortymile. On 11 July, a bull moose was followed for some four hundred yards up the draw from Second Vermilion Lake toward the col previously mentioned. Subsequent examination of Edith Pass revealed that the game trail into the Fortymile was well used, with recent movement by moose in both directions apparent. No indication of any movement over the pass north of Hillsdale was seen, but discussions with Warden E. Royle from Healy Creek indicated that moose came down that valley, fed in the Bow marshes, and returned south up the creek again.

As a result of this apparent situation, the Waterfowl Lakes area was studied to determine if this movement might be common to other sections of the Park. Reports of earlier years indicated a large moose population in this area, it being not uncommon to see up to ten animals present at one
time. However, only three cows and one calf were seen during several visits throughout the summer. It was noted, and confirmed by Warden R. Haskell, that they did not stay permanently at the Upper Lake, but came and went periodically. Examination of the area indicated little movement to the north, along the Mistaya River toward the Howse River, but well-worn trails south up to Mistaya Lake area were evident. One cow was followed along this route until she reached the high ground east of Mistaya Lake.

It seemed, then, that here, as in the Bow, a movement to and from wet vegetation was taking place. A number of samples of wet and underwater vegetation had been collected at the Vermilion Lakes; a similar collection was made here (see Table V). Inquiry elicited the information that pond-weeds were once most plentiful in Upper Waterfowl Lake; now they were extremely scarce. It was only by wading or rowing downstream from a feeding animal that samples (lost from the mouth) were obtained. These proved to be two of the same species found in the Bow Valley. It seemed probable that pond-weeds once drew moose to the area, but subsequent scarcity of such foods, plus overbrowsing of adjacent willow growth, had discouraged significant summer migrations and occasioned the seeming paucity of moose in the area. In other words, there were probably just as many moose as ever but they no longer congregated in the one area.

Following this the Spray Valley, from Goat Creek to
Table V. Pond plants collected from some moose summer ranges in Banff National Park in 1949.

Second Vermilion Lake and area—collected during July

Equisetum fluviatile L.
Equisetum palustre L.
Hippuris vulgaris L.
Myriophyllum exalbescens Fern.
Potamogeton richardsonii (Benn) Rydb.
Potamogeton pectinatus L.
Ranunculus circinatus Sibth.

Second Vermilion Lake and area—collected during August

Ranunculus purshii Rich.
Sagittaria latifolia Willd. (deep water form)
Sparganum angustifolium Michx.
Utricularia vulgaris L. var. americana Gray

Upper Waterfowl Lake—Collected during July

Drepanocladius sp. (moss)
Potamogeton pectinatus L.

Seven Mile Beaver Dam—collected during August

Chara sp.
Eleocharis acicularis R. and S.
Hippuris vulgaris L.
Potamogeton amplifolius Tuck.
Potamogeton panoramitanus Biv. var. major G. Fisch.
Potamogeton pectinatus L.
Sparganum angustifolium Michx.
Utricularia vulgaris L. var. americana Gray
Vallisneria americana ? Michx. (introduced)

*Identifications by Dr. T. M. C. Taylor of University of British Columbia.
the 15 Mile cabin, was checked. A well-used trail was found along the westerly side of the valley, apparently leading to Sundance Pass (and the Bow Valley). It showed every evidence of frequent use by moose, and a heavily browsed strip confined to a few feet on either side of the trail indicated transient utilization. Thus it seemed most probable that Spray Valley moose conformed to the pattern and periodically fed in the Vermilion Lakes area. A similar trail and browse condition was found along the Cascade River south of Cuthead. There seemed little doubt that here again the same pattern obtained, with the moose possibly migrating to the Bow Valley for wet vegetation.

A reconnaissance of the Graveyard area in the northern section of the Park indicated that moose fed there in the swamps and sloughs in summer. Animals were seen almost completely submerged, feeding on pondweeds. Plant species appeared to be the same as in the Bow area, though no collections were made for confirmation. Few observations were made in this district, but past moose counts indicated movements similar to the Bow and Waterfowl areas. Observations in the areas of Johnston and Baker Creeks, and Boom and Helen Lakes, indicated moose were present during the summer. No evidence of regular summer movements was noted in the Johnston and Baker Creek areas, but regular movement between Boom and Altrude Lakes was indicated. Similarly, it seemed probable that movement was taking place between Helen Lake
and Hector Lake areas.

Observations of winter movements of the moose were not, of course, obtainable during this study. But from inquiry it appeared that most of the moose disappear from the swamps with the first appearance of ice. Most of the wardens claimed that they go to the many tributary streams and valleys to winter; the old bulls going often to the summits or passes. There willow (*Salix vestita* Pursh. and *S. subcoerulea* Piper = *S. Drummondiana Barrat var. subcoerulea* (Piper)) would be plentiful, but snow frequently deep. A few moose remain in the willow brakes, around Vermilion Lakes, made available as the tourist season ends. Toward spring, too, large numbers of moose have been seen in the 17 Mile meadow area. However, Mr. LaCasse estimated the total population from Banff to Lake Louise, exclusive of tributary valleys, at about forty, and maintained that the large number (reportedly forty moose) seen in the 17 Mile meadow in 1942 or 43 was not normal and so not indicative of the local situation. It is possible that the advent of the first wolf might have caused this eflux to the valley, or unusual snows might have occurred; unfortunately no records are available for check. It was not possible, from check of Wardens' diaries, to detect any significant difference in the number of sight observations of moose during winter or summer, except on the summer concentration areas already mentioned. It remains to be determined then, if
any major winter migration takes place, or if moose merely distribute themselves more evenly throughout the dry food areas during that season.

During the summer, several hundred "moose minutes" were spent observing the food eaten by moose in the Bow Valley region. They were observed to browse entirely, eating willows, dwarf birch, black and white poplar (*Populus balsamifera* L. and *P. tremuloides* Michx.), and various other low shrubs, plus occasional lodgepole pine tips, until the equisitum (*Equisitum fluviatile* L. and *E. palustre* L.) became evident along the edge of the Vermilion Lakes about 26 May. This latter food, then, was eaten avidly, in conjunction with periods of browsing willows (*Salix Bebbiana* Sarg.). By 7 June pondweeds became available (see Table V), and remained the major attraction of the Vermilion Lakes and 7 Mile Beaver Dam area throughout the summer. Periodic browsing of willow continued throughout. No evidence of other than casual grazing of dry grasses and forbs was seen, and this appeared to be mainly accidental. However, by 18 June some new sedge growth (*Carex* spp.) was being eaten, and later some slough grass (*Beckmannia Syzgachne* (Steud) Fern.) was grazed slightly in the vicinity of the Beaver Pond. No attempt was made to determine relative times spent feeding upon the different species, but moose were seen to feed in the Vermilion Lakes for over an hour at a time. At Upper Waterfowl Lake, a cow moose was observed feeding in the glacier-fed waters for just over
two hours. When observations concluded the end of August, underwater and/or marsh vegetation was still being consumed in conjunction with willow.

Checks were made of Boom Lake, Cirque Lake and Edith Pass areas between 27 July and 16 August. It was interesting to note that the only fresh browsing evident was upon False Azalia (*Menziesia ferruginea* Hook.). Willow and dwarf birch showed moderate winter browsing, but the False Azalia appeared to be the favored browse of the fluid summer populations.

**VITAL STATISTICS OF MOOSE**

Observations on reproduction were made chiefly in the Bow Valley area from Banff to Eisenhower. However, records were kept of all personal observations, and of reliable reports received from various other regions of the Park. The first calf seen was born 12 May in the Vermilion Lakes area, and the last newborn calf was found 22 June. During this period fourteen calves (including one set of twins) were noted, while sixteen cows were known to be in the area. At least one of the three dry cows was not yet of breeding age. One additional cow was known to be in the 17 Mile meadow area at this time and it is believed she was dry. Thus there were fourteen calves for sixteen cows or a 1:1.4 calf to cow ratio.
One cow and calf and one cow and yearling were reported in the Spray Valley. Two cows and calves were reported in the Johnston Lake area, and two cows and calves were seen in the Cascade area. Three cows were seen at Upper Waterfowl Lake several times but only one calf was noted; it is believed two of the cows were dry. On the Howse River two cows were seen and both had calves. In two trips past the Graveyard area four cows and two calves were seen. It was possible the same cow and calf were seen each time so the count had to be taken two cows and one calf. It is seen, however, that the lowest calf-cow ratio noted was 1:3. It was not known what the summer movements of dry cows were, but from observations of migrations to pondweed areas there was no reason to believe that they segregated themselves or avoided the lakes. Therefore the calf-cow ratios observed were taken as a reliable indication of the calf crop.

For the same reason, it was believed that the sex and age counts made in the Vermilion Lakes area were a reliable index of the composition of the moose population in the Park. By 27 May twenty-one moose (less calves) were known to have been in the area. By 18 June the population present was eighteen plus ten calves. Thereafter only day records were kept except in the case of calves, and major counts are shown in Table VI. As noted earlier, by 27 May the yearlings (three males and one female possible) made up nineteen per cent of the total (less calves). On 2 July the yearlings constituted at least twenty-one per cent of the population, with a sex
Table VI. Classification, by age and sex, of moose known to be in the Vermilion Lakes-17 Mile meadow area, Banff National Park, from May to July, 1949.

<table>
<thead>
<tr>
<th>Date</th>
<th>Adult Males</th>
<th>Adult Females</th>
<th>Young Males</th>
<th>Young Females</th>
<th>Yearlings</th>
<th>Calves</th>
<th>Undetermined</th>
</tr>
</thead>
<tbody>
<tr>
<td>27 May</td>
<td>2</td>
<td>7</td>
<td>7</td>
<td>2(1)</td>
<td>3(4)</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>18 June</td>
<td>3</td>
<td>12</td>
<td></td>
<td>2</td>
<td></td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>2 July</td>
<td>4</td>
<td>8</td>
<td>(2)</td>
<td></td>
<td>7(5)</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>3 July</td>
<td>3</td>
<td>8</td>
<td></td>
<td></td>
<td>3</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>4 July</td>
<td>6</td>
<td>6</td>
<td></td>
<td></td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>8 July</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

()brackets indicate possible numbers where sex determinations in doubt.

ratio of five males to two females, with two of the males possibly two year olds. On 3 July the yearling ratio was one male to two females; on 8 July two males to one female. Thus an approximate ratio of three males to two females was observed in yearlings. Young males and females were recorded separately in early counts but lumped in with adults as the summer progressed. July figures were considered most indicative for adult sex ratios, since during the calving season the cows particularly selected the valley bottom. It is believed the ratio ran very close to 1:1. In all, there was nothing
seen to indicate an unbalanced or declining population. Green, from study of Wardens' returns and personal observations, estimates the 1950 moose population as 247. This figure compares favorably with interpretation of Wardens' reports for earlier years, and indicates a more or less static condition since 1945 (as opposed to the situation outside the Park in Alberta where moose have declined). (Green, unpublished report.) Cowan, in his earlier studies, found moose to be declining. It is considered probable that moose in the Park reached a maximum population density in the late 1930's and then declined slightly to a steady level about 1945.

MOOSE LOSS FACTORS

Loss factors with respect to moose have been adequately covered by Cowan (1943:18-19 and 1944:73). The winter tick (*Dermacentor albipictus*) appears to be of some importance. No serious condition was seen in 1949, but from conversation with other persons it appeared that these ticks have caused, or have contributed to, considerable losses. Predator losses did not appear significant (see also Cowan, 1947:167), and only two probable wolf kills were noted.

However, Wardens maintained that wolf kills did occur, and
as stated earlier, opinion differed as to severity of predation compared to that upon elk. It should be again noted, however, that since the moose population was far below that of the elk, numerically equal predation upon both would have far greater significance with respect to the moose. Warden P. G. Woodworth stated that he found five dead moose in the Little Pipestone country early in the spring of 1949, but he could not say they had been killed by wolves. Some losses of calves occur due to drowning, when the cows swim or wade across lakes too deep and too wide for their offspring. There is an obvious loss, shown by the vital statistics, from calf to yearling age. This is attributable, it is believed, to non-survival of the first winter. It was considered in 1949 that the Park supported, in most areas, the maximum numbers of moose desirable for good management. It seems probable, then, that winter competition for food mitigates against the calves to the point where, despite high reproductive success, the population is only able to maintain the steady level noted. Thus the loss factors, presently not critical, point up a situation of possible future concern should range conditions worsen.

MOOSE RANGES

It was not possible to adequately deal with the moose range from Banff to the 7 Mile Beaver Dam area in the
Bow Bailey without considering the combined effects of beaver activity, waterkill and moose browsing. Without doubt, the beaver, in the past, contributed largely to the desirable summer habitat and food found in this area. However, their continued activities were considered to be somewhat of a mixed blessing. They doubtless maintained the existent water levels, and were therefore instrumental in retention of the excellent underwater vegetation; as well as the wet area willows that still persisted along lake and marsh edges. At the same time, they had maintained water levels such that large sections of willow brakes, in the Third Vermilion Lake and 7 Mile Beaver Dam areas, had been unquestionably water-killed, thus removing these significant areas from use by moose. It has already been pointed out that the summer moose population was migratory or transient, and much larger than the area could sustain over any period of time. Such animals divided their time between wet vegetation and browse. By August the willows in the immediate vicinity of the lakes and marshes showed ninety to one hundred per cent utilization, with considerable destructive browsing of the major brakes. Wet vegetation still continued to be excellent. The flood kill of willows in the general area, then, contributed to the concentration of these transient animals, and no doubt hastened the trend toward ultimate destruction of the browse species.

In the Muleshoe area, in June, five cows and four calves were present—working the small green runs in
conjunction with willow browsing. On 3 July no moose were seen; and browse was found to be ninety to one hundred per cent utilized; browsing animals could no longer survive there. Farther west, in the vicinity of the 7 Mile Dam, willow height in the open flats was twelve to eighteen inches, and all growth was heavily browsed. Tall willow brakes along the stream edges were ninety to one hundred per cent utilized, and no live stems over four feet in height survived. Normal height for the open flat willows would be at least four to five feet, and for those in the brakes ten to twelve feet and higher. The Fortymile, Johnston, Baker and Boom Creek areas bore excellent willow growth, and browse generally was good. No check was made of the Healy Creek and Red Earth Creek areas. At the 17 Mile meadow, early investigation indicated moderate to heavy winter utilization of browse species. However, in the main area summer willow growth and fruiting were excellent. This was due to complete lack of summer usage, a situation believed due to complete absence of equi-situm or pondweed in the nearby lake and to the destructive browsing by elk of surrounding areas.

The area leading to Helen Lake was in very good condition, and the Bow Summit itself showed excellent browse conditions. West of Upper Waterfowl Lake, including up to and around Cirque Lake, moose range was again excellent. At the Waterfowl Lakes, however, the condition was similar to that at Vermilion Lakes. Willows were heavily to destructively
browsed, except where protected by the road camp (this demonstrated summer browsing since the camp was only open during the summer). The degree of utilization decreased as one moved progressively farther from the lake, again demonstrating summer usage. South up the Mistaya River and tributary creeks browsing was heavy. As earlier mentioned, however, underwater vegetation was negligible except at the entrance of the Mistaya River into Upper Waterfowl Lake. Carrying capacity generally, then, was low.

The Howse River area showed indications of eighty to ninety per cent browse utilization in meadows when inspected early in the summer. Due to the dry season recovery was not one hundred per cent by August, but it was sufficient to indicate good range condition. Browse conditions appeared to be good in the Graveyard area, and also at Owen Creek. In the latter area aspens had about fifty per cent of the leaders removed in some small localities.

The Cascade moose areas generally were in good condition. As stated earlier, some deterioration of browse species was seen on the Cascade Valley floor south of Cuthead, but it was not yet significant. In the Spray Valley conditions were not good. South and east of the 15 Mile cabin the main tall willow brakes were heavily browsed generally. Browsing was heavy along the trail leading to Sundance Pass. It was considered that this area was carrying the maximum numbers concomitant with continued good range management.
This was considered true of all major moose ranges in the Park, in particular the summer concentration areas. Only minor creeks and slide areas indicated possible underpopulation.

**MOOSE IN RELATION TO ELK**

Little indication was seen of any direct conflict between moose and elk, possibly due to the fact that elk use of browse areas is largely confined to the winter while these studies were carried out during the summer. Inquiry elicited no instances of physical conflict, however, and reports were received of the two species living compatibly in certain areas. Some observed instances of elk browsing have already been noted; and it was considered significant that in the main, Bow Valley elk concentration areas browse species were heavily over-utilized or killed, while aspen reproduction was negligible. It cannot be doubted that considerable area was thus removed from use by moose. However, in view of the solitary habits of the moose, it is unlikely that this situation was a major factor in limiting the moose population. The tendency of elk to gradually press against the moose swamp areas, though, would seem to indicate that if such areas dried up gradually, elk would take them over, eliminating moose or altering their migration patterns. This
latter effect may already have occurred, since no moose were seen to move from Johnston Creek through Hillsdale to the Vermilion Lakes during the summer. Too, the 17 Mile meadow area was completely unused by moose during the summer, possibly due to the destructive activities of the elk in the surrounding area.

Mention has already been made of the situation in the Cascade Valley. In 1949 the movement of elk to the valley floor had not yet resulted in serious browse deterioration. There is little doubt, however, that if this new behaviour pattern persists, the browse will soon be eliminated and the main valley floor made untenable for moose.

A more complex effect is seen in the removal of aspen growth and reproduction by elk. In the Bow Valley this is contributing to the eventual extirpation of the beaver, which in turn will remove the pondweed areas and hasten return of dry conditions detrimental to the moose. It must be recognized, then, that elk are affecting the normal plant succession of the area, and will in turn unfavorably influence the moose. The full significance of this influence may not yet be apparent.
MOVEMENTS AND FOOD HABITS OF MULE DEER

Since the study in 1949 was particularly directed to moose studies, little attempt was made to determine movements and food habits of the mule deer, beyond recording observations. Deer, or deer signs, were noted throughout the summer in all sections of the Park. Cowan (1943:11) states that most of the summer deer population migrates out of the Park in the autumn, and winters at the lower levels of the foothills. Thus the major problem of winter range is limited in the Park. However, the Bow Valley, which maintains a certain resident population throughout the summer, presently provides a wintering ground for a distance of some seven miles from Banff to the area of the 7 Mile Beaver Dam. Edwards, in his studies on the Malheur National Forest ranges in Oregon, states that the deer spend nearly four months on a large winter assembly area before moving to the winter concentration area for the two critical months February to April (Edwards, 1942:213). If this situation obtains to any degree in Banff Park, then a much larger area than that already described may be vital to winter survival of deer.

It was most noticeable that while some few deer were seen throughout the Bow area, the main summer deer population was found in close proximity to Banff itself, or those areas where tourist traffic had, apparently, restricted the destructive action of elk. They were also found in the deep
to semi-open woods surrounding the lakes and swamps—areas little frequented by elk and held to be typically moose habitat. Thus fifty-one sight records were noted for the area from Banff to the 7 Mile Beaver Dam, while only eighteen were noted for the entire area from 7 Mile to the junction of the Lake Louise-Jasper Highways—a distance of nearly thirty miles. Yet all this latter area should have been suitable deer territory; most of it should have been winter as well as summer range. Most observations were made before the end of the first week in June, since by that time most deer appeared to have migrated. They returned by the middle of August but time did not permit of worthwhile observations.

No attempt was made to determine the food habits of the deer in the Park. Studies of deer foods and food habits are numerous and exhaustive in detail. It can be stated generally that deer are browsers by preference but do eat grasses and forbs in quantities varying from season to season. Use of these latter two forage types varies also from a basic minimum to maxima dependent upon range condition. Percentage of total diet made up by any single species depends upon availability. Cowan (1944:49-52) gives some data on deer food habits in Jasper Park, and it was assumed, for purposes of the study, that the food habits were essentially the same in Banff Park. Aspen and willow were present in the area where the greater population count was made, but throughout most of the remaining semi-open areas of the Bow Valley
willow and aspen were unimportant for deer since the two species had been virtually eliminated by elk. *Shepherdia* was present but not sufficiently abundant to be of significant value. Bearberry was abundant and probably the chief support of deer throughout the winter ranges shared with the elk.

**VITAL STATISTICS OF MULE DEER**

Time did not permit attempting an actual full count of deer in the Bow Valley during the summer study, but sight counts were tallied. The highest single count for one day was six deer. This was in direct contrast to the situation as reported in the earlier years of the Park. Hewitt (1921:238) quotes a warden's report of early 1919 which stated that seventy-one sheep and twelve deer were seen near Massive (Hillsdale area?)—presumably in one day. He further quotes the Superintendent as reporting in April of the same year that along the motor road for ten miles west of Banff 375 sheep, 10 goats and 16 deer were seen (Ibid:237). Mr. LaCasse reported to me that prior to about 1936-37 willows used to be plentiful and in excellent condition throughout the Hillsdale area, and that deer and sheep were plentiful. A check of the diaries of Warden G. P. Woodworth for 1942
revealed that the two largest daily sight records for the entire area Banff to Lake Louise to the Divide, were five and nine deer. These were during the month of May, so comparable to the earlier counts, as well as those of 1949. Other counts by Woodworth for 1942 were higher but not considered useful for comparison as most of the deer were undoubtedly seen in the Lake Louise district. However, a general check of the records seemed to indicate that the deer population remained practically static from that year to 1949. This is interpreted to mean that removal of elk by slaughter since 1943 has failed to produce significant increase in deer; resultant range improvement has not been reflected in the deer population to date.

In a summer study as carried out in 1949, it was not possible to make any intelligent estimate of fecundity of deer, or to determine increment. The does habitually hide their fawns while they themselves feed or move about, frequently a considerable distance away. The fawns remain cached for the greater part of each day—even after attaining the age of considerable activity. Too, most of the does had dispersed from the Bow Valley concentration areas prior to fawning. Thus not more than half-a-dozen fawns were seen throughout the summer, although every day was spent in the field (not in search of deer). As previously stated, the deer were re-appearing in the valley by mid-August, but valid doe-fawn counts were not possible before the first of
September when the investigation ended. Figures given by Green (unpublished report) for 1948, in the Bow Valley, indicate that yearlings made up approximately 13.6 per cent of the total herd. Comparison of this figure with the 17 per cent and 12 per cent given by Cowan for 1943 (1943:11-12) would seem to indicate that there has been little change in the situation since the earlier date. Robinette and Olsen (1944:160-161) found in central Utah that yearlings constituted 27.4 per cent of the total herd. Herd increment in the Bow Valley, then, appears to be low.

MULE DEER LOSS FACTORS

Loss factors in the deer population of Banff Park remain relatively unknown. Cowan (1943:12 and 1944:33-34) has dealt with this problem in both Banff and Jasper Parks, and has discussed in particular parasites and diseases. It is not desired to comment further on this aspect of the situation. However, it was noticed that there was a relatively heavy population of coyotes present in Banff Park in 1949, and one cannot doubt that a number of fawns must annually fall prey to these predators. Further, the significant wolf population in the Park must have some effect upon the deer. These latter, unable to compete adequately with elk for food, would be expected to succumb more readily to predation than the elk.
Thus losses would be greater than would be expected on the basis of chance encounter alone. Loss factors generally would be aggravated in importance due to the paucity and poverty of the prey population.

MULE DEER RANGES

Deer summer generally throughout the Park, and are so scattered as to make range determinations difficult if not impossible. Thus no attempt was made, in 1949, to take particular cognizance of deer summer range conditions. Browse was plentiful along the minor streams and valleys, slides and small openings, and it was considered that the dispersed deer population would experience no difficulty in coming through the summer in good condition. Since the only major winter range within the Park is in the Bow Valley, most emphasis was placed upon this area in the study. It has already been stated that browse species were almost completely wanting throughout the winter range area. Some improvement in graze species was noted, as compared to the situation prior to the implementation of an elk removal program in 1943, but graze conditions generally were still far below normal. It was considered that the entire winter range was marginal and precarious for deer.
MULE DEER IN RELATION TO ELK

The influence of elk on deer has been ably discussed by Cliff in his paper presented to the North American Wildlife Conference in 1939 (Cliff, 1939:560-569). It is realized that the range foods of the Oregon territory discussed vary considerably from those of the Banff area, but the same basic relationships exist and one cannot escape the same conclusion—that elk flourish at the expense of deer. Cliff found that over a 17-year period (including a period of intense range overuse) elk showed an average annual increase of twenty-three per cent compared to 14.4 per cent for the mule deer. He estimated that one elk replaced three deer in his area. No data are available for the Bow Valley but it is not believed the replacement ratio has been so high. The yearling percentages already given would seem to indicate that deer should have been increasing more rapidly than elk. It is believed, however, that these figures do not reflect the true situation as the high deer yearling counts were mainly for areas not greatly frequented by elk. It is believed that upon the heavily used elk ranges (once excellent deer ranges) counts would show an extremely low survival rate of deer and a static or failing total population—as compared to an increasing elk population.

Cliff also found (Ibid:567-568) that the size and weight of the mule deer decreased as competition with elk
increased. Stoddart and Rasmussen (1945:254) found in Utah that deer on overbrowsed range produced an annual fawn crop of 18.7 per cent of the female herd compared to 75 per cent and 77 percent in other sections of the State. Deer of all ages from the overbrowsed area averaged about 70 per cent of the weight of the other deer, calculated from kill data. They state that "There is no question that an underfed deer not only is smaller than normal deer but also its capacity to reproduce is less". This has been further confirmed by Morton and Cheatum (1946) and Cheatum and Severinghaus (1950) in their work on whitetail deer in New York State. There are no data as yet available to prove or disprove such a situation in Banff Park. But the thought presents itself that here, with much of the once excellent winter range now marginal, and with the main winter deer populations of the Bow Valley restricted to extremely limited areas, the same condition could very well obtain. Mule deer are known to be tenacious in their adherence to home ranges and customary feeding grounds. It is considered unlikely that the various populations involved in competition with elk in Banff Park have moved to new winter areas from the summer ranges. Rather it is more probable that they have suffered the debilitating and degrading effects of impoverished range conditions.

There was no reason to believe that elk were affecting the deer of the North Saskatchewan Valley. Browse conditions in that area were still good. Practically all other
deer of the Park winter outside its boundaries, so nothing was learned of their wintering conditions. However, Clark, in his report on the Park in 1939, gave it as his opinion that the Park was fully stocked with deer (Clark, 1939:9). No data were observed in this study to suggest that such was not the case. Thus it must be presumed that any encroachment of elk upon deer range within the Park would result in conditions unfavorable to deer, with a subsequent downward trend in their numbers. There can be no question that some such encroachment has occurred.

MOVEMENTS AND FOOD HABITS OF BIGHORN SHEEP

The ecology and life history of the bighorn sheep of Banff National Park have recently been extremely well covered by Green (1949). Most of the information, then, given for this species has been drawn from his work. However, certain personal ideas and observations have been incorporated into this brief recapitulation.

According to Green (1949:20), the bighorn of Banff Park are not confined to any one range within the region, but move, in bands of varying numbers, from range to range—often remaining in each locality only for a few days. Well travelled trails join most of the ranges, and are used until
well into the winter, or until deep snow limits movement. Distances travelled vary from less than five to more than twenty-two miles. It was reported in 1949 that there had been some movement of sheep from the Aylmer range area to the Vermilion lick, but no evidence was actually seen of widespread sheep movements.

These sheep are diurnal in their activity, and can usually be seen upon the ranges—feeding, loafing and resting. They have so lost their fear of humans in the Park that the ewes and young males can often be readily approached—especially at licks. The rams, in separate bands in summer, tend to remain more wary and suspicious. From observations made in 1949, it can be said that the flocks appeared to follow no set routine. They appeared at the Vermilion lick and again disappeared with apparent lack of regularity or reason. The numbers appearing varied from day to day, although some of the same individuals appeared to be present successive times.

There appears to be little seasonal migration among the Banff Park sheep. Rather they appear to move somewhat indiscriminately about their ranges, tending to favor southerly and westerly slopes. In winter they frequent areas where snow is least heavy or has blown clear. These again are mainly southerly and westerly slopes which are most exposed to the prevailing winds. Cowan (1943:4-5) discusses sheep winter ranges in some detail.

Sheep are basically grazers but do consume small
quantities of browse. Cowan (1944:51) found in Jasper Park that grasses and sedges constituted eighty-three per cent of the total food consumed, forbs ten per cent and shrubs only seven per cent. It may be presumed that essentially the same situation obtains in Banff Park. Feeding periods alternate with resting and loafing periods. During the summer, at least, considerable time is spent at mineral "licks". At such times the bands of sheep work the dirt of the "lick", nip occasional sedges and grasses in the vicinity, possibly drink if water is nearby, and generally give the appearance of resting. Free water in the immediate vicinity is not, apparently, an essential to good sheep range. Escape cover appears to be a main consideration when sheep are grazing in a closely confined area. It is not known just how much this need dictates food choice.

VITAL STATISTICS OF BIGHORN SHEEP

It is extremely difficult to arrive at any definite conclusions regarding sheep populations in Banff Park without a detailed study. They wander over several ranges, from large or small flocks at random and break and reform with a certain amount of shuffling, thus making accurate counts most difficult. Lambs may or may not accompany ewes to the licks.
Special marking techniques would be invaluable in the study of such populations.

Throughout the summer of 1949, daily counts were made of sheep in the Bow Valley. Undoubtedly considerable duplication occurred. However, the total count for the summer was 278 sheep of all ages. This aggregate was made up of ages and sexes as follows: 63 adult rams, 42 adult ewes, 27 yearlings, 21 lambs and 125 unaged and unsexed. In percentages this worked out to 22.7 per cent adult rams, 15.1 per cent adult ewes, 9.7 per cent yearlings, 7.5 per cent lambs and 45.0 per cent unaged and unsexed. Green (1949:30) gives composition of aggregate counts made from April to September, for the five years 1944 to 1948 inclusive. These show relative stability in sex and age ratios. Figures for 1948 are 16.1 per cent rams (over two years), 60.8 per cent ewes (over two years), 3.0 per cent rams and ewes two years, 3.4 per cent rams and ewes yearling and 16.5 per cent lambs. Comparison of his figures with the 1949 figures indicates certain rather great discrepancies, but Green shows no unaged and unsexed group so the figures are not strictly comparable, especially for ewes, young rams and yearlings. Great difficulty was experienced in 1949 in distinguishing between two year old rams and ewes of various ages. This was gradually overcome with experience, but hasty or distant observations were still uncertain. This certainly caused inaccuracy in counts. However, it is believed that the greater percentage of the
unaged-unsexed group was ewes, which would bring the total somewhat in line with Green's figures. Yearling counts were felt to be just fairly accurate, but compared favorably with the 1948 figures for the Dormer flock (Green, 1948:11). Adult rams and lamb counts were considered to be quite accurate. It is believed that Green's figures for rams are low, and not indicative of the true situation. They were compiled from counts taken entirely at the Vermilion lick, where adult rams are infrequently seen.

It is difficult to state if the 1949 figures indicate any significant change in population composition. Green (1949:31) shows a progressive decline in lamb mortality from 17.3 per cent in a 1944 to 13.6 per cent in 1947, which suggests an increasing population. It is possible that lamb survival to yearling age improved substantially the winter of 1948-49, so accounting for the high percentage of yearlings seen during the study. However, no plausible reason for the drop in lambs in 1949 is apparent, unless the rapid deterioration of the upland ranges finally made itself felt through reduced fertility or fecundity. A follow-up study is necessary to provide further data in this regard. One other possibility is lamb loss to predators, as coyotes appeared to be active in 1949. Unfortunately there are no comparative data with which to check this possibility.

Aggregate counts at the Vermilion lick indicated little change in population. Table VII shows the counts for
the years 1944-49 inclusive.

Table VII. Number of counts and aggregate totals of bighorn sheep seen at Vermilion lick, Banff National Park, for 1944 to 1949 inclusive.

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Counts</th>
<th>Aggregate Total</th>
</tr>
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<tbody>
<tr>
<td>1944</td>
<td>29</td>
<td>444</td>
</tr>
<tr>
<td>1945</td>
<td>35</td>
<td>445</td>
</tr>
<tr>
<td>1946</td>
<td>35</td>
<td>540</td>
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<td>1947</td>
<td>35</td>
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<tr>
<td>1948</td>
<td>49</td>
<td>587</td>
</tr>
<tr>
<td>1949</td>
<td>29</td>
<td>297</td>
</tr>
</tbody>
</table>

Green made the 1944-48 counts from April to September (Green, 1949:30). The 1949 counts were made from May to August inclusive. It is not known whether the 1949 count represents a drop in population, or merely reflects the shorter period covered.

There can be little doubt that the sheep population of the Park has dropped very considerably in the past ten or more years. As already noted, a Park Warden early in 1919 counted 71 sheep near Massive, and the Superintendent reported in April of the same year that 375 sheep were seen within ten miles of Banff, west along the highway. Mr. U. U. LaCasse
stated that in comparatively recent years sheep used to be plentiful in the Massive area. Green (Ibid:28) indicates that twenty years ago 300 to 400 sheep were observed yearly on the Sawback-Vermilion range. Highest count from 1942 to 1948 was 147. The situation in the Cascade area was seen to be even more serious. A Park Warden reported fifty-two sheep on Cuthead mountain early in 1919 (Hewitt, 1921:238). Park Warden E. Stenton stated that in 1927 or 1928 he and Mr. James Simpson counted between 600 and 700 sheep on the Palliser range. It was not uncommon to count 250 sheep during a trip along the Palliser and Cuthead ranges en route to Windy Cabin. By 1949 one was lucky to see twenty head on such a trip. According to Green (Ibid:28), the highest count on the Palliser from 1942 to 1948 was forty-three. During the several trips made through this area in the 1949 study, no sheep was seen on the two main ranges.

Further evidence of decline in population is seen in the gradual disappearance of sheep from the areas south of the Bow River. According to Green (Ibid:28) old Park files make mention of one hundred sheep south of the Bow in 1914. Whether some of these were summer migrants or not is not known. Green presumes they were all included in a permanent population on Goat Range, but it is known that there were and still are sheep on the Mt. Bourgeau Range. Cowan, in 1943, suggests a liberal estimate of the Goat Range population would be fifteen (Cowan, 1943:6). As far as could be
determined in 1949, the last of these had been extirpated. The Mt. Bourgeau flock still numbers about twenty-five. It is impossible to escape the conclusion, then, as both Cowan and Green have noted, that the bighorn sheep of the Park have declined greatly and, in spite of the apparent decline in lamb mortality, may not yet be holding their own at the reduced level.

BIGHORN SHEEP LOSS FACTORS

Loss factors, relating both to annual losses and to progressive population decline, have been thoroughly discussed by Cowan (1943:6-8, 1944:16-20 and 59-63) and Green (1949:30-31 and 34-49). It is perhaps repetitious to recapitulate in any detail their observations and findings. It is desired, however, to later point up certain features of these possible loss factors and to this end some repetition is necessary. Actinomycosis has been found to be of general occurrence in the sheep of Jasper Park and presumably then too in Banff Park flocks where its presence is known. This disease is considered more chronic than acute, but it can kill through the medium of malnutrition of the host. Two species of lungworm are present in bighorn, the hair lungworm
(Protostrongylus stilesi) and the thread lungworm (Dictyocaulus viviparus). Both these parasites induce a pneumonic condition, and while rarely directly fatal, they can and do cause debility and lowered vitality which cause the host to fall prey to predators, malnutrition or some other more serious disease such as Haemorrhagic septicemia (caused by Pasteurella oviseptica). Potts (1938:896) believes that septicemia was responsible for the great losses in sheep in Rocky Mountain National Park, Colorado, but suggests that Lymphadinitis caseosus (caused by Corynebacterium pyogenes) following lungworm infestation may be equally important.

Stomach worms of the genus Ostertagia were found by Cowan in every sheep examined in the Parks; here again the same factor of debilitation, through blood loss and secondary infection, is presented. Several other internal parasites are known to occur in sheep but their importance has yet to be demonstrated. External parasites, in the form of the winter tick (Dermacentor albipictus) and the Rocky Mountain tick (Dermacentor andersoni) are known to occur in Banff sheep, but no serious effect has yet been shown. It should be noted, however, that again these parasites foster a lowered vitality of the host.

Green, in particular, has given detailed information regarding predators in Banff and their effect upon the bighorn (Green, 1949:34-44). It is not desired to enlarge
upon his work, but he lists cougars, wolves and coyotes as main probable predators. As far as cougars are concerned, it must be remarked that during the four months spent in study in the Park in 1949, not one cougar track was identified although many trails, of both horses and game, were covered on foot by the investigator. One doubtful track, not new, was seen along Carrot Creek but it is believed that it was an old wolf track since it was slightly longer than wide. Thus it is believed that Green hit very close to the truth when he stated that one cougar could have been responsible for all the sight observations he has noted. Or it may be that the Park is on the travel route of the occasional itinerant cougar, inasmuch as the sight observations extend over several years. It is doubted that the Park contains any significant resident cougar population.

Wolves were noted to be present in some numbers in 1949, as were coyotes too. With the latter it was difficult to determine exact numbers since individual animals wandered greatly and were difficult to re-identify. Two coyotes were seen stalking a group of lambs and ewes near the Vermilion lick. The two separated and attempted to cut the sheep off from nearby escape terrain, but the final outcome was fore-stalled by a shot fired at one coyote. It was apparent, though, that some harassment at least was taking place.
Discussion of the ranges will be given in subsequent paragraphs. But it is apt to point out here that much of the best sheep range in the Park is composed of open slopes a considerable distance from escape terrain. Excellent visibility affords some protection, but it is possible for cursorial predators to harass flocks and so confine them, upon occasion, to the less suitable and marginal portions of their range. Murie (1944:142) has noted this situation with wolves and sheep during his investigations in Mt. McKinley Park in Alaska. As will be noted later, then, the combination of debilitating parasitism and disease, harassment by predators forcing use of marginal range, and range abuse and overuse by competitive herbivores could well constitute environmental resistance beyond the ability of the bighorn to withstand. While it seems highly probable that the original large flocks were heavily decimated by either Haemorrhagic septicemia or verminous broncho-pneumonia, (Cowan, 1943:7), it may well be that they are being further decimated or held at a dangerous low by the combination of factors herein described.
BIGHORN SHEEP RANGES

Green (1949:18-19) gives eleven ranges for bighorn sheep in Banff Park, described as Eisenhower, Johnston Creek, Sawback, Vermilion, Aylmer, Carrot Creek, Palliser, Dormer, Bare Mountain, Red Deer and Mount Wilson areas. He includes the Upper Cascade River Valley to Flint's Park within the Palliser area; the Panther River and Snow Creek within the Bare Mountain area, and Tyrrell, McConnell and Divide Creeks within the Red Deer area. The map across page shows these ranges as outlined by him. He has, however, overlooked several other sheep ranges, including the Bourgeau Range, Sulphur Mountain (summer range only) and the Mt. Drummond-Cyclone Mountain area (exact status unknown). These concur fairly well with the areas noted by Cowan (1943:4-5) with the exception that by 1949 no sheep were known to be resident south of the Bow River other than on the Bourgeau Range. Thus the Goat Range flock has been eliminated. Cowan deals more particularly with winter ranges, as being the acute problem, but since the winter ranges are, in the main, part of the larger ranges described by Green it is considered suitable to deal with the more general areas.

The Mount Wilson and Red Deer areas were not examined in 1949, and the Bare Mountain and Dormer areas were observed cursorily from a distance. However, from knowledge of the
elk situation in the Mount Wilson area, it was assumed that it had not yet suffered from the depredations of elk and was still in good condition. The Red Deer, Bare Mountain and Dormer Ranges were utilized by elk in summer (Green, 1949: 32-33) and it was considered, as judged by other ranges, that this competition would be to the detriment of the ranges and the sheep. All the other sheep ranges were heavily used by elk at some time of the year, and were considered to be over-utilized to some degree. Elk were seen high on the Eisenhower, Johnston Creek and Sawback sheep ranges during the summer, and it was deduced from pellet observations that they had been on some of the lower levels of the Vermilion Range. The Carrot Creek Range was heavily grazed, with areas showing the typical elk utilization condition of browse killing and aspen deterioration.

The Palliser range showed incipient erosion, from both hooves and grazing, and poor graze conditions. This situation was aggravated by the extreme drought of early summer in 1949. The Aylmer Range is a summer elk range, and it was seen to be in just fair condition. Thus it is seen that of all the sheep ranges in Banff Park, possibly only one, at Mount Wilson, has escaped the elk.

It was pointed out in the history of the Park that practically all ranges but alpine meadows have been created by fires. Certainly practically all the winter sheep ranges
are fire created. Thus normal forest succession, extension and regrowth constantly exert pressure upon already restricted ranges. Recent fires have opened up some new ranges, and Cowan suggested in 1943 that approximately the same total amount of range has remained available for the past thirty or forty years. However, Park authorities are making every effort to perfect fire prevention and fire fighting techniques, and it seems probable that forest pressure will further limit the sheep over the forthcoming years.

**BIGHORN SHEEP IN RELATION TO ELK**

The encroachment of elk upon sheep range has just been discussed. No direct studies have been carried out to determine similarities in food habits of the two species in Banff Park, but Pickford and Reid, in their studies into competition between elk and domestic livestock in Oregon, found that the food preferences were very similar, and they concluded that competition was keen. They found that a small group of plant species provided the major bulk of food for both species, and estimated that 1.25 elk replaced five domestic sheep (Pickford and Reid, 1943:328-332). It is believed that similarity of food habit in the Park has led to direct competition between these two species. The vigor and aggressiveness of the elk
herds, plus exceptional versatility in food habit, has led to almost complete occupation of all major sheep ranges—to the detriment of the less aggressive sheep. These latter have been forced, through lack of food or for as yet unknown psychological reasons, more and more to the edges of the ranges, where living is marginal and precarious. It is not known if sheep dislike elk and will not range freely over common ground, but it was noted that ranges frequented by elk were little used by sheep. This was particularly seen on some portions of the Vermilion and Sawback ranges. However, it was reported that on the Dormer range both species still feed over the same range. Thus it was considered more probable that it was a matter of sheer physical inability of sheep to compete with elk for food. In any event, the sheep are being slowly but surely pushed off much of the choice range.

One can only speculate on what has happened to them in the past. It seems probable that the epizootics believed to have decimated the flocks prior to the first investigations in the 1940's were the result of sudden virulence of the disease in conjunction with high populations contained within rather restricted ranges. This concentration would be particularly evident in the winter time. Since this major decline, worsening range conditions would not only prevent adequate recovery; they might well contribute directly to a progressive
decline in the species.

It has been suggested that elk carried disease onto the ranges where sheep then fell victims to it. There seems to be little to substantiate this reasoning. It is felt that the situation is one of a less vigorous species falling before the rigors of heavy environmental pressure. It was pointed out that most of the diseases suffered by sheep are of the debilitating type, and that predators may tend to harass them into marginal areas. These factors, combined with the general range poverty and marginal existence thrust upon them by elk, make the situation precarious to the point where any minor change in the balance might mean heavy loss or extirpation. It has been stated that lack of adequate food predisposes domestic stock to disease, and that most instances of mortality in deer were the result of malnutrition, through range depletion and secondary infection. (Taylor and Hahn, 1947:321.) There appears to be little reason to doubt that the bighorn sheep of Banff Park are failing before just such a combination of circumstances. They may be expected to fall easy prey to septicemic, actinomycotic and bronchial-pneumonic epizootics.
SUMMARY DISCUSSION OF DYNAMIC INTER-RELATIONSHIPS OF ELK WITH PARK BIOTA

There has been outlined a situation wherein the region now known as Banff National Park has passed from the grasslands of the immediate post-glacial era to a now heavily wooded primarily coniferous biome. Deciduous types, in particular aspen, are found along watersheds, in some semi-foothill areas, and intermixed with Lodgepole pine as a fire type. Willows and other shrubs grow in low regions, slide areas, along creeks and in near-alpine to alpine associations. Alpine meadows still exist, and with burned-over areas and a few true prairie regions make up the major grazing components.

Record of mammalian fauna is scanty, except for very recent times. But it has been seen how deer, sheep and goats have been indigenous for as long as records permit appraisal, with deer and sheep in particular dependent, for population success, upon fire type vegetation produced through natural
causes. Into this biome then came the beaver-moose complex, of very recent origin but nonetheless in natural ecological sequence. Fires produced satisfactory beaver habitat; beaver activity provided suitable summer habitat for moose. Predators have probably been present for as long as herbivorous prey were available.

The natural dynamic aspects of the situation become apparent. While any one of the mammalian species above-mentioned might survive in limited numbers in the coniferous climax association, all are dependent upon fire and the resultant seral stages in the flora for ultimate occupation and success (interpreted as long term population survival at optimum level). Their fortunes are intimately associated with fire action and inter-specific competition for food. Any factor affecting the balance of available range or normal population movement or increase must necessarily have some immediate repercussions upon the whole ecological complex. Thus the National Park policy of fire prevention could not fail to place certain stresses upon all these indigenous populations. The beaver have eaten themselves out and their populations have waned. Subsequent drying up of beaver dam sites and swamps has limited summer moose range. It seems probable that this would be a natural ecological sequence of events in so limited a beaver habitat, but fire control could not fail to quicken this progression. Similarly, the ranges
of deer and sheep have been curtailed and contained, and sheep in particular have been affected. It is believed that the major fires of the early 1900's, in conjunction with total protection of the sheep, opened up opportunities for maximum increase. More adequate fire control in later years, combined with forest encroachment and regrowth, limited the possibility of subsequent expansion. Thus the situation developed where maximum but contained populations fell before epizootics.

The tourist activity of the National Park has most certainly affected the normal ecological sequence of events. Any wild species subjected to observation by large numbers of people can scarcely be expected to maintain a completely normal habit pattern. As early as 1899 there were 7,389 visitors to Banff Park (Canada, 1907:3); by 1950-51 the figure stood at 459,273 (Canada, 1950-51:14). Tourist trade too means roads, traffic, disposing of certain ranges, and an overall policy directed to entertainment of the public. As early as 1907 there were two stretches of road totalling ninety-six miles in the Park (Canada, 1907:4). The now proposed Trans-Canada highway through the winter range of one major elk herd in the Park, and through the chief summering range of the moose, will be a major blow to these species and emphasizes again the incompatibility of wilderness concept with tourist trade. But without any doubt, the
greatest impact upon the ecological picture of Banff Park was created by the importation of elk to provide one more attraction for the public.

Primarily, three vital points were overlooked in the stocking program. The first was the failure in the beginning to appreciate the vigorous behaviour and voracious and versatile feeding habits of the elk. The second was that the first elk were wintered over in what might normally have been considered spring or summer range—at least if their pattern followed that of the region from which they were obtained. In Yellowstone Park they are known to migrate 150 to 200 miles out to the winter ranges (Gaffney, 1941:436) and it might well have been expected that they should migrate from this planting area to the adjacent foothills where range was more abundant. But, according to Murie (1951:64), the migratory habits of elk are conditioned by habit, and having once spent a winter in any given locality they will return to it—usually by the same route. Thus the conditions of these plantings tended to establish the pattern for the future. This situation was aggravated by the fact that one elk plant was made west of Banff townsit. This meant that the main avenue of escape for any surplus population was cut off once the migration pattern was established to the west. From the beginning, then, the stage was set for a problem of overpopulation. The third factor to be considered is that a major
herbivore was planted in an area where no major predator existed in significant numbers. Some cougar presumably were present but in 1935, when elk were already nearing a critical high, control measures were instituted and nine cougar were removed from one of the major elk problem areas. It was not until serious elk overpopulation was an accomplished fact that wolves first appeared in the Park. These predators were then powerless to affect the continued increase of the prey. In the North Saskatchewan Valley alone, where prey and predator were first recorded within a few years of one another, the elk appear to be in harmony with the coexistent biota.

The predator-prey relationship has been further aggravated by misguided though well-meant wolf control. The Staff of the Park have the fairly typical antipathy to these predators, and carry out control measures continuously as opportunity permits—by tacit understanding of authority if not by actual order. Certain of the game species, particularly deer and sheep, may require some protection but the overall effect of these actions has been the reduction of a much needed control upon the elk. This has probably worsened a bad situation.

It has been pointed out that one cannot point the finger directly at elk as a factor detrimental to the welfare of moose in the Park. However, they have unquestionably
assisted in the overbrowsing of certain probable moose areas, they have contributed to overbrowsing of main avenues of approach to the moose summer swamp areas, and they have completely removed aspen reproduction and crippled willow and dwarf birch growth over much of the Bow Valley. This latter action has contributed to the eventual "eat-out" by beaver, and has lessened any hope of repopulation by them. This in turn will hasten the eventual decline of moose in the Park. A further possibility of conflict has been discussed, the use of the Cascade Valley floor by elk in winter. It seems apparent that, while no major conflict is yet apparent, the elk are exerting a steady pressure against moose every place they coexist. It is suggested that the moose, more solitary by nature, will lose in this competition.

The elk have unquestionably influenced the deer population of the Park by their destruction of browse species throughout most of the Bow Valley region. Deer have been forced to marginal areas adjacent to towns, Wardens' cabins and to the deep woods adjacent to swamps. In these latter areas they may be competing on a minor scale with moose, adding to the destructive use already described. It seems possible that the elk, if uncontrolled, will eventually consign the deer to the role of a rare or occasional species in the Park.

It is perhaps with respect to bighorn sheep that the
elk have been most harmful. Confined to limited areas, but reproducing with great vigor, the elk invaded every sheep range in the Park (with one possible exception) to some degree. They have driven them from the bottom lands and have overgrazed many of their winter ranges. They have now commenced the same invasion of the sheep summer ranges. Typical of this situation is the Palliser Range. It is not known if heavy use of a range by elk makes it repugnant to sheep, or if they are just unable to compete physically for food, but they have been slowly and surely forced into marginal areas, and their numbers have decreased. It has been suggested that the major loss of sheep was due to one or more epidemics—probably haemorrhagic septicemia. Potts (1938:896) suggests that this disease is not so highly contagious as believed, but rather that it is endemic but dormant in most sheep herds. He believes that high herd loss is due to simultaneous exposure to bad weather and malnutrition. It is suggested that if this disease is present in the Banff Park, any sudden increase in virulence might well prove fatal to flocks suffering debilitating parasitism and impoverishment—the latter largely attributable to elk. The situation is aggravated by the encroachment of forest growth vigorously protected from fire. Under existing circumstances in the Park it seems possible that bighorn sheep, even more than deer, may be doomed to revert to the state of a rare
species existing upon marginal habitat.

Little mention has been made of goat and caribou within the Park but some comment seems desirable. One can only speculate upon the possible effect of elk upon these species. But observations made in 1949 of the agility of elk, combined with the knowledge of their versatility of food habit, would lead one to believe that they may, if uncontrolled, feed upon some choicer ranges used by goat. Since goat at all times appear to lead a somewhat marginal existence, any intrusion upon their range by elk, or displaced bighorn, would be detrimental to them. Similarly, any hope of increase in caribou would be obviated by any movement of elk into their marginal ranges.

Excessive range use and incipient erosion in the Park, both due to elk, may have more far reaching consequences than the elimination of competitive faunal species. Skinner, while discussing the effects of overpopulation by elk, has noted this same problem. He states that almost permanent changes take place in the soil if plant retrogression (due to range overuse) is allowed to continue. Trampling becomes progressively more severe and humus in the top soil is reduced. Ability to absorb and retain moisture is lessened and finally erosion by rain, snow and wind takes place. And he points out that while plant reduction is fairly easy to correct, soil breakdown is most difficult to arrest. It may often take
longer than a lifetime. (Skinner, 1950:23.) Thus it will be seen that the conditions of trampling and erosion, so obviously apparent in 1949, may well alter floral succession beyond the limits of present vision, thus influencing the entire ecology of a delicately balanced biota.

One cannot escape the conclusion that the introduction of this major, vigorous and aggressive herbivore into the Park must affect the normal dynamic complexes to be found among the biota. Not only have the mammalian species been influenced but other classes, too. Birds peculiar to a deciduous habitat have been limited by the destruction of aspen and understory species. Bird life in the willow thickets must have been adversely affected. One can only surmise the changes with respect to invertebrate life as a result of the destructive vegetative changes, both above and below ground, that have been caused by elk. But in the combined changes wrought upon both vegetative character and faunal composition of the Park one reads the lesson that man is, in fact, a member of the complex biotic community wherever he exists, and his actions influence the immediate dynamic trend of evolution—often far beyond his perception.
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